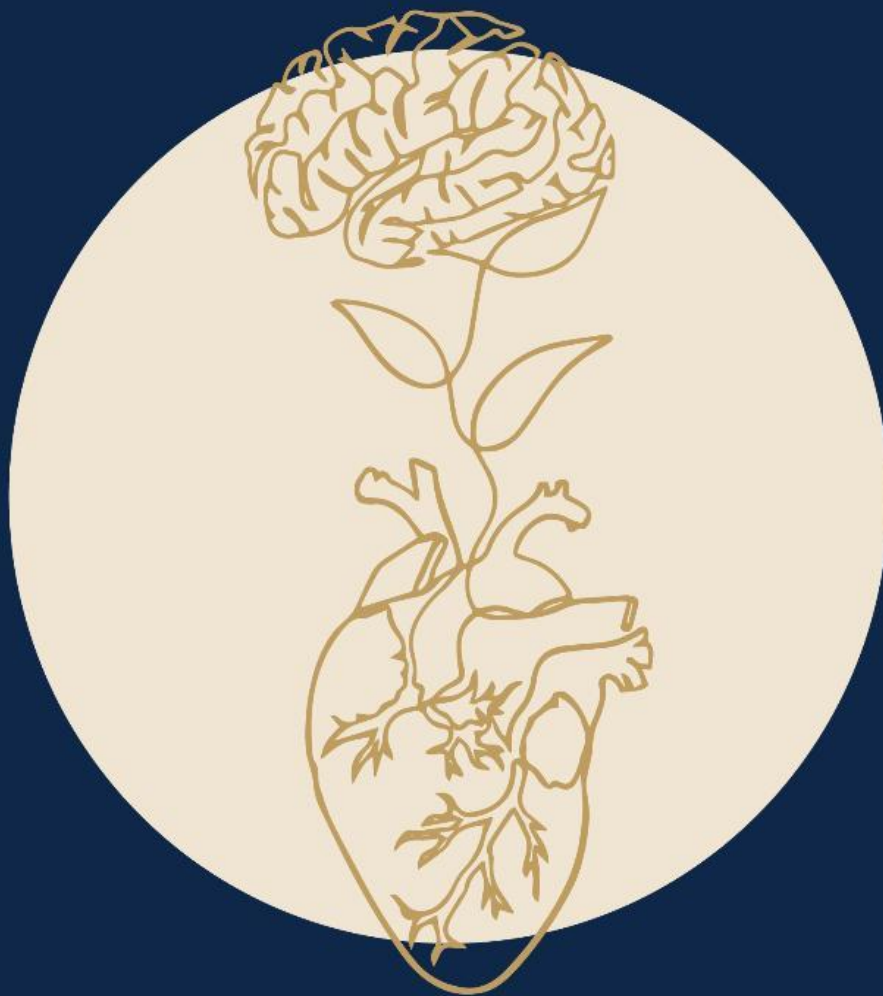


PhD Thesis by Valerie N Rodríguez-Hernández

NEUROCOGNITIVE FACTORS IN THE PROCESSING OF PERSUASIVE HEALTH MESSAGES: THE INTERPLAY BETWEEN INDIVIDUAL CHARACTERISTICS AND PHYSIOLOGICAL REACTIVITY

Promoters: Dra. Alicia Salvador Fernández-Montejo
and Dra. Vanesa Hidalgo Calvo



Valencia, January 2024
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Agradecimientos



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Contents



Table of Contents

Agradecimientos	- 3 -
Abbreviations.....	- 15 -
Thesis Outline	- 19 -
 CHAPTER I: General Introduction	 - 23 -
Social Influence: Persuasion	- 25 -
Elaboration Likelihood Model	- 26 -
Individual characteristics.....	- 27 -
Psychological traits.....	- 27 -
Situational states.....	- 30 -
Psychophysiology of Persuasion.....	- 31 -
Peripheral Nervous System	- 31 -
Heart-rate variability.....	- 32 -
Central Nervous System	- 32 -
EEG resting state.....	- 33 -
Event-Related Potentials.....	- 34 -
Aims and Hypotheses.....	- 35 -
 CHAPTER II: Emotional and cognitive processes underlying persuasion, moderating factors, and physiological reactions: A systematic review	 - 39 -
Introduction	- 41 -
Method	- 46 -
Results	- 48 -
Literature search	- 48 -
Studies examining the effects of discrete emotions in information processing	- 50 -
Studies examining the moderating effects of affect- and cognition-based orientations on information processing	- 53 -
Studies examining the effects of framing on information processing	- 55 -
Studies exploring the psychophysiology of persuasion.....	- 56 -
Discussion	- 68 -
Conclusions	- 73 -

CHAPTER III: How do we process nutrition-related health messages?	
An Online Survey	- 75 -
Online study	- 77 -
Methods.....	- 77 -
Participants and Procedure	- 77 -
Measurements.....	- 80 -
Results	- 82 -
Persuasiveness of the strategies	- 82 -
Persuasion and psychological characteristics	- 82 -
Discussion	- 84 -
 CHAPTER IV: Social dominance and persuasiveness of health messages: An exploratory Event-Related Potentials study	- 87 -
Introduction	- 89 -
Materials and Methods	- 93 -
Participants.....	- 93 -
Procedure.....	- 93 -
Persuasion task	- 94 -
Social Dominance Orientation.....	- 95 -
EEG recording and data analyses	- 96 -
Statistical Analyses.....	- 97 -
Results	- 97 -
Discussion	- 100 -
 CHAPTER V: Heart rate variability response to persuasive health messages: the importance of perceived stress and neuroticism	- 105 -
Introduction	- 107 -
Materials and Methods	- 110 -
Participants and procedure	- 110 -
Measurements.....	- 111 -
Self-report measures	- 111 -
Persuasion task	- 112 -
Cardiovascular data	- 113 -
Statistical analyses.....	- 113 -
Results	- 114 -

Discussion	- 118 -
CHAPTER VI: Need for Cognition role in EEG resting state and the Recall and Recognition of Persuasive Messages.....	- 123 -
Introduction	- 125 -
Methods.....	- 128 -
Participants	- 128 -
Procedure	- 128 -
Psychological measure	- 129 -
Memory assessment.....	- 130 -
EEG resting state recording and spectral analysis.....	- 131 -
Statistical Analysis	- 132 -
Results	- 133 -
Discussion	- 136 -
CHAPTER VII: General Discussion	- 141 -
Overview of the Main Findings	- 143 -
CHAPTER VIII: Main Conclusions	- 153 -
CHAPTER IX: General summary in Spanish.....	- 157 -
Introducción general.....	- 159 -
Influencia social: Persuasión.....	- 159 -
Modelo de Probabilidad de Elaboración	- 161 -
Características individuales.....	- 161 -
Rasgos psicológicos.....	- 161 -
Estados situacionales	- 163 -
Psicofisiología de la Persuasión	- 164 -
Sistema Nervioso Periférico	- 164 -
Variabilidad de la Frecuencia Cardíaca.....	- 164 -
Sistema Nervioso Central	- 165 -
EEG en Estado de Reposo y Potenciales Evocados.....	- 166 -
Objetivos e hipótesis.....	- 167 -
Metodología	- 169 -
Participantes.....	- 170 -

Procedimiento.....	- 170 -
Revisión sistemática.....	- 170 -
Encuesta en línea.....	- 171 -
Fase experimental	- 171 -
Variables.....	- 173 -
Variables psicológicas	- 173 -
Variables fisiológicas	- 174 -
Resultados principales.....	- 175 -
Principales Conclusiones.....	- 179 -
References.....	- 183 -
Funding	- 207 -

Abbreviations



Abbreviations

AI: Affective Intensity

ANS: Autonomic Nervous System

BAS: Behavioral Activation Systems

BIS: Behavioral Inhibition Systems

CNS: Central Nervous System

COPE: Coping Orientation to Problems Experienced Inventory

CS: Corrugator Supercilia

EC: Eyes Closed

ECG: Electrocardiography

EDA: Electrodermal Activity

EEG: Electroencephalography

ELM: Elaboration Likelihood Model

EMG: Electromyography

EO: Eyes Open

EOG: Electrooculogram

ERP: Event-Related Potential

fEMG: Facial Electromyography

FFT: Fast Fourier Transform

GHG: Greenhouse Gas

HR: Heart Rate

HRV: Heart Rate Variability

IBI: Inter-Beat Interval

ICA: Independent Component Analysis

NCC: Need for Cognitive Closure

NEO-FFI: NEO Five Factor Inventory

NFA: Need for Affect

NFC: Need for Cognition

PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses

PSA: Public Service Announcements
PSS: Perceived Stress Scale
rmANOVA: Repeated-Measures ANOVA
RMSSD: Root Mean Square of Successive Differences
ROI: Region of Interest
RR: Respiration Rate
rsEEG: Resting State EEG
RT: Reaction Time
SCL: Skin Conductance Level
SCR: Skin Conductance Responses
SDNN: Standard Deviation from Normal-to-Normal
SDO: Social Dominance Orientation
STPS: Susceptibility to Persuasion Scale
WHO: World Health Organization
ZM: Zygomaticus Major

Thesis Outline



Thesis outline

People are constantly exposed to persuasive messages from multiple sources and with various message frames. Persuasion is a type of social influence that attempts to produce a change in a person's beliefs, attitudes, or behaviors by providing information on an issue. Attempts to persuade can be made by an individual, a group, or a social entity, such as a marketer, a political party, or a health enterprise. Persuasive literature is abundant in the study of factors that affect the persuasive efficacy either in the source, the recipient, or the message, however, the psychophysiology of persuasion is still an emerging area of research. In this line, is relevant to explore how individual characteristics and the physiological reactivity of the recipient are related to the processing of health messages framed with different persuasive strategies. This is relevant to study for use in the field of health and adherence to treatments.

In this Doctoral Thesis, persuasion was studied concerning different psychological traits (Social Dominance Orientation (SDO), Need for Cognition (NFC), and Neuroticism) and states (Perceived Stress). In addition, the response to the persuasive health messages was explored through physiological (heart rate variability (HRV)) and neurophysiological (electroencephalographic (EEG) frequency bands and event-related potentials (ERPs)) measures. Lastly, the predictive role of a state biomarker (EEG resting state (rsEEG)) in the subsequent recall and recognition of the health messages was studied.

The *first chapter* is a general introduction to the studies included in the Thesis. It discusses the study of persuasion as a main type of social influence, the dual process theory of the Elaboration Likelihood Model (ELM), the relevance of individual characteristics, and the physiological response to persuasion. Lastly, it includes the main aims and hypotheses of this Doctoral Thesis.

The *second chapter* is a systematic review that gathered empirical articles from the

principal databases related to persuasion, emotions, cognition, and the psychophysiology of persuasion.

The *third chapter* describes an initial online survey of the task employed in the Thesis. In that study, we examine the presentation of the messages to a general population without exclusion criteria. In addition, we studied the differences by age and gender in the perceived persuasiveness of the strategies and considered individual differences in personality, perceived stress, and coping styles.

The following three chapters describe the three main empirical studies of the Thesis. Each study includes an introduction, methodology, results, and discussion section.

In the *fourth and fifth chapters*, two studies are presented that investigated how individual characteristics (SDO, Neuroticism, and Perceived Stress) and physiological reactivity (ERPs and HRV) predict the cognitive processing that underlies persuasion. The *sixth chapter* describes a study about how a biomarker (EEG resting state) differs according to a psychological trait (NFC), the predictive role of the spectral power bands in the recall and recognition of persuasive health messages immediately and delayed after being exposed to them (explored by NFC groups), and lastly, the differences in the recall and recognition of each persuasive strategy (i.e., ethos, pathos, or logos) based on the level of NFC.

The *seventh chapter* includes a general discussion of the main findings of the studies, in addition to a reflection on the limitations and strengths of the studies. Also, the consideration of future directions is included. The *eighth chapter* summarizes the main conclusions, and lastly, the *ninth chapter* presents a summary of this Thesis in Spanish.

CHAPTER I: General Introduction



General Introduction

Social Influence: Persuasion

Social Influence refers to the action intentionally or unintentionally to change another individual's preferences or behaviors (Gass, 2015), something common in many social animal species. Persuasion, one of the main types of social influence, is unique to humans and is the intentional attempt by an individual, group, or social entity to change another's person beliefs, attitudes, or behaviors by conveying information about an issue (Cacioppo et al., 2018). Persuasion is a major subject for politics, economics, public health, marketing, and militia, among other enterprises that have the aim and benefit of influencing others. Moreover, people are strongly influenced by others at an individual level. For example, someone trying to convince a loved one to quit smoking, or to start exercising, a health provider trying to convince people to do health screenings, or a candidate appealing to the voters through its political agenda.

Persuasion has become a main subject in social psychology, but its study dates to Greek philosophers. Aristotle in his renowned work *Rhetoric* describes that persuasive success depends on the character of the speaker, the emotional state of the audience, and the argument itself (Johnson et al., 2005). Later, the scientific and organized study of persuasion began supported by the U.S. Army during the Second World War using propaganda and mass media techniques to influence soldier's attitudes about the ideological issues behind the war (Hovland et al., 1949), regarding the allies and the enemies. The study of *attitude*, which refers to the general evaluation individuals have regarding any issue, eventually turned to the study of *attitude change* (Petty and Briñol, 2012).

From there, researchers have dedicated a great amount of work to elucidate the main factors that compose persuasive communication: source, recipient, messages, and contextual

factors (Wagner and Petty, 2022). Among the mentioned factors, some of the aspects studied are, for example, source expertise or credibility, the recipient's need for cognition, the message/argument strength or appeal, and the context in which the message is communicated, whether written or verbal.

In addition, the communication's issuer (or source) can use different persuasive strategies to increase the persuasive efficacy. Among several persuasion strategies or principles, for this Thesis, we chose to study three strategies based on the Aristotelian rhetoric and with well-differentiated perspectives: Ethos, Pathos, and Logos. They influence differently based on their perspective on how to address information and on the individual characteristics of the message recipients. Ethos focuses on factors associated with the source, such as authority, expertise, and popularity. Pathos appeals to the emotions and empathy of the audience. Lastly, Logos relies on the logic of the argument, appealing mostly to rationality and critical thinking (Berlanga et al., 2013; Stucki and Sager, 2018).

There were many theories of persuasion and none of them had a consensus regarding when and how those main factors affect attitude change (Petty and Cacioppo, 1986). That is when dual-process theories of persuasion return from the old belief in the duality of emotion vs. reason but intending to organize research findings under the view that there are two distinct routes to persuasion: central and peripheral. In this Thesis project, we will focus on the ELM.

Elaboration Likelihood Model

More contemporary process models compare more effortful modes of cognitive processing with those less effortful in the recipient (Johnson et al., 2005). The ELM posits that there is an elaboration continuum that determines the motivation of an individual to extend in the processing of a message. When a person's motivation and ability to engage in issue-relevant

thinking is high, is most likely that they scrutinize and allocate considerable cognitive resources to the message: this is the transit of the *central route*. While, when a person's motivation and/or ability to think is low it is more likely that it relies on simple cues as a low-effort mechanism rule which is the transit of the *peripheral route*.

ELM key elements about how a variable can affect the amount and direction of an attitude change are through the *argument quality*, *peripheral cues*, and affecting the recipient's argument elaboration (Petty and Cacioppo, 1986). To affect the recipient's argument elaboration, it is necessary to determine the individual's engagement in the message processing and their cognitive activity, which is somehow possible by self-reports, psychophysiological measures, or taking into consideration individual differences, among other ways. As individual differences, among the most studied factors are the recipient's personality, the need for cognition, psychological consistency or ambivalence, and incidental emotions (Wagner and Petty, 2022).

Individual characteristics

Psychological traits

The effectiveness of persuasion varies among individuals based on individual characteristics such as psychological traits or situational states. In persuasion literature, the effect of matching message content to the functional basis of a person's attitude (Petty and Wegener, 1998) has been widely studied and consistent in its positive results. However, it is still not clear if matched messages produce more persuasion because it increases the motivation and personal relevance of the recipient, or in contrary if it biased the processing for a peripheral route (based on ELM). Either way, the effectiveness of matching in the literature is robust. In addition, *framing and tailoring* are other common methods used where the message is constructed or adapted to

highlight some aspects in a certain interpretative framework to increase the influence, based on the recipient's characteristics.

Tailoring a persuasive message frame with the recipient's personality beyond the demographic characteristics of the group increased the possibility of a behavior change (Oyibo and Vassileva, 2019). Persuasive technology is growing rapidly, and researchers point out the need to personalize the systems and consider personality traits since individuals give different responses to the same persuasion attempts based on their characteristics. The one-size-fits-all notion has been demonstrated not to be adequate, especially in fields such as health. Some studies have investigated the relationship between persuasion and personality (Alkis and Temizel, 2015; Halko and Kientz, 2010; Hirsh et al., 2012; Oyibo and Vassileva, 2019; Wall et al., 2019), differing in the persuasive strategies studied.

Regarding the Big Five personality traits, Alkis and Temizel (2015) found *Agreeableness* to be the most susceptible personality trait to Cialdini's persuasive principles (reciprocation, scarcity, authority, consensus, liking, and commitment), since agreeable individuals are more prone to be affected by their peers' opinions and by authority. *Conscientious* people were more susceptible to authority, but not to consensus, whereas individuals high in *Openness* were more inclined to their ideas rather than to an authority or social group. Lastly, *Extraversion* and *Neuroticism* were more prone to scarcity persuasive strategy. Wall et al. (2019) studied Big Five, Type D, and Dark Triad personalities' susceptibility to persuasion, and from all those traits found three distinct profiles: *Socially Apt*, *Fearful*, and *Malevolent*. Individuals high in *Socially Apt* were more susceptible to commitment, while those in the *Fearful* profile were more susceptible to authority. Lastly, *Malevolent* individuals are less involved in reciprocity and obeying authoritative figures, and more prone to the scarcity strategy because of their selfish ways.

Oyibo and Vassileva (2019) studied the impact of personality traits on susceptibility to social influence strategies (social learning, social proof, and social comparison). They found that *Neuroticism*, *Openness*, and *Conscientiousness* are the three traits most determinant of the users' susceptibility to the social influence strategies studied. High *Neuroticism* was more susceptible to all three social influence strategies, low *Openness* was more susceptible to social proof and comparison, and low *Conscientiousness* to social learning and proof. Particularly, in this Thesis, we studied *Neuroticism* and its moderating role in the relationship between HRV and persuasion. *Neuroticism* is related to psychological distress and negative affect. It is a predictor of different mental and physical disorders (Lahey, 2009), and in addition, is known to be a primary driver of perceived stress (Conard and Matthews, 2008). For these reasons, we found it relevant to study the role of neuroticism in the processing of persuasive health communication addressed through the Ethos, Pathos, and Logos strategies.

In addition to the personality traits mentioned, other main characteristics that have been studied in relation to persuasion are the *Susceptibility to Persuasion* (STPS) measure to Cialdini's strategies and developed by Kaptein (2012), the individual differences in the activation level of the *Behavioral Inhibition* (BIS) and *Behavioral Activation* (BAS) motivational systems (Carver and White, 1990; Gray, 1990; Shen, 2007), or one of the most studied in the persuasion literature, the *Need for Cognition* (NFC) (Cacioppo and Petty, 1982).

The NFC is an individual difference widely studied in persuasion research and in relation to the ELM, because of its capacity to explain an individual's low or high motivation to process and elaborate on a given information. It is defined as the tendency to engage in and enjoy effortful cognitive endeavors. In the sixth chapter of this Thesis project, we choose to investigate how the level of NFC affects differently the electroencephalographic resting state (rsEEG) and memory performance.

Moreover, a human's personality is a range of traits more complex which encompasses characteristics more prone to being persuaded while others, on the contrary, are more associated with not being persuaded (Wall et al., 2019). *Social dominance orientation* (SDO) is an attitudinal orientation toward hierarchical and inequalitarian intergroup relations and dynamics (Pratto et al., 1994). To our knowledge, just one article (D'Errico, 2020) has studied this characteristic in the recipient of the persuasive attempt. However, regarding social, ideological, and/or political topics that aim the use of persuasion, is relevant to consider the level of SDO in the recipient of the message since it will affect the susceptibility to engage in a communication that promotes more fair and reasonable proposals. In this line, in the fourth chapter of this doctoral project, we investigated the relationship between SDO and the response to persuasion through self-reports and event-related potentials (ERPs). The persuasion topic is the limit of meat consumption because of its effect on health, environment, and animal abuse, in sum a topic with personal, social, and political relevance.

Situational states

One of the ELM postulates is the variations in a person's elaboration about a message due to individual and situational factors (Petty and Cacioppo, 1986). When the elaboration is high, there is an allocation of more cognitive resources that allow issue-relevant processing of persuasive arguments. In contrast, when the elaboration is low, there is a lack of thoughtful processing that results in an attitude change produced by a simple cue. Some of the most common situational factors studied in the persuasion literature that affect the level of elaboration are personal relevance or involvement, motivation, responsibility, message repetition (Petty and Cacioppo, 1986), and thought confidence (Petty et al., 2002). However, there are other situational and psychological factors scarce in the persuasion literature that are very relevant, such as state anxiety and perceived stress. In relation to this Doctoral Thesis and

our interest in the study of persuasion in the health field, we found it especially relevant to consider these situational factors in the recipient of the message. A person with high perceived stress experiences more difficulty processing messages, especially if they are threatening, which could be any health message (Millar, 2005). For that reason, in the fifth chapter of this project, we study the relationship between perceived stress, cardiovascular response (i.e., HRV) and perceived persuasiveness of the messages.

Psychophysiology of Persuasion

Peripheral Nervous System

The Psychophysiology of persuasion is an emergent field that aims to study the physiological correlates of the emotional and cognitive processing of persuasive communication. There is still no unified understanding, but a few studies have investigated how and when physiological changes occur during a persuasive attempt (Spelt et al., 2022). However, most of the research about the psychophysiology of persuasion focuses on the psychological reactance that is reflected in physiological arousal (Clayton, 2022; Spelt et al., 2019), while the study of the physiological response to persuasion itself is lacking. Studies on persuasion have traditionally used behavioral measures and self-reports, however, the limitations of the introspective self-reports and incapacity of the behavioral tasks to assess the cognitive processing simultaneously to the persuasive attempt has led to the growing employment of electrophysiological measures in the field. The most common peripheral physiologic measures explored as potential indexes of persuasion are heart rate (HR), HRV, electrodermal activity (EDA), and facial electromyography (EMG). The main results of the recent literature on the Psychophysiology of persuasion are presented in the systematic review conducted (chapter 2). In the fifth chapter of this Thesis, we investigated the HRV response to persuasion.

Heart-rate variability

HRV is the temporal variation between consecutive heartbeats, and the result of the balance between sympathetic and parasympathetic mediators of the HR (Karim et al., 2011). HRV represents the ability of the heart to respond to physiological and environmental stimuli. Low HRV is associated with impaired self-regulation, which reduces the organism's ability to cope with internal and external stressors (Kim et al., 2018), something that has led to the use of HRV as a stress index. Evidence points out this measure as a powerful tool for the clarification of the relationship between psychological and physiological processes (Berntson et al., 1997). For this reason, we choose HRV as the psychophysiological index to study in relation to persuasion, with the addition of the perceived stress measure since persuasive health messages can be potentially stressful.

Central Nervous System

The Neuroscience of persuasion is also a growing research area, especially with the integration of neuroimaging (e.g., functional resonance imaging (fMRI) and EEG) (Cacioppo et al., 2018) and the identification of a network of regions in the brain associated with persuasion. Results have revealed an association between persuasion and the dorsomedial prefrontal cortex (DMPFC), posterior superior temporal sulcus (pSTS), temporal pole (TP), and ventrolateral prefrontal cortex (VLPFC), a common network with social cognition and mentalizing (Falk et al., 2010). Consistent across numerous studies have been the implication of the medial prefrontal cortex (MPFC) in response to persuasion and changes in behavior, also as a reflection of greater engagement in the processing of communication. However, the association between the MPFC and persuasion has its boundaries related to the different messages' features (Vezich et al., 2017), and individual differences of the recipient (Aquino et al., 2020), which lets us see that is still an emerging area with remaining questions.

Aside from the research using fMRI, the Neurophysiology of persuasion has developed with the use of the EEG measure. The EEG consists of the recording of the electrical activity along the scalp in a direct, non-invasive, and real-time way, from where different frequency bands and ERPs can be studied. Frequency bands range from slow delta (0.5-4 Hz), and theta (4-8 Hz), to fast, alpha (8-12 Hz), beta (13-30 Hz), and gamma (> 30 Hz). From the frequency bands, some common indexes studied in the persuasion literature are the engagement index (Benlamine et al., 2015; Berka et al., 2007; Correa et al., 2015; Pope et al., 1995; Villata et al., 2018) computed from the theta, alpha, and beta bands; the workload index (Chaouachi and Frasson, 2011), frontal alpha asymmetry (Borawska et al., 2020), or individual differences in interhemispheric EEG alpha abundance response to persuasion (Cacioppo et al., 1982), among others.

Also, from the brain waves the person's resting state is a widely studied measure, however, to our knowledge, no studies have investigated how the individual differences in brain activity during resting state are associated with the processing of persuasion. Likewise, rsEEG has been studied in relation to cognitive performance, however, the use of rsEEG as a predictor of memory performance in the recognition and recall of persuasive messages after being exposed to them has not been explored and hence is one of the objectives of this Thesis.

EEG resting state

The EEG resting state (rsEEG) rhythms are recorded during a short period in eyes-closed and -open conditions, and it reflects the baseline neurophysiology activity of a participant. In clinical contexts, is used to unveil neural dysfunctions reflected in the brain activity in a quiet wakefulness state that may affect higher cognitive functions such as attention, episodic memory, and executive frontal functions (Babiloni et al., 2020). Neuroimaging studies have revealed a pattern in brain activity known as the default mode network (DMN) that is active

during the resting state and plays an important role in cognitive processes (Smallwood et al., 2021). Moreover, research results have suggested that the rsEEG signal has the potential to accurately predict cognitive performance (Wan et al., 2023).

In this line, the sixth chapter of this Thesis explores how the rsEEG predicts the subsequent recognition and recall of persuasive messages. Specifically, we compared how individuals with low vs. high NFC differ in their resting state and memory performance.

Event-Related Potentials

ERPs are neural responses to specific sensory, cognitive, and/or motor events; electrical potentials related to specific events. ERPs originate from postsynaptic potentials which occur when neurotransmitters bind to receptors and change the flow of ions. ERPs provide an instantaneous, millisecond-resolution measure of neural activity (Luck, 2014). In addition to the EEG indexes, studying ERPs in the context of persuasion can enhance our understanding of the neural response to specific time-locked persuasive attempts. Even though there are no ERP components explicitly elicited by attention, several components vary their amplitudes when a stimulus is attended (Coull, 1998). The parameters usually measured in the ERPs' components are their amplitude and latency. The amplitude indexes the extent of neural activity (Friedman et al., 2001) and permits estimating attentional resources, while the latency indexes the time required to detect and evaluate a stimulus.

Some of the most common ERP components studied in the persuasion literature are the N100 and P300. The N100 is a negative component related to early attentive processing, that has a maximum peak around 100 ms after the stimulus onset. Its amplitude increases when a stimulus is attended, showing further processing of the attended stimulus compared to any other unattended one. The P300 is a late positive component, with a maximum peak around 300 ms

after stimulus onset, associated with the processing of new stimuli that requires an update in the working memory (Polich, 2007), and with a more controlled attention processing.

Ruiter et al. (2006) studied the attention allocated to tailored vs. nontailored health messages while a specific odd auditory stimulus was presented, and the attention allocated to it was measured through the N100 and P300 ERPs. However, very few studies (Kessels et al., 2011; 2014) have used the ERPs measure to study the attentive processing of persuasive messages. For this reason, in the fourth chapter of this Doctoral Thesis, we proposed to explore the P300 component in response to the processing of each persuasive message and the command to answer how convincing the messages presented were considered. With this methodology, we aimed to explore and compare the attentive processing assigned to the messages in each persuasive strategy, considering also individual differences in SDO.

Aims and Hypotheses

The general objective of this Doctoral Thesis is to deep into the psychobiological basis of the persuasion taking into consideration different strategies of presentation of health messages and individual characteristics as well as exploring the employment of some physiological indicators. This knowledge could contribute to increasing the efficacy of health communication and adherence to treatments. With this general aim, this Doctoral Thesis addressed the following specific objectives:

First aim: to evaluate through a self-reported assessment which persuasive strategy (i.e., Ethos, Pathos, and Logos) seems more convincing. This objective is explored in the third, fourth, and fifth chapters respectively. In this regard, we hypothesize that Ethos (because of the peripheral cue of source expertise; ELM), and/or Pathos, will be perceived as more persuasive than Logos.

Second aim: to explore how some individual characteristics (traits: SDO and neuroticism, and states: perceived stress) affect health messages' processing and perceived persuasiveness. This objective is investigated in the fourth and fifth chapters of the Thesis. Firstly, regarding the SDO, we hypothesize that it will be positively related to the persuasiveness of Ethos because this strategy emphasizes the authority of the source, and individuals high in SDO prefer hierarchical order. Secondly, regarding neuroticism and perceived stress, we hypothesized they would moderate the direction and magnitude of the relationship between the persuasiveness and the cardiovascular response, in such a way that both the higher neuroticism and/or perceived stress, the higher perception of persuasiveness (for the Ethos and Pathos strategies) and the cardiovascular reactivity.

Third aim: to explore the cardiovascular (HRV) and neurophysiological (ERPs) responses to different persuasive strategies in health communications. This objective is explored in the fourth and fifth chapters of the Thesis. We hypothesize that there will be higher cardiovascular reactivity (lower HRV) and larger P300 amplitude in response to the strategy perceived as more persuasive.

Fourth aim: to examine how a state biomarker (rsEEG) differs based on an individual characteristic (NFC), determine if the spectral power of the bands in rsEEG are predictors of memory performance (exploring separately in the low and high NFC groups), and explore if there is a difference in which persuasion strategy (i.e., ethos, pathos, or logos) is better recalled and recognized based on the level of NFC (low vs. high). This fourth objective is addressed in chapter six of the Thesis. Firstly, we hypothesize that individual differences in NFC would be reflected differently in the delta and theta rhythms. Secondly, we hypothesize that theta power would positively predict memory performance in individuals high in NFC, whereas the alpha power would do it negatively. Lastly, we hypothesize that individuals high in NFC would better recall and/or recognize the messages in the Logos strategy. In contrast, the low NFC group

would recall and/or recognize better the Ethos or Pathos strategies, because of the peripheral cues.

CHAPTER II: Emotional and cognitive processes underlying persuasion, moderating factors, and physiological reactions: A systematic review



Introduction

People are constantly exposed to persuasive messages from multiple sources and with various message frames. Attempts to persuade can be made by an individual, a group, or a social entity (Cacioppo et al., 2018), such as a marketer, a political party, or a health enterprise. Persuasion is one of the most important types of social influence. Specifically, it refers to the attempt to produce a change in a person's attitude, beliefs, desires, or behavior. This is an age-old subject in human societies, so persuasion was an object of reflection in Greek philosophy many centuries ago. The relevance and ubiquity of persuasive messages have led to a growing body of research aiming to identify the factors intervening in effective persuasion, that is, in obtaining a behavior change.

Framework

Much of the work on this topic is explained using dual and multi-process theories of persuasion (Petty and Briñol, 2015), which posit that the extent of elaboration the individuals engage in influence the effectiveness of the message. Petty and Cacioppo (1986) formulated the Elaboration Likelihood Model (ELM) to explain the existence of two distinct routes to persuasion: central route, when people have a thoughtful and analytic message elaboration; and peripheral route, when people rely on a shortcut decision-making rule, without message scrutiny. The ELM states that a persuasive message can affect the amount and direction of an attitude change in three ways: affecting the *argument quality* (i.e., the persuasiveness of the message itself), affecting the recipient's *argument elaboration*, and serving as a *peripheral cue*.

While "*argument quality*" refers to how the message is constructed by the source or persuader, "*argument elaboration*" refers to the recipient's cognitive elaboration; the latter affects information processing, especially the motivation to scrutinize a message. One factor influencing argument elaboration is personal relevance, also called involvement (Cacioppo and

Petty, 1982; Petty et al., 1981). When a topic has high personal relevance, the tendency to carefully consider argument quality is greater; however, when personal relevance is low, the message's peripheral cues become more dominant. Other important factors also influencing argument elaboration are personal responsibility (Petty and Cacioppo, 1986), self-perceived vulnerability (Das et al., 2003), thought confidence (Petty et al., 2002; Briñol et al., 2023) and the need for cognition (Cacioppo and Petty, 1982), among others. Lastly, *peripheral cues* act when the elaboration is low or absent. In this case, some of the most common cues the recipient uses are source expertise (Cacioppo and Petty, 1982; Petty et al., 1981), source attractiveness (Chaiken, 1979), and emotions (Petty and Briñol, 2015), among others. Regarding emotions, its relationship with persuasion is complex and has effects via multiple processes, depending on the extent of elaboration the individual engages in, high or low (Briñol et al., 2007). Finally, is important to mention that the persuasive efficacy through the transit of the central route in the processing of persuasion is more enduring than via the peripheral route (Petty and Cacioppo (1986).

Strategies to enhance the efficacy of a persuasive message: matching and framing

Besides the aforementioned factors influencing the recipient's argument elaboration, there are components used by the source to enhance the efficacy of a persuasive message, such as matching and framing an argument to people's attitudes or tendencies. *Matching* messages with people's psychological states boosts involvement and message elaboration (Petty and Cacioppo, 1986), increases subjective processing fluency (i.e., easier processing) (Lee and Aaker, 2004), enhance the recognition and recall of the target (Lee and Labroo, 2004; Mayer and Tormala, 2010), influences the time spent reading messages (See et al., 2008), and is likely to bias the recipient's perception of message validity and, in turn, post-message attitudes (Lavine and Snyder, 1996). However, the functional match of the message is more effective

when argument quality is strong; if it is weak, the match could have the opposite effect, since the recipient could be more engaged in scrutinizing content that matches their attitudes or tendencies. If the arguments are weak, the mismatching is likely to be more persuasive and effective (Petty and Wegener, 1998).

Framing is a typical method to express the match/mismatch effect. The framing effect is a process of social influence connecting the message discourse with the recipient (Pan and Kosicki, 2005). *Message framing* involves a message source highlighting some aspects of an issue in a certain interpretative framework to influence the recipient's subsequent evaluation of the target. A *psychological frame* is endogenous to the individual, a cognitive node stored in people's memory about social objects. They are activated by dispositional individual differences and situational factors, such as frequency (Shen, 2010). Once the cognitive construct is activated during message processing, it is more likely to be applied in response to subsequent evaluations, known as the accessibility effect. Repetitive exposure to certain frames over others results in an information accessibility bias (Price and Tewksbury, 1996; Nabi, 2003). By using these strategies, the information's framing makes certain elements look more important and subsequently influences an individual's judgment (Pan and Kosicki, 1993).

Psychological traits

As stated above, argument elaboration is also influenced by individual tendencies for need for cognition (NFC) and need for affect (NFA). On the one hand, NFC is defined as an individual's need to understand and structure situations (Cacioppo and Petty, 1982; Cohen et al., 1955). Individuals high in NFC tend to enjoy the act of thinking, engage in effortful cognitive activities, and seek out more information before making an evaluation or judgment (Haddock et al., 2008), whereas individuals low in NFC tend to use other sources, such as heuristics, to understand situations (De Holanda Coelho et al., 2018). On the other hand, NFA is defined as

people's general motivation to approach or avoid situations and activities that are emotion-inducing for themselves and others (Maio and Esses, 2001). It involves a desire to understand emotions and use them to shape judgments and behavior. The tendencies towards NFC¹ and NFA are moderators in determining the extent of the argument elaboration, and which type of processing route to travel through (Cacioppo and Petty, 1982), central or peripheral. In addition to these dispositional determinants of the extent of elaboration, there are situational factors or psychological states which determine which route of processing would be followed.

Emotions (Psychological States)

The effects of emotions on persuasion have been widely studied. According to Petty et al. (2001), "emotions can influence attitudes by peripheral mechanisms (such as classical conditioning), serve as items of issue-relevant information, bias message processing, and determine the extent of message scrutiny" (p. 228). If an individual's cognitive elaboration is seen as a continuum, emotions have a different effect depending on which end of the continuum the individual is: at the low end (i.e., low motivation and ability to think), or at the high end (i.e., high motivation and ability to think systematically). Petty and Briñol (2015) called it "moderated mediation," since the level of elaboration will moderate the effect an emotion will have in any persuasive attempt.

Some works have studied the role of emotions from a positive versus negative affective valence perspective (Lerner and Keltner, 2000; Petty et al., 2001), while others have focused on the effects of discrete emotions of the same valence (Keltner et al., 1993; Lerner and Keltner, 2000). For instance, in low-elaboration conditions, positive emotions are associated with more

¹ NFC and NFA are two of the individual tendencies most studied in the persuasion literature, however, are not the only ones, as other relevant ones are personality, Behavioral Inhibition System/ Behavioral Approach System, and demographics, among others. We chose to study NFC as an individual factor of great relevance to the ELM because it refers directly to the motivation to think and therefore, to message processing. As for NFA, it was added as a counterpart to NFC that considers the affective dimension.

positive attitudes, less message elaboration, no argument quality distinction, and thereby, more persuasion by peripheral mechanisms (Mackie and Worth, 1991; Petty et al., 1993; Petty et al., 2001; Schaller and Cialdini, 1990). In contrast, negative emotions produce more negative attitudes, more elaboration, more differentiation between strong and weak arguments, and more attention to central appeals (Keltner et al., 1993; Petty et al., 2001; Schaller and Cialdini, 1990).

Psychophysiology of persuasion

A relevant aspect to understand the consequence of persuasion on a person's motivational state is to explore its physiological state. From a psychophysiological perspective/point of view, it is assumed that every mental state has a physical substrate, and it can be more comprehensible to study both aspects. For this reason, through the study of the psychophysiology of persuasion, it is possible to clarify the relationship between information processing and the corresponding underlying mechanisms.

Most persuasion literature that studies the physiological response, has results in line with the psychological reactance to persuasion. People experience psychological reactance when something is perceived as a threat to certain freedoms. According to the theory of psychological reactance (Brehm, 1966), any persuasive message may arouse a motivation to reject the advocacy (Dillard and Shen, 2005). Feelings of reactance are best described as unpleasant motivational arousal (Steindl et al., 2015), with negative cognitions and emotions. Since persuasion aims to change an attitude or intention that results in a behavioral change, an individual may feel frustrated or annoyed when confronted with a restriction to their free behavior, leading to a state of reactance.

While the psychophysiological reactance findings are promising and worth exploring, the evidence about the physiological response to persuasion itself is scarce. This is relevant as the existing literature has demonstrated that both affective valence and the level of arousal

influence consumers' choices and decision-making (Di Muro and Murray, 2014). According to Storbeck and Clore (2008), while the affective valence (i.e., positive, or negative) of emotions gives information about the value of an object or a stimulus, the affective arousal dimension informs about the importance of personal relevance. The motivational state of arousal can affect judgment, processing, attention, and memory.

In sum, knowing the principal factors that moderate the extent of persuasive elaboration and the underlying processes is relevant in many fields such as health, advertising, politics, economics, and social issues; all of which use persuasion to try to change attitudes or behaviors. We know some important factors such as personal relevance or individual tendencies that affect the persuasion processing, however, the overview of how those factors interacted in the emotion and persuasion relationship is something to explore. In addition, the study of the principal moderator factors that determine which processing route to take and the physiological reactions in response to that momentary state, can increase the persuasive efficacy and our understanding of persuasion. In particular, the understanding of the psychophysiology of persuasion which is still lacking evidence. Lastly, knowing the persuasive techniques used to influence a person's attitudes, opinions, or behavior is also useful from the recipient's perspective. It could even be beneficial in developing people's critical thinking and identifying how a persuasive attempt makes them feel through the state of affective arousal.

Method

Data sources

The present review was conducted and reported according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA; Moher et al., 2009). The search was performed in the Web of Science, Scopus, Embase, PsycINFO, and PubMed databases on articles that were published until September 2023. The following keywords were used in all

databases: (argumentation* OR persuasion) AND cognition* AND emotions*; and: persuasion* AND (psychophysiology* OR psychobiology*). The search was not limited by any terms.

Eligibility

The titles, abstracts, and keywords of all the search results were evaluated. Relevant articles based on our aims were further examined in full text. The inclusion criteria were the following: 1) empirical articles; 2) studies evaluating different persuasion appeals; 3) articles examining the effect of different discrete emotions on argument elaboration; 4) studies including the “need for cognition” and the “need for affect” constructs; 4) studies about the framing effect; 5) articles analyzing the matching versus mismatching attitude effects; 6) articles exploring the psychophysiology of persuasion; 7) human participants; and 8) the English language. The exclusion criteria were: 1) theoretical articles, systematic reviews, and meta-analyses; 2) studies on persuasion that did not analyze the effect of emotions or cognition; and 3) studies using the functional magnetic resonance imaging (fMRI) technique.

Data synthesis

Data extracted from eligible studies were divided into four categories: 1) studies examining the effects of discrete emotions on information processing, 2) studies evaluating the moderating effect of affect- and cognition-based orientations on information processing, 3) articles examining the effects of framing on information processing, and 4) studies exploring the psychophysiology of persuasion. Data is included in Tables 1–4.

Results

Literature search (Fig. 1)

The systematic database search identified 302 articles for the keywords: (argumentation* OR persuasion) AND cognition* AND emotions*, and persuasion* AND (psychophysiology* OR psychobiology*). Of these, 79 articles were excluded for being duplicates, with 223 remaining. After reviewing titles and abstracts, 175 articles were excluded that did not meet the criteria and 48 were assessed in full text. Finally, 20 were eliminated for various reasons: for not describing persuasive appeals (n= 4); for examining types of argumentation, but not persuasion (n= 2); for dealing only with information processing or attitude formation, but not with persuasion (n=4); for evaluating non-verbal communication (n= 1); for studying persuasion as the independent variable (the production of it) and not as dependent (n= 1); for being theoretical articles (n= 2) and conference paper (n=1); and for not offering access to full-text versions (n= 5). In total, 28 articles were included in the review (marked with the symbol (*) in the references section).

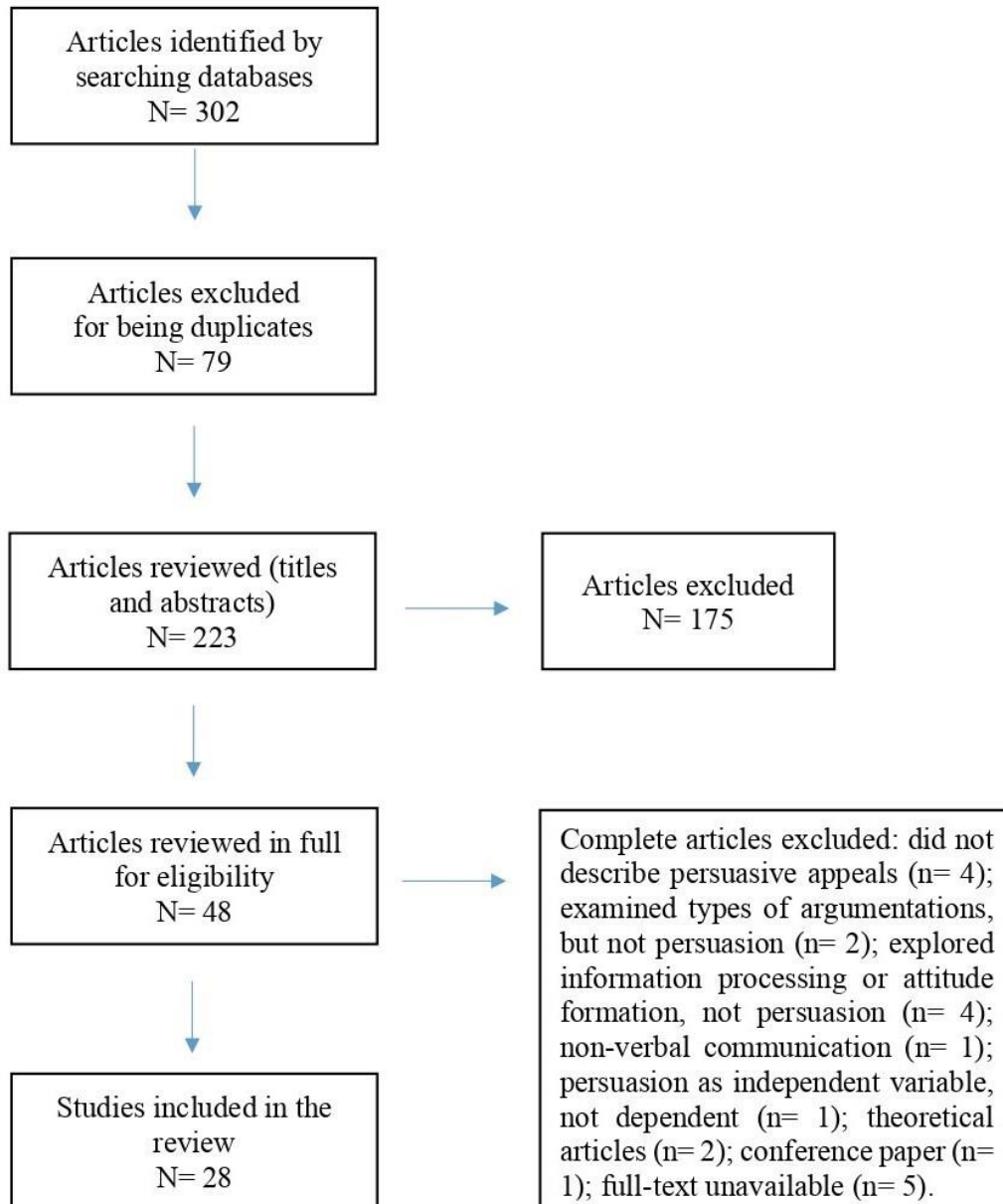


Fig. 1. Flow of the identification and selection of studies for keywords: (argumentation* OR persuasion) AND cognition* AND emotions*; and: persuasion* AND (psychophysiology* OR psychobiology*)

Studies examining the effects of discrete emotions in information processing

The effect of discrete emotions on information processing is examined in ten articles. Table 1 presents a synthesis of the results. Most articles include several studies: two articles include four or five studies, two articles include three studies, three articles include two studies, and the last three articles include one study. To analyze the effect of discrete emotions on the persuasion process, two of the ten articles compare happiness versus sadness as mediators of the persuasion process (Briñol et al., 2007; Sinclair et al., 2010), and one compared how positive or negative messages facilitate or constrain the persuasion process (Muis et al., 2022).

Happy people tend to process a persuasive message using a cue, such as a likable source since it has the potential for mood maintenance; sad people, however, elaborate persuasive messages regardless of the likability of the source and have more positive attitudes toward strong arguments (Sinclair et al., 2010). Muis et al. (2022) compared how positive and negative discrete emotions facilitate or constrain the persuasion process with the aim of increasing individuals' willingness to take preventive action regarding the COVID-19 pandemic. Results revealed that the positive persuasive text was more effective in increasing individuals' willingness to engage in preventive action, in social distancing and isolation, compared to the negative or control text condition. Moreover, results suggest that the effect can be extended to the actual preventive behavior.

The results by Briñol et al. (2007), with four different studies on the effect of emotions on evaluative judgments, confirm that the effect of emotions is mediated not only by the level of elaboration, but also by changes in thought confidence. For people low in NFC, their happy state and a mood-maintenance source act as a cue leading to positive attitudes but with more heuristic processing and no distinction in argument quality. However, individuals high in NFC and happy report more confidence in their thoughts and have more favorable attitudes toward strong arguments. Emotion induction mostly consisted of asking participants to think and write

about either happy or sad personal experiences (Briñol et al., 2007), to read happy or sad statements extracted from Velten's (1968) procedure (Sinclair et al., 2010), or framing messages negatively (number of deaths) or positively (saving lives) (Muis et al., 2022).

Three articles evaluate the difference in emotions of the same valence (Dillard and Peck, 2000; Griskevicius et al., 2010; Karsh and Eyal, 2015). Griskevicius et al. (2010) argue that happy people rely more on systematic or heuristic processing depending on what type of positive emotion is experienced, as each emotion has a different function. Karsh and Eyal (2015) compare *pride* and *joy*, both positive emotions, but with different effects due to the differences in their level of construal (i.e., abstractness) and perspective (near vs. distant). Pride is temporally distant and abstract, while joy is proximate and more concrete. As a result of this difference, pride promotes more elaborative processing and persuasion. Dillard and Peck (2000) support the benefits of examining the specific signals tied to each emotion and not only the dimension of the valence (whether it is positive or negative). For example, they observe that positive emotions like happiness and contentment have unique effects. While happiness is associated with increased message acceptance, contentment is associated with an uncritical rejection of the stimulus. Some of the strategies used in these articles to elicit emotions were presenting public service announcements about different topics (Dillard and Peck, 2000); asking participants to write about a personal experience related to a specific emotion, or reading a provided cover story (Griskevicius et al., 2010); and imagining a future hypothetical emotional event (Karsh and Eyal, 2015), among others.

Two articles focus on anger appeals: one studies the role of self-efficacy beliefs in the context of student protests (Turner et al., 2020) and the other examines the consequences of appraisals on the validation of thoughts after the experience of four different emotions, namely, anger, disgust, surprise, and awe (Briñol et al., 2018). Specifically, Briñol et al. (2018) study the implications of the pleasantness/unpleasantness and confidence/doubt appraisals. These

authors state that some pleasant (unpleasant) emotions are accompanied by the feeling of certainty or confidence and others by the feeling of uncertainty or doubt. The results are consistent across five studies and suggest that in the confidence appraisal, the emotions of anger and disgust validate the subject's thoughts even though they are unpleasant; in the pleasantness appraisal, however, the emotions of surprise and awe validate the subject's thoughts even though they are associated with doubt. The results obtained by Turner et al. (2020) suggest that the emotion of anger leads individuals to more systematic processing of arguments only when they have a high self-efficacy belief in their ability to engage in the appropriate course of action. Considered jointly, the emotion of anger validates people's thoughts (Briñol et al., 2018) or beliefs about themselves. High anger paired with high efficacy beliefs increases argument quality distinction, while high anger paired with low efficacy beliefs reduces their processing ability.

The last two of the ten articles examine fear appeals through the communication of the health consequences of stress (Das et al., 2003), and the promotion of endometriosis screening (Worsdale and Liu, 2023). In Das et al. the participants' vulnerability, the severity of the health consequences, and the argument quality were manipulated. The results reveal that a high level of severity (i.e., of fear appeal) leads to a more positive attitude toward the action recommendation. Specifically, when the participants feel high vulnerability toward the health consequences, positive attitudes increase for the action recommendation. But, when they feel low vulnerability, even when the severity is high, they feel more motivated to scrutinize the arguments.

In contrast, Worsdale and Liu (2023) found that the use of positive emotional appeals (e.g., hope appeals) instead of negative emotional appeals (e.g., fear appeals) in narrative health messages is more effective in increasing positive affect following message exposure. No significant differences were observed between the hope and fear appeals in the subsequent

behavioral intention. However, through an indirect effect of hope appeal, positive affect mediates the relationship between the type of appeal and the behavioral intention so that hope appeal increases the positive affect which in turn increased the screening intentions.

Studies examining the moderating effects of affect- and cognition-based orientations on information processing

Six articles focus on the effect of the argument's affective or cognitive contents on information processing. Two articles include three studies, one includes two studies, and the remaining three articles include one study each. Table 2 presents a synthesis of the results.

Two articles compare how the matched or mismatched effects between the recipient and the stimulus influence persuasion processes. Huntsinger (2013) evaluates the effect of affective coherence or incoherence on information processing and thought confidence in three experiments. Affective coherence occurs when the elements of the emotional experience are in harmony, whereas affective incoherence occurs when happy feelings are accompanied by sad thoughts (Huntsinger, 2013), or the other way around; it depends on the match effect and on the order of presentation of the stimuli. The experience of affective coherence produces superficial processing with no effect of argument quality, while the experience of affective incoherence produces more detailed processing and a greater effect of argument quality. The manipulation of the timing influences thought confidence. If the participants read the arguments before emotional induction, the affective coherence experience validates the thoughts generated while reading the arguments; the experience of affective incoherence, however, invalidates the thoughts.

Keller and Block (1999) reported affect- and cognition-based dissonance, which is like a further division of the incoherence experience mentioned above. Affect-based dissonance and cognition-based dissonance produce two types of dissonance-reducing strategies. Cognition-

based dissonance leads to less denial, more refutation, and more pertinent thinking, with a tendency to judge the message as lower in quality and less persuasive (Keller and Block, 1999). People trying to reduce affective-based dissonance tend to undermine the message, with higher message denial and less pertinent thinking. Both contrast with the coherence or the match effect, in which people tend to judge the information as more credible.

In Dubé and Cantin (2000), results support the hypothesis that the persuasive efficacy of communication depends on the attitude toward the focal item (affective or cognitive) and the desired behavioral outcome (consumption change or liking). The topic of the experiment is milk consumption. The emotional appeals of the persuasive statements are more influential for food liking, whereas the informational/cognitive appeal is more influential for inducing a consumption change. Particularly, there is a matching effect between the affective responses of the subjects (food liking) and the persuasive attempt with emotional appeals. Naimi et al. (2023) compared the effectiveness of emotional or cognitive appeals to increase the likelihood of entrepreneurs to source funding for their business from lenders through prosocial crowdfunding platforms. Results revealed that cognitive appeals attract more resources than emotional appeals, with the use of negative emotional frames correlating negatively to the average amount of funding.

Lastly, two articles evaluate the effect of NFA and NFC on the argument elaboration (Haddock et al., 2008; Appel and Maleckar, 2012). As has been documented in the literature and previous articles in this section, a persuasive message induces more attitude change when the arguments match the recipient's initial attitude, which in many studies is created or induced it. However, in Haddock et al. and Appel and Maleckar's articles, they study the matching effect between the messages's affective or cognitive content with individual differences based on the personality traits of NFC and NFA. Results suggest that individuals high in NFA become more persuaded and have more positive attitudes toward affect-based messages. In contrast,

individuals high in NFC are more persuaded and have more positive attitudes toward cognition-based messages. Appel and Maleckar (2012) report that NFC and NFA influence the processing of paratextual information in narrative persuasion. For individuals high in NFC, a fake story is less persuasive than a fictional or non-fictional story, while individuals high in NFA develop strong beliefs for the story itself regardless of whether the frame type is true or false. These results provide evidence of the moderating effects of NFC and NFA as individual characteristics on message processing.

Studies examining the effects of framing on information processing

Five articles examine the effects of framing on persuasion, particularly on affective and cognitive responses. One of the articles includes three studies, two articles include two studies, and the last two articles include one study each. Table 3 presents a synthesis of the results.

Two articles evaluate how affective and cognitive message frames, such as “feel” and “think,” change attitudes (Mayer and Tormala, 2010; Ryffel and Wirth, 2016), and also consider differences based on gender. Another article explores how individual differences in age, NFC, and affective intensity (AI) interact and moderate framing effectiveness (McKay-Nesbitt et al., 2011). Results suggest affective messages are more successful in changing affect-based attitudes, while cognitive messages are more successful in changing cognitive-based attitudes (Ryffel and Wirth, 2016), which is a matching effect driven by message frames. Regarding gender, Mayer and Tormala (2010) find women are more persuaded by feel-framed messages and men by think-framed messages. Concerning age, younger adults recall more units of a message when it is emotionally framed (vs. rational), whereas older adults have more positive attitudes toward rational-appeal frames (vs. emotionally negative appeals) (McKay-Nesbitt et al., 2011).

The last two articles examine the effect of framing on persuasive health messages (Shen and Dillard, 2007; Shen, 2010). In Shen and Dillard (2007), out of several measures, participants respond to affective close-ended scales about their emotional reactions to the messages, which are later associated with the behavioral inhibition system (BIS), and the behavioral approach system (BAS). BIS was expected to correlate with negative emotions and BAS with positive emotions. The results show positive associations between BIS and disgust, anger, fear, and sadness and between BAS and fear; the latter was not expected, as fear is not a positive affect emotion. Shen (2010) examines message frames in anti-smoking public service announcements considering three frames: health consequences, secondhand smoke, and industry manipulation. Overall, the three message frames cause negative emotions, probably due to the unpleasant topic. However, the emotion of fear predicts the attitude toward smoking in two of the three message frames, health consequences, and secondhand smoke.

Studies exploring the psychophysiology of persuasion

Seven articles examine the psychophysiological processes of persuasion. The results of the study are synthesized in Table 4.

One article researched whether narrative persuasion could influence donation behavior (Correa et al., 2015). There are two groups and versions of the narrative: The most-just versus the least-just version. Some of the measures used to compare both groups are Electroencephalography (EEG), electrocardiography (ECG), donation behavior, and affective state, among others. Overall, there are no differences between the groups in donation behavior, or in the engagement values extracted from the EEG or heart rate (HR) from the ECG; however, there is a significant difference in heart rate variability (HRV) and affective state. An increase in overall HRV is observed in those who do not donate as opposed to those who do, while those who donate and viewed the least-just version experience a more negative affective state.

Two articles explore different physiological measures—cardiovascular arousal (Spelt et al., 2018), respiratory rate (RR), electrodermal activity (EDA), and facial electromyography (fEMG) (Spelt et al., 2022b)—in response to four of the six persuasion principles proposed by Cialdini (2007): authority, scarcity, commitment, and consensus. Results suggest there is no significant difference in physiological reactivity during different persuasion principles, but rather between the exposure to persuasion compared to a baseline or startle period (Spelt et al., 2018; 2022b). Both studies also find susceptibility to persuasion assessed using the susceptibility to persuasion scale (STPS) (Kaptein, 2012) helps to explain variance in some of the physiological parameters, such as in the inter-beat interval (IBI) (Spelt et al., 2018), standard deviation from normal-to-normal peaks (SDNN), skin conductance level (SCL), skin conductance responses (SCR), zygomaticus major (EMG-ZM), and corrugator supercilii (EMG-CS) (Spelt et al., 2022b). Lower susceptibility to some principles appears to be related to a higher physiological reactivity and vice versa.

Three articles compare different message frames, high versus low controlling language (Spelt et al., 2019), gain- versus loss-framed persuasive messages (Spelt et al., 2022c), and dogmatic vs. suggestive anti-vaping public service announcements (PSAs) (Clayton, 2022). Neither of them persuaded participants to change their behavior (i.e., limit meat consumption, change oral health care behavior in the long term, or quitting the use of e-cigarettes). However, persuasive manipulation was successful in changing people's motivational state (Clayton, 2022; Spelt et al., 2022c) and level of reactance (Clayton, 2022; Spelt et al., 2019). The latter is assessed through self-report measures, ECG, EDA, and EMG. Specifically, in Clayton (2022), daily e-cigarette users in the dogmatic anti-vaping PSA condition had a greater level of reactance evidenced by greater self-reported freedom threat and intention to continue the use of e-cigarettes than the users in the suggestive anti-vaping PSA condition. The greater psychophysiological reactance in the dogmatic vs. suggestive condition was also revealed with

an increase in the SCL and corrugator muscle activation, HR deceleration and worse recognition memory, indicating there was a greater activation of the aversive motivational system.

Lastly, Spelt et al. (2022a) presented a persuasive video advocating the limit of meat consumption while measuring the physiological activity, with the aim to explore how the misalign between people's initial motivations and the topic reflects in their physiological response. The persuasive attempt was successful in changing some of the motivational states measured, such as moral belief, perceived behavioral control and reduction intention after watching the video. Moreover, the physiological arousal was explained by initial motivations, as higher reduction intention prior to the video was related to a lower arousal. In contrast, participants with greater misalignment between their current behaviors (about meat consumption) and the persuasive attempt (advocating vegetarianism) experienced more arousal in all the physiological parameters measured (i.e., cardiovascular and electrodermal activity).

Table 1

Studies examining the effects of discrete emotions on information processing

Authors (year)	Sample	Method	Results
Briñol et al. (2007)	Study 1: N= 92	IV: Argument quality (strong vs. weak); Emotion induction (happy or sad); Message focus (argument focus or control). DV: List of thoughts; Attitudes; Emotion manipulation check.	With the emotional induction after the message exposure, there is a larger argument quality effect for happy participants. Happiness also enhances the effect of thoughts; happy participants rely more on their thoughts (favorable or unfavorable) than those in the sad induction.
	Study 2: N= 89	IV: Argument quality (strong vs. weak); Emotion induction (happy or sad). DV: Attitudes; Thoughts; Thought confidence; Emotion manipulation check.	Thought confidence mediates the effects of emotion on judgment. Specifically, and in line with previous results, thought confidence via happiness (vs. sadness) leads participants to rely more on their thoughts.
	Study 3: N= 79	IV: Argument quality; Emotion induction; NFC. DV: Thoughts; Attitudes; Thought confidence; Emotion manipulation check.	<i>High in NFC:</i> The effect of thought confidence produces a greater argument quality effect on a happy state. <i>Low in NFC:</i> Emotion has a direct effect on judgment without confidence mediation.; emotion acts as a simple cue, regardless of argument quality.
	Study 4: N= 78	IV: Argument quality; Emotion induction (happy, sad, or neutral). DV: Behavioral intentions; Emotion manipulation check; Distraction.	Replicates previous results.
Briñol et al. (2018)	Study 1: N= 140	IV: Thought valence (positive vs. negative); Emotion induction (anger vs. surprise); Appraisal type (confidence vs. pleasantness). [About the self] DV: Attitudes; Trait favorability.	<i>Confidence appraisal condition:</i> Anger increases the impact of thought valence on attitudes. = Anger is associated with more confidence (than surprise). <i>Pleasantness appraisal condition:</i> Anger decreases the impact of thought valence on attitudes. = Anger is a less pleasant emotion (than surprise).
	Study 2: N= 159	IV: Same as study 1. [About others] DV: Attitudes; Thought favorability.	Same as study 1. Extending the contribution from self-attitudes to others.
	Study 3: N= 125	IV: Argument quality (strong or weak); Emotion induction (anger vs. surprise);	Same as previous studies. Extending the contribution from self and others' evaluations to a health-related topic.

		Appraisal type. [About health behavior] DV: Same as study 2.	
	Study 4: N= 132	IV: Thought valence; Appraisal type; Emotion induction (disgust vs. surprise). DV: Attitudes.	Similar to previous studies but extending results to another emotion: disgust. Confidence appraisal (cognitive information): Disgust validates thoughts. Disgust is associated with certainty (vs. surprise). Pleasantness appraisal (affect-focused information): Disgust leads to less thought use. Disgust is associated with unpleasantness (vs. surprise).
	Study 5: N= 258	IV: Thought valence; Emotion induction (awe vs. anger); Appraisal mode. DV: Attitudes; Thought favorability; Perceived validity.	Confidence appraisal: Anger leads to greater use of thoughts (vs. awe). Pleasantness appraisal: Anger leads to less use of thoughts (vs. awe). Replicates previous results.
Das et al. (2003)	Study 1: N= 184	IV: Vulnerability group (low or high); Severity (low or high); Argument quality (strong vs. weak). DV: Persuasion; Negative Affect; Thought listing.	<i>High vulnerability</i> = more positive attitudes toward the action recommendation, regardless of severity and argument quality. <i>Severity of the health risk</i> = more severity leads to more positive attitudes toward the action recommendation, regardless of argument quality. <i>Low vulnerability</i> = motivates individuals to scrutinize arguments.
	Study 2: N= 111	IV: Vulnerability group; Severity; Argument quality; Systematic processing instructions (present or absent). DV: Same as study 1.	<i>Argument quality</i> : More favorable attitudes when the recommendation is supported by strong arguments, and under conditions of <i>low vulnerability</i> .
	Study 3: N= 118	IV: Same as study 1. DV: Persuasion; Negative Affect.	<i>Severity</i> : Increases in severity have a greater impact on attitudes in the low vulnerability condition, regardless of argument quality. <i>Intention</i> : More intention to accept the action recommendation in the high vulnerability condition.
Dillard and Peck (2000)	Study 1: N= 140	IV: Heuristic condition (heuristic-enabled, heuristic-disabled, or natural); Order of presentation; Exposures (8 PSAs / 7 discrete emotions). DV: Affective responses; Cognitive responses; Perceived effectiveness; Attitudes.	-No main effect for the heuristic condition. -Each emotion causes a significant impact on attitudes. -Positive association between perceived persuasiveness and attitude toward the issue. -Effect of cognition and emotion on attitude is mediated by perceived persuasiveness.
	Follow up: N= 55	IV: Affective tone (positive or negative); Exposures (2 PSAs); Order of presentation. DV: Affective responses; Perceived effectiveness; Liking; Attitudes.	Effectiveness is a more consistent predictor (relative to liking) of attitude toward the issue regardless of the affective tone of the message.

Griskevicius et al. (2010)	Study 1: N= 398 (249 W, 149 M)	IV: Emotion inductions (7: Anticipatory enthusiasm, amusement, attachment love, contentment, nurturant love, awe, and neutral/control); Argument strength (strong vs. weak). DV: Attitudes.	Positive emotions can lead to heuristic or systematic processing, depending on which positive emotion is elicited. Anticipatory enthusiasm, amusement, and attachment love facilitate heuristic processing. In contrast, awe and nurturant love lead to more systematic processing.
	Study 2: N= 337 (175 W, 162 M) Mean age: 19.4	IV: Emotion inductions (5: Neutral, awe, nurturant love, amusement, and anticipatory enthusiasm); Argument strength (weak). DV: Attitudes; Appraisal dimension ratings; Thought listing.	<i>Mediation effect:</i> Different positive emotions are mediated by different cognition processes. <i>High-responsibility appraisals:</i> Predict greater persuasion and a bias toward favorable thoughts. <i>Anticipatory enthusiasm:</i> Has a bias toward favorable thoughts.
Karsh and Eyal (2015)	Study 1a: N= 106 (67 W, 39 M) Study 1b: N= 147 (82 W, 65 M)	IV: Construal-level manipulation (high or low); emotional manipulation (pride or joy). DV: Attitudes. / Study 1b: Attitudes and intentions.	<i>High-level construal</i> (temporal distance) = the consideration of pride leads to more persuasion than joy.
	Study 2: N= 166	IV: Construal-level manipulation: (superordinate or subordinate); emotional manipulation (pride or joy). DV: Willing to contribute (WTC).	WTC was greater following the consideration of a pride-eliciting event (vs. joy) and in a superordinate category.
Muis et al. (2022)	N= 1,078 (who completed the first and the follow-up surveys)	IV: Text condition (negative, positive, or control text) DV: Self-reports: COVID-19 concern, Emotions about the pandemic, Willingness to engage in preventive action, and 1-week later actual preventive action.	<i>Willingness to engage in preventive action:</i> The positive persuasive text increased the willingness to engage in preventive action, compared to the control or negative text condition. <i>Actual preventive action:</i> Also, the positive persuasive text increased individuals' engagement in preventive action one week later, compared to the control or negative text condition. In addition, emotions mediate the relationship between the willingness to engage in preventive action and the actual preventive action.
Sinclair et al. (2010)	Study 1: N= 77 (60 W, 17 M)	IV: Source likability (likable or dislikable); Mood induction (happy or sad); Argument strength (strong vs. weak). DV: Argument evaluation; List of thoughts.	<i>Sad mood induction:</i> Elaborates persuasive messages regardless of the likability of the source. <i>Happy mood induction:</i> Elaborates only when the source of the arguments is likable.

	Study 2: N= 91 (54 W, 37 M)	IV: Source likability; Mood induction (happy); Cognitive load (present or absent); Argument strength. DV: Argument evaluation; Attitudes.	<i>Cognitive load and happy mood induction:</i> Equally persuaded by strong or weak arguments from a likable source. With no message elaboration, source likability serves as a cue to process.
Turner et al. (2020)	N= 267 (174 W, 93 M) Mean age: 20.10	IV: Anger (high vs. low); Efficacy (high vs. low); Argument quality (high vs. low). DV: Thought listing; Behavioral intentions.	<i>High anger and high efficacy:</i> Increase systematic processing and lead to greater intentions to engage in activism, after processing strong arguments. <i>High anger and low efficacy:</i> Less likely to engage in activism, even when presented with strong arguments.
Worsdale and Liu (2023)	N= 326 All women. Mean age: 19.03	IV: Narrative vs. non-narrative messages; Hope vs. fear appeals in the narrative condition. DV: Self-efficacy; Positive emotional response; Individual's readiness to change; Behavioral intention.	-Narrative messages were not more effective at increasing behavioral intention to get the endometriosis screening than non-narrative messages. -No significant differences between fear and hope appeal conditions were observed in self-efficacy or behavioral intention. -However, a significant difference between the two conditions was observed in the positive affect response. Individuals in the hope appeal condition experienced greater positive affect. -In addition, positive affect mediates the relationship between types of emotional appeal and intention.

Abbreviations. DV: dependent variables; IV: independent variables; M: men; N: sample group; PSA: public service announcement; W: women; NFC: need for cognition; WTC: willing to contribute.

Table 2

Studies examining the moderating effects of affect- and cognition-based orientations on information

Authors (year)	Sample	Method	Results
Appel and Maleckar (2012)	Study 1: N= 135 (88 W, 47 M) Mean age: 22.31	IV: Paratextual labels (non-fiction, fiction, or fake). DV: NFC; NFA; Expectations.	- <i>Non-fiction:</i> <u>Perceived</u> as more trustworthy and useful. - <i>Fiction:</i> Participants <u>expect</u> to be more immersed (entertained and transported). - <i>Fake:</i> Receives the lowest trustworthiness and usefulness ratings. -No relation between NFA, NFC, and the paratext dimensions.
	Study 2: N= 186 (108 W, 78 M) Mean age: 31	IV: Stories; Paratext conditions (non-fiction, fiction, fake, or control story). DV: Transportation; Beliefs; NFC; NFA.	-Fiction condition more persuasive than fake condition. -Fake condition has the lowest scores in transportation. -The higher the NFA, the larger the persuasive impact of a story. -The higher the NFC, the lower the belief scores in the fake condition.

Dubé and Cantin (2000)	N= 95 (89W, 6 M) Mean age: 23	IV: Attitude basis (affect-based or cognition-based); Type of appeal (informational or emotional). [About milk consumption] DV: Milk liking; Consumption change intent; Immediate feeling responses; Immediate thought responses.	Affect-based participants: -Consumption change intent: The informational appeal is more effective. (cognitive response) -Liking: The emotional appeal is more effective. (affective response). There is a matching effect on affect-based participants, not in cognition-based participants.
Haddock et al. (2018)	Study 1: N= 24 (16 W, 8 M) Mean age: 19.8	IV: Message type (affect vs. cognition); Information preference (affect vs. cognition). [About a beverage] DV: Attitudes.	-Affect-based messages lead to more positive attitudes in individuals high in NFA. -Cognitive-based messages produce more positive attitudes in individuals high in NFC.
	Study 2: N= 50 (45 W, 5 M) Mean age: 20	IV: Message type; Information preference. [About a fictional animal] DV: Attitudes.	Individual differences in NFA and NFC influence receptivity to affect-based and cognition-based messages.
	Study 3: N= 58 (52 W, 6 M) Mean age: 19.5	IV: Same as study 2. DV: Recognition task.	-Higher in NFA is associated with greater recognition of affect-based messages. -Higher in NFC in turn is associated with greater recognition of cognition-based messages.
Huntsinger (2013)	Study 1: N= 109 (81 W, 28 M)	IV: Mood manipulation (positive vs. negative) [before arguments]; Priming (a lexical decision task: with happy or sad words); Argument quality (strong vs. weak). DV: Attitudes.	- <i>Affective coherence</i> : Equally persuaded by strong and weak arguments. Superficial processing. - <i>Affective incoherence</i> : More persuaded by strong arguments. More detailed processing.
	Study 2: N= 206 (139 W, 67 M)	IV: Same as study 1, except for the order. Arguments before mood manipulation and priming. DV: Thought confidence; Attitudes.	<i>Thought confidence</i> : Those experiencing affective coherence reported more confidence in their thoughts than those in the affective incoherence condition.
	Study 3: N= 213 (146 W, 64 M)	IV: Manipulation of the timing. / Mood manipulation (happy) [either before or after arguments]; Priming (happy or sad); Argument quality. DV: Thoughts; Attitudes.	- <i>Induction before reading the arguments</i> : There is a greater effect of argument quality on the affective incoherence condition. - <i>Induction after reading the arguments</i> : In contrast, the effect of argument quality is more pronounced on the affective coherence condition.
Keller and Block (1999)	N= 93 All women.	IV: Prior intentions (low vs. high); Manipulation of fear arousal (high vs. low). [About Safe Sex and the use of condoms] DV: Thoughts (supportive vs. refutation); Persuasion (behavioral intention); Affect scale; Cognitive scale; Message quality.	-High prior intentions: More supportive thoughts and more persuaded (vs. low prior). -Low fear condition: More refutation thoughts (vs. high fear). -Low prior intentions and high-fear appeal = affect-based dissonance. -High prior and low fear = cognition-based dissonance.
Naimi et al. (2023)	N= 2,098 entrepreneurs	IV: Entrepreneurial narratives (type of appeal: cognitive or emotional); Psychological elements (positive emotions,	-In a prosocial crowdfunding setting, cognitive appeals attract more resources than emotional appeals. -In addition, negative emotional frames were negatively related to the average

		negative emotions, cognitive words) DV: Loan amount (average amount of funding sourced per day)	amount of funding sourced per day, while positive emotions had no significant relationship with the amount of funding. -Female entrepreneurs and groups of entrepreneurs source a higher average amount of funding than male entrepreneurs and individual entrepreneurs.
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Abbreviations. DV: dependent variables; IV: independent variables; M: men; N: sample group; NFA: need for affect; NFC: need for cognition; W: women.

Table 3

Studies examining the effect of framing on information processing

Authors (year)	Sample	Method	Results
Mayer and Tormala (2010)	Study 1: N= 65	IV: Affective-cognitive orientation; Message frame (feel or think). DV: Behavioral intentions.	-Affective-orientation condition: Participants have more favorable behavioral intentions in the feel condition (vs. think). -Cognitive-orientation condition: In contrast, participants have more favorable behavioral intentions in the think condition.
	Study 2: N= 75	IV: Prime (affective vs. cognitive) [both negative]; Message frame. DV: Attitudes; Processing fluency; Involvement.	-Attitudes: In the cognitive-prime condition, the second message is more persuasive if there is a matching effect, i.e., if it is framed in think. Same effect on the affective-prime condition. -Processing fluency: Participants process the second message more easily if there is a matching effect between the priming and framing condition. -Involvement: No significant effect.
	Study 3: N= 74	IV: Message frame; Gender. DV: Attitudes; Message perceptions; Emotional orientation.	-Gender: Male participants report more favorable attitudes toward the think framing and women toward the feel framing. -Message perceptions: Men rate the messages as more convincing and less doubtful (vs. women). -Emotional orientation: Women classify themselves as more emotional (vs. men).
McKay-Nesbitt et al. (2011)	Younger adults: N= 151 (77 W, 74, M) Mean age: 20	IV: Age (younger vs. older); Affective intensity (AI) (high vs. low); NFC (high vs. low); Appeal frame (rational, negative-emotional, positive-emotional). DV: Ad recall; Involvement; Attitudes; Verbal ability (WAIS).	- <i>Younger adults</i> : Emotional appeals are more persuasive, and they remember them better than rational appeals. / Negative appeals are more persuasive than positive appeals. - <i>Older adults</i> : More positive attitudes toward rational appeals than emotional appeals. / Positive appeals are more persuasive than negative appeals.

	Older adults: N= 124 (84 W, 40 M) Mean age: 70		-High in NFC individuals report more involvement, attitudes, and recall, regardless of age, than those low in NFC.
Ryffel and Wirth (2016)	N= 189 (131 W, 58 M) Mean age: 21.17	IV: Attitude induction (affective or cognitive); Framing (affective or cognitive); Persuasion strength (weak or strong). DV: Attitude basis; Attitude change; Processing fluency.	-Attitude change: strong persuasive appeals are more effective in changing attitudes (vs. weak). -Processing fluency: “Mediates the effect of message matching on attitude change for strong and weak persuasion appeals” (p.59).
Shen (2010)	N= 315 (195 W, 120 M) Mean age: 19.78	IV: Message frame (health consequence, secondhand smoke, and industry manipulation); Message sequence (4 PSAs). [About anti-smoking] DV: Discrete emotions; Cognitive responses (thoughts); Message sensation value; Attitudes; Smoking behavior.	-In general, message frames influence cognitive and affective responses. -Affective responses (7 discrete emotions): <i>Health consequences:</i> Lead to more surprise, fear, sadness, disgust, and guilt. <i>Secondhand smoke:</i> Causes more fear and happiness. <i>Industry manipulation:</i> Leads to more anger, and guilt.
Shen and Dillard (2007)	Study 1: N= 286 (209 W, 77 M) Mean age: 20	IV: Framing (advantage vs. disadvantage). DV: Affective responses; Cognitive responses; BIS and BAS scales; Attitudes; Behavioral intentions.	-Advantage framing: Produces positive emotions. -Disadvantage framing: Produces negative emotions. -BIS: Positive associated with disgust, anger, fear, sadness, and surprise. -BAS: Associated with fear. Not with happiness, as was expected.
	Study 2: N= 252 (179 W, 73 M) Mean age: 20.29	IV: Same as study 1. DV: Same as study 1, and Message sensation value.	-Replicates previous results. -Advantage framing influences BAS activation, whereas... -Disadvantage framing causes BIS activation.

Abbreviations. AI: affective intensity; BAS: behavioral approach system; BIS: behavioral inhibition system; DV: dependent variables; IV: independent variables; M= men; N= sample group; NFC: need for cognition; PSA: public service announcement; W= women.

Table 4

Studies exploring the psychophysiology of persuasion

Authors (year)	Sample	Method	Results
Clayton (2022)	N= 100 75% W Mean age: 20.36	IV: Four anti-vaping PSAs; Message condition (dogmatic vs. suggestive). DV: Threat to freedom; State psychological reactance; Behavioral intentions; Self-reported arousal and	-Users in the dogmatic anti-vaping PSA condition self-reported greater freedom threat, psychological reactance, intention to use e-cigarettes, and unpleasantness than users in the suggestive condition.

		valence; Recognition memory; Physiological responses (HR, SCL, EMG-CS).	-Physiological responses: Also, users in the dogmatic anti-vaping PSA condition had greater corrugator muscle activation, SCL, and HR acceleration. -Recognition memory: lower for participants in the dogmatic condition than those in the suggestive anti-vaping PSA condition.
Correa et al. (2015)	N= 49 (28 W, 21 M) Mean age: 40.7	IV: Narrative (least just vs. most just). DV: Attention (engagement and workload- EEG); Emotions (HR and HRV- ECG); Post-narrative questionnaire; Donation behavior; Self-report measures: BDI, STAI, IPIP-NEO PI-R, IRI.	-Donation behavior: No differences between the least- vs. most-just version, and donation behavior. -Affective state: Those who view the least-just version experience a more negative affective state. Specifically, among those who donated. -HRV: Those who do not donate have a significantly greater HRV, regardless of narrative version. And no differences in the affective state. -Self-report: Those who donate have a higher IRI, morality, sympathy, and dutifulness.
Spelt et al. (2018)	N= 56 Mean age: 48	IV: Persuasion principles (authority, scarcity, commitment, and social proof). DV: Past behavior and attitude; STPS; Arousal (ECG).	-Cardiovascular arousal and STPS: A significant negative correlation between the authority principle and reactivity in IBI. Lower susceptibility to authority -> higher IBI. - Cardiovascular arousal and persuasion principles: Significant difference during persuasive principles compared to baseline or startle response in IBI and SDNN. - No differences between different persuasion principles.
Spelt et al. (2019)	N= 56 Mean age: 24	IV: Persuasive messages (high vs. low controlling language) (HCL vs. LCL). DV: Motivational state; Attitudes; Intentions; Psychological reactance; ECG; EDA.	-Persuasive messages: Neither HCL nor LCL persuade participants to change attitude, but they are more reactant in the HCL condition. -Physiological measures and persuasive messages: Significant difference during persuasive messages ↑ vs. rest state ↓ in ECG.
Spelt et al. (2022a)	N= 70	IV: Persuasive video advocating the limit of meat consumption; Group (M: medium meat consumption, and H: high meat consumption). DV: Self-reports: demographics, initial motivational states, and after video survey; EDA (SCL and SCRs); ECG (HR and HRV).	-Time (before/after video): lower scores before the video for moral beliefs, perceived behavioral control, and reduction intention than after. -Consumption patterns: lower reduction intention in the high meat consumers group than the medium consumers, both before and after the video. Physiologic data: During the video, lower RMSSD and SDNN, and higher SCRs compared to baseline. / During the survey, higher HR, RMSSD, SDNN, and SCL, and lower SCRs compared to the video. -No effect of group was found in the physiologic data. -Initial motivational state variables explained variance in physiological reactivity parameters (except for SDNN).

Spelt et al. (2022b)	N= 75 Mean age: 40	IV: Persuasive messages (gain- or loss-framed). DV: Pre- and Post-Attitudes and Intentions; Motivational orientation (BIS/BAS scales); Behavioral compliance; ECG; EDA; RR; facial EMG.	-Message frame: Loss-framed messages are more effective in general. -Short-term persuasion (attitude and intention): Significant increase in instrumental and affective attitude, and intention from before to after the intervention. -Long-term persuasion (behavioral compliance): No changes in behavior or attitudes two weeks later. -Physiological measures: Significant difference during persuasive messages compared to rest state in HR, RR, EMG-CS, and SCR. No differences between conditions.
Spelt et al. (2022c)	N= 56 Mean age: 48	IV: Persuasion principles (authority, scarcity, consensus, and commitment). DV: Past behavior and attitude; TIPI; STPS; ECG; EDA; RR; facial EMG.	-Physiological measures and persuasion principles: Significant difference during persuasion principles vs. rest. No differences between different persuasion principles. -STPS: Explains variance in reactivity of SCL, SCR, ZM, and CS. Lower susceptibility -> higher physiological reactivity, and vice versa.

Abbreviations. PSA: public service announcement; HR: heart rate; HRV: heart rate variability; IBI: inter-beat interval; SDNN: standard deviations of normal-to-normal heart rate; BDI: beck depression inventory; STAI: state trait anxiety inventory; IPIP-NEO PI-R: international personality item pool representation of the NEO personality inventory-revised; IRI: interpersonal reactivity index; STPS: susceptibility to persuasion scale; TIPI: ten-item personality inventory; ECG: electrocardiography; EDA: electrodermal activity; SCL: skin conductance level; SCR: skin conductance response; RR: respiration rate; EMG; electromyography; EMG-ZM: zygomaticus major; EMG-CS: corrugator supercilii; HCL: high controlling language; LCL: low controlling language; BIS/ BAS: behavioral inhibition/ behavioral activation system.

Discussion

This study aimed to review the existing data about the relationship between emotions and persuasion, the principal moderator factors in such interaction, and the psychophysiological substrates. For this, we described and analyzed the findings of the effect of discrete emotions and the principal variables that moderate between emotions and the extent of the persuasive elaboration. Lastly, we gather the existing data about the physiological reactions to persuasion (e.g., reactance).

From a valence-based approach, findings suggest positive emotions (e.g., hope, or empathy) can be more persuasive in engaging individuals to follow an action recommendation through the increase of positive affect (Worsdale and Liu, 2023; Muis et al., 2022). Positive emotions such as happiness, anticipatory enthusiasm, amusement, and attachment love facilitate more heuristic processing in which individuals use a cue to understand and establish their attitudes (Griskevicius et al., 2010; Mackie and Worth, 1991). However, the cue itself motivates individuals to engage in more systematic processing if there is another factor (e.g., high in NFC) that moderates the relationship and the level of argument elaboration is high (Petty et al., 1993); thus, individuals become more persuaded by strong (vs. weak) arguments (Sinclair et al., 2010).

As for negative emotions, they are typically associated with the systematic processing of information, and they are also mediated by various cognitive processes. A negative emotion like sadness tends to signal that a situation is problematic, causing more attentive and systematic processing, and more positive attitudes toward strong arguments (Sinclair et al., 2010). Since sad individuals do not benefit from a mood-maintenance cue, they tend to engage in deeper message scrutiny. Thus, from a motivational perspective, peripheral cues like source attractiveness have little impact because they have little to contribute to the attempt to form an informed opinion (Sinclair et al., 2010).

Beyond the emotional valence, results in the collected data revealed the principal factors that influence persuasion elaboration, as is: personal motivation (e.g., mood maintenance, or issue involvement) (Sinclair et al., 2010), NFC and NFA (Haddock et al., 2008), thought confidence (Briñol et al., 2007; Huntsinger, 2013), appraisal approach (Briñol et al., 2018; Smith and Ellsworth, 1985), level of construal (Karsh and Eyal, 2015), self-perceived vulnerability (Das et al., 2003), and efficacy beliefs (Turner et al., 2020), among others. Regarding the latter ones, both self-perceived vulnerability and efficacy beliefs are important mediators between emotion and behavioral outcome. When individuals feel high vulnerability, they have more positive attitudes toward the action recommendation regardless of the quality of the arguments (Das et al., 2003). It seems they try to undermine the negative aspects of the threat and process the positive aspects as more efficient and persuasive. This is similar to the positive bias in the anticipatory enthusiasm emotion (Griskevicius et al., 2010), which makes it plausible for a person who feels vulnerable to a threat to also feel this type of emotion to an action recommendation as it represents a potential benefit. In contrast, when the vulnerability is low, there is an increase in the motivation to scrutinize the arguments (Das et al., 2003), lower persuasion, and lower intentions to engage in the action recommendation, a similar reaction described as a *cognitive-based dissonance-reducing strategy* (Keller and Block, 1999).

In this line, the effectiveness of fear appeals continues to produce inconsistent results in the literature. In this review, some studies found that fear appeals are more effective in engaging individuals to follow the action recommendation (Das et al., 2023) and that it is positively associated with BAS (Shen and Dillard, 2007; Shen, 2010), while other found that fear appeals were less effective than a positive emotion such as hope, to increase positive affect and behavior intention (Worsdale et al., 2023). More recently, increasing positive affect have been considered in health communication research as an effective way to persuade behavioral

intentions (Fitzgerald et al., 2019). In addition, this apparent contradiction emphasizes that cognition mediates the effect of emotions on persuasion.

Moreover, findings demonstrate the influence of recipients' orientation, either affective or cognitive, on their message processing (i.e., matching effect) (Dubé and Cantin, 2000; Haddock et al., 2008; Mayer and Tormala, 2010; Ryffel and Wirth, 2016). The matching effect can be studied by tailoring a message frame with the recipient's attitude bases (Petty and Wegener, 1998), or individual tendencies (Haddock et al., 2008). In general, there are some discrepancies in the literature about whether the matching effect produces more persuasion either by a central route enhancing message scrutiny (Petty and Wegener, 1998) or by a peripheral route increasing processing fluency (Lee and Aaker, 2004). Ryffel and Wirth (2016) find that matching a message with a recipient's attitude bases heightens the processing fluency, thus serving as a peripheral cue. However, if the message is particularly strong, it triggers a mismatching effect and produces higher scrutiny (Ryffel and Wirth, 2016). This result contrasts with the findings of Petty and Wegener (1998), who state that weak arguments are the ones that can disrupt the fluency in the matching effect. Although in apparent opposition, both findings support the idea that the type of processing route transited, either central or peripheral, is affected firstly, by the dispositional state of elaboration (i.e., lower, or higher elaboration) and, secondly, by the strength of the argument. The extent of message elaboration depends on the individual's motivation and ability to think. Individuals constrained to be low in their thinking will transit the peripheral route regardless of the quality of the message, whereas individuals with a higher level of elaboration will more likely be engaged in scrutinizing the message, so its strength becomes more relevant (Teeny et al., 2020). Matching effects also increase message recognition, which suggests deeper information processing and differences in message elaboration (Haddock et al., 2008).

Other individual characteristics that moderate the effectiveness of message framing are gender (Mayer and Tormala, 2010) and age (McKay-Nesbitt et al., 2011). Overall, results suggest women and younger adults are more persuaded by emotionally framed messages. Mayer and Tormala (2010) report that women are more emotionally oriented than men, and thus more persuaded by feel-framed arguments. However, Cacioppo and Petty (1982) find that NFC does not vary as a function of gender. Perhaps the differences in the processing of message frames may be due to the individual's self-perception of the issue or tendency for NFC or NFA, irrespective of gender. Regarding age, younger adults recall emotionally negative messages better than rational ones, while older adults prefer positive and rationally framed messages. Nevertheless, very few studies consider the gender and age variables, which are relevant for distinguishing persuasive elaborations by groups.

Lastly, with respect to the psychophysiology of persuasion, findings are still very scarce. However, there is growing interest in the use of physiological measures to complement traditional predictors of persuasion and help explain variance in the motivational state and behavior of an individual caused by persuasive messages. Findings indicate differences in reactivity by higher HR (Spelt et al., 2022b; 2019; 2022c), lower SDNN (Spelt et al., 2022b), more RR (Spelt et al., 2022c), more frowning in EMG-CS (Spelt et al., 2022b; 2022c), and more SCRs (Spelt et al., 2022b; 2022c) during the processing of persuasive messages compared to a rest state, regardless of message framing. These results were also replicated in a study conducted in our laboratory where cardiovascular reactivity during persuasion was higher than baseline reflected in lower RMSSD (Rodríguez-Hernández et al., submitted for publication). Interestingly, studies were consistent in finding that a greater misalignment between initial behavior and the persuasive attempt led to a defensive message processing reflected in more EMG-CS, SCL, and HR (Clayton, 2022; Spelt et al., 2022a), which suggests that physiological measures reflect a reactance state, characterized as a state of higher arousal. To conclude,

persuasion is effective in changing motivational states and behavioral intentions, both of which are reflected in physiological reactivity.

Future Directions

ELM is a framework widely used in the persuasion literature in the attempt to understand which route of information processing is more effective or commonly transit. Our review contributes to the persuasion literature by providing an overview of the principal factors that mediate and moderate which processing route is taken. There is a growing literature on the underlying processes of persuasion (Cacioppo et al., 2018), however, there is a lack of integration presented in systematic reviews about the main factors that influence persuasion efficacy. Also, a promising future direction is to explore how situational states such as perceived stress or state anxiety influence the processing of persuasive health communications.

In the area of health communication and persuasion, research about the effect of reactance has found strategies to mitigate it, such as ‘choice-enhancing language’ in opposition to ‘freedom-threatening language’ (Reynolds-Tylus, 2019). However, we suggested further exploration of the effect of situational states as perceived stress in the processing of persuasion and physiological reactions. Stressful situations decrease the processing of information and discrimination between strong and weak arguments (De Miguel et al., 2009), which suggests more heuristic processing as the individual would probably feel high in vulnerability (Das et al., 2003). Perhaps, persuasion in public health communications or medical adherence to treatments could be more efficient in promoting action recommendations if message frames were adapted to situational stress individuals, beyond the disadvantage-frames or fear appeals commonly used.

Limitations

Results in the present review support the idea that emotions affect the processing of persuasive communication through multiple cognitive processes, as stated by the ELM (Petty and Cacioppo, 1986). We highlight the principal moderator factors identified in the relationship between emotions and persuasion, which is relevant in the attempt to tailor any intervention. Despite this, we excluded articles about the neural correlates of persuasion using fMRI from this review, since we focus on psychophysiological measures, so there is a lack of integration with the already known underlying mechanisms of persuasion. The study of the psychophysiological patterns of persuasion is still in its infancy, and this review is just an effort to overview the relationship between persuasion processing, emotions, and physiological reactivity. Future work of this kind is needed to bring together the behavioral, physiological, and neural mechanisms of persuasion.

Conclusions

Overall, the results of the studies included in the present review suggest that several important factors affect persuasion efficacy, such as the route of cognitive elaboration transited. Meanwhile, the extent of elaboration is moderated by various factors such as personal motivation or relevance, individual differences in NFC and NFA, thought confidence, appraisal approach, self-perceived vulnerability and efficacy, demographics, persuasive strategies such as framing and matching, and physiological reactions. The effect of discrete emotions depends on those previously stated factors. However, there are mixed findings regarding their persuasiveness, since some studies still found the emotion of fear effective in engaging individuals in the action recommendation, while more recently others found positive emotions (e.g., hope) more effective for health-related behavior changes. Regarding the psychophysiology of persuasion, the difference in physiological arousal between the

processing of persuasive messages versus a rest state and the reactance phenomenon should be further explored. Moreover, for future directions of research, we suggested the study of more situational states such as perceived stress in persuasive health communication. Finally, a more in-depth analysis of gender and age differences in the processing of persuasive communication would be useful for further research studies.

CHAPTER III: How do we process nutrition-related health messages? An Online Survey



Online study

An online survey was conducted to explore through a self-reported assessment which persuasive strategy (i.e., Ethos, Pathos, and Logos) seemed more convincing to a general population. To study persuasion through a somehow controversial topic, we chose the limit of meat consumption. The messages were drafted based on scientific evidence with different frames based on the strategy. The survey was carried out during the COVID-19 lockdown, between April and June 2020.

The main objectives were first to explore which of the three persuasive strategies was considered more persuasive to a diverse population. Secondly, to examine how the perceived persuasiveness of the strategies differ based on some individual differences (e.g., age, gender, educational level, and work status) and in addition to exploring gender differences by dividing the sample by age group (i.e., younger, middle-aged, and older adults). Lastly, to explore the correlation between psychological characteristics (i.e., perceived stress, personality, and coping styles) and persuasive strategies.

The main hypothesis is that Ethos (because of the peripheral cue of source expertise; ELM) or Pathos (Benlamine et al., 2017), will be perceived as more persuasive than Logos. Also, this hypothesis holds to the notion that the study was conducted during the COVID-19 confinement period when most of the news appealed to authority (Ethos) and to the empathy (Pathos) of the people.

Methods

Participants and Procedure

The total sample that participated in the online survey was 422 volunteers. However, 112 entries were incomplete, so that the final sample was composed of 310 volunteers (227 women, 83 men, mean age: 40.8; SD= 15.9). Participants were recruited through the call to known

people, family members, students, and colleagues, among others. No exclusion criteria concerning age, sex, or country of residence were applied. The characteristics of the sample are shown in **Table 1**.

The survey was composed of demographic questions, psychological questionnaires, and a persuasion task. The questionnaires presented were the Perceived Stress Scale (PSS-4), NEO Five-Factor Inventory (NEO-FFI-60), and the Brief-Coping Orientation to Problems Experienced Inventory (Brief-COPE-28), all of them in their Spanish-validated versions. The persuasion task consisted of 30 messages: 10 messages per each of the three persuasive strategies. The entire survey had a duration between 15-20 minutes and was presented through the online survey tool LimeSurvey.

Table 1. Sample characteristics by age group, and for men and women.

	Young adults (18-35 years old)			Middle-aged adults (36-55 years old)			Older adults (56-75 years old)		
	Total sample (n= 140)	Men (n= 33)	Women (n= 107)	Total sample (n= 92)	Men (n= 20)	Women (n= 72)	Total sample (n= 77)	Men (n= 29)	Women (n= 48)
Age M (SD)	25.8 (4.8)	28 (4.2)	25.1 (4.7)	45.1 (5.7)	44.3 (5.5)	45.3 (5.8)	62.9 (3.9)	63.3 (4.0)	62.5 (3.9)
Residency N									
Europe	100	24	76	64	17	47	56	23	33
America	37	9	28	28	3	25	21	6	15
Other	3	0	3	0	0	0	0	0	0
Educational level N									
Basic studies	2	1	1	3	0	3	3	0	3
High school	17	2	15	7	1	5	12	6	6
University or Higher educ.	63	13	50	49	12	37	45	16	29
Postgraduate (Master, PhD)	58	17	41	33	6	27	17	7	10
Work status N									
Unemployed	18	6	12	5	1	4	4	0	4
Employed	61	16	45	84	18	66	29	10	19
Retired or pensioner	0	0	0	2	1	1	41	18	23
Unpaid domestic work	2	0	2	0	0	0	2	0	2
Student	59	11	48	1	0	1	1	1	0
PSS-4	6.1 (2.9)	5.6 (2.8)	6.3 (3.0)	5.0 (2.6)	5.3 (3.0)	5 (2.4)	4.1 (2.9)	4.1 (2.8)	4.2 (2.9)
COPE-28									
Cognitive coping	5.0 (0.9)	5.0 (0.9)	5.0 (0.9)	5.0 (0.8)	4.8 (0.9)	5.1 (0.8)	4.8 (1.1)	4.7 (0.9)	4.9 (1.2)
Avoidance coping	2.6 (0.8)	2.7 (0.9)	2.6 (0.8)	2.4 (0.7)	2.2 (0.7)	2.5 (0.8)	2.2 (0.7)	2.2 (0.7)	2.1 (0.7)
Emotional coping	5.8 (1.6)	5.3 (1.5)	5.9 (1.7)	5.1 (1.8)	4.3 (1.8)	5.3 (1.8)	4.7 (1.4)	4.4 (1.3)	5.0 (1.4)
Spiritual coping	1.7 (2.0)	2.0 (2.1)	1.5 (2.0)	2.7 (2.2)	1.4 (1.9)	3.1 (2.1)	2.7 (2.2)	2.2 (2.3)	3.0 (2.2)
Personality									
Neuroticism M (SD)	34.0 (9.3)	31.6 (8.9)	34.7 (9.3)	31.8 (7.9)	28.5 (6.5)	32.7 (8.0)	28.3 (7.2)	29.1 (6.9)	27.7 (7.4)
Extraversion M (SD)	42.2 (8.0)	41.5 (7.7)	42.5 (8.1)	41.3 (6.8)	40.5 (8.5)	41.5 (6.3)	41.7 (5.8)	41.4 (5.6)	41.9 (6.0)
Openness M (SD)	43.6 (7.0)	44.3 (7.3)	43.3 (6.9)	42.0 (6.4)	42.6 (8.3)	41.9 (5.9)	40.9 (6.8)	39.7 (6.1)	41.5 (7.1)
Agreeableness M (SD)	41.6 (4.8)	40.4 (4.7)	41.9 (4.8)	43.9 (5.0)	42.4 (4.9)	44.4 (5.0)	44.4 (5.2)	42.6 (5.4)	45.5 (4.9)
Conscientiousness M (SD)	43.1 (6.8)	39.9 (5.6)	44.1 (6.8)	43.9 (6.0)	44.8 (6.4)	43.6 (5.9)	44.6 (5.5)	43.9 (4.4)	45.1 (6.1)

Note: M (mean); SD (standard deviation)

Measurements

Persuasion task

Persuasion was assessed through the presentation of messages about meat consumption framed in one of three strategies: Ethos, Pathos, or Logos. Each strategy was presented in a block of 10 messages, for a total of three blocks in the native language of the participants (Spanish). Each message appeared with the question: ‘How convincing is this message?’ with a range from 0 (*Nothing convincing*) to 4 (*Very convincing*). Block and message order were counterbalanced by LimeSurvey.

Perceived Stress Scale (PSS)

For this research, we used the validated Spanish version (Remor, 2006) of the PSS (Cohen et al., 1983; Cohen and Williamson, 1988). Participants respond on a 5-point Likert scale from 0 (*Never*) to 4 (*Very often*) to the PSS-4 (items 2, 6, 7, and 14 from the original PSS-14). Items 6 and 7 were reverse-scored. Higher scores indicate higher levels of perceived psychological stress during the last month. The Cronbach’s α was .74.

NEO Five-Factor Inventory (NEO-FFI)

We used the Spanish version (Costa and McCrae, 1999) of the NEO Five-Factor Inventory (Costa and McCrae, 1992), which consists of 60 items that measure the Big Five personality traits, each with 12 items (neuroticism, conscientiousness, extraversion, openness, and agreeableness). With a 5-point Likert scale, participants respond from 0 (*Totally disagree*) to 4 (*Totally agree*). The Cronbach’s α was .71.

Brief-Coping Orientation to Problems Experienced Inventory (COPE)

Coping strategies were examined through the validated Spanish version (Morán et al., 2010) of the Brief COPE (Carver, 1997), which consists of 28 items and 14 subscales of 2 items each, omitting two subscales from the original COPE-60 (Carver et al., 1989). With a 4-point Likert scale, participants respond from 0 (Nothing) to 3 (Lot) to different ways of coping with stress. As in Morán et al. (2010), we did the factorial analysis which grouped all the items into 11 subscales (emotional support, active coping, alcohol or drug, humor, religion, self-distraction, denial, relief, self-incrimination, disengagement, and positive reinterpretation), followed by a second order analysis to regrouped to 4 factors: cognitive, avoidance, social support, and spiritual coping. Cronbach's α for all items was .75.

Statistical Analysis

For the first objective (i.e., to explore which of the three persuasive strategies was considered more persuasive to a diverse population), a rm-ANOVA with Strategy (Ethos, Pathos, Logos) as a within-subject factor was employed. To examine the second objective (i.e., to study the differences in the perceived persuasiveness of the strategies based on individual differences in Age, Gender, Educational level, and Work status), a one-way ANOVA was executed with the self-reported scores given to each persuasive strategy as the dependent list and Age, Gender, Educational level, and Work status separately as the between-subject factors. In addition, for this objective, the sample was split by age group followed by the one-way ANOVA comparing Gender. Finally, for the last objective (i.e., to explore the correlation between psychological characteristics and persuasive strategies), a bivariate Pearson's correlation analyses were performed between the individual characteristics of personality, coping strategies, and perceived stress and the persuasive strategies.

Results

Persuasiveness of the strategies

A rm-ANOVA revealed a significant effect of Strategy ($F(2, 618) = 92.4, p < .001, \eta^2_p = .230$). The strategy of Ethos had a significantly higher score on the ‘*How convincing is this message?*’ question ($M = 3.0, SD = 0.6$) than Logos and Pathos (both $p < .001$). Whereas Logos ($M = 2.7, SD = 0.6$) had a higher score than Pathos ($M = 2.5, SD = 0.8$) ($p < .001$), the latter being considered the least persuasive.

Persuasion and demographics

For the second objective, a one-way ANOVA revealed significant differences in the perceived persuasiveness of Ethos ($p < .001$), Pathos ($p = .002$), and Logos ($p = .024$) strategies between women and men. However, no differences were found in the perceived persuasiveness of the three strategies comparing by age (all $p > 0.4$), educational level (all $p > 0.3$) or work status (all $p > 0.3$).

Furthermore, the differences by gender were constant when the sample was split by age group. Significant differences in the perceived persuasiveness of the Ethos and Pathos strategies between women and men in middle ($p = .025; p = .016$, respectively) and older age ($p = .006$) were found. Means, SD, and p -values among each persuasive strategy comparing women and men by age group are shown in **Table 2**.

Persuasion and psychological characteristics

Bivariate Pearson’s correlation analyses revealed that the personality traits of Extraversion ($p < .001$) and Conscientiousness ($p = .002$) correlated positively with the Ethos strategy, while the trait of Openness ($p = .008$) with the Logos strategy. As for the coping styles, cognitive

coping, and social support correlated positively with the three strategies (all $p < .025$), while avoidance coping correlated with the Pathos strategy ($p = .005$). No relationship was found between PSS, Neuroticism, Agreeableness, or Spiritual coping with any of the strategies (all $p > .055$) (see **Table 3**).

Table 2. Comparison of means for each persuasive strategy by age group, and for men and women.

Young adults (18-35 years old)				Middle-aged adults (36-55 years old)			Older adults (56-75 years old)		
	Men (n= 33)	Women (n= 107)		Men (n= 20)	Women (n= 72)		Men (n= 29)	Women (n= 48)	
Ethos	2.8 (0.6)	3.0 (0.6)	$p = .133$	2.7 (0.6)	3.0 (0.6)	$p = .025^*$	2.7 (0.6)	3.1 (0.6)	$p = .006^{**}$
Pathos	2.4 (0.9)	2.6 (0.8)	$p = .161$	2.1 (0.8)	2.6 (0.8)	$p = .016^*$	2.2 (0.8)	2.5 (0.9)	$p = .126$
Logos	2.6 (0.7)	2.7 (0.6)	$p = .493$	2.4 (0.6)	2.7 (0.6)	$p = .122$	2.4 (0.6)	2.7 (0.7)	$p = .066$

Note. Means (standard deviations)

Table 3. Pearson's correlation values among the persuasive strategies and psychological variables studied.

	Ethos	Pathos	Logos
PSS	-.093	.012	-.048
Neuroticism	-.033	.109	.030
Extraversion	.190**	.003	.048
Openness	.061	.108	.150**
Agreeableness	.099	.072	.001
Conscientiousness	.174**	-.004	.076
Cognitive coping	.253**	.173**	.131*
Avoidance coping	.060	.158**	.085
Social Support	.164**	.163**	.153**
Spiritual coping	.109	.046	-.022

* $p < .05$. ** $p < .01$

Discussion

As was mentioned at the beginning, the objectives of this study were, first, to examine which persuasive strategy about a health topic seems more convincing to a diverse population. Overall, we found the strategy of Ethos (appeals to the source's authority) to be the more persuasive, followed by Logos (appeals to the logic of the argument), ending with the Pathos strategy (appeals to the emotions and empathy of the audience) considered as the less persuasive.

A second objective was to study the differences in the perceived persuasiveness of the strategies based on individual differences (i.e., age, gender, educational level, and work status). Results revealed differences in the perceived persuasiveness between women and men, but no differences by age, educational level, or work status were found. Moreover, when the sample was split by age group, results revealed differences between women and men in the assessment of the Ethos and Pathos strategies, in middle and older adults, being women the ones that considered significantly more persuasive both strategies than men.

Lastly, the third aim was to evaluate the relationships of the perceived persuasiveness of the strategies and the psychological characteristics of the participants (i.e., perceived stress, personality traits, coping styles). We found that higher Extraversion and Conscientiousness correlated with more persuasiveness of the Ethos strategy, while higher Openness appeared related to more convincing the Logos strategy. Regarding the coping styles, we found a positive correlation between the avoidance coping strategy and the Pathos strategy, which is a type of strategy that uses peripheral cues to distract the processing of the argument from more thoughtful thinking, while the avoidance coping style is characterized for denial or mental disengagement from the relevant or stressful issue (Carver et al., 1989). In addition, cognitive coping and social support correlated positively with the three strategies. Individuals who employed more the social support coping strategy seek out advice, assistance, or information,

which explains its positive correlation with the three strategies. Cognitive coping is a type of active coping that may motivate individuals to be more influenced by the persuasive attempt regardless of the type of strategy to direct action.

To conclude, the Ethos strategy was considered the most persuasive in health messages, here focused on nutrition-related topics, to a general and diverse population. In addition, middle and older women assessed the Ethos strategy as more persuasive than men did of the same age. It is important to point out that this online survey was shared in 2020 during the COVID-19 lockdown, which was a critical moment of much exposure to health communication delivered especially by authorities, which makes it more understandable that the Ethos strategy was perceived as the more persuasive regardless of the characteristics of the group.

This online study served as preliminary research for what the experimental phase would be. The persuasive strategies proved to differentiate between them, by being considered differently in the assessment of the messages. For the experimental in-person phase, we aimed to duplicate the number of messages, add more psychological questionnaires, and integrate the physiological measures.

CHAPTER IV: Social dominance and persuasiveness of health messages: An exploratory Event-Related Potentials study²



² Rodriguez-Hernandez, V., Garrido-Chaves, R., Hidalgo, V., and Salvador, A. Social dominance and persuasiveness of health messages: An exploratory Event-Related Potentials study. [Manuscript under revision for publication].

Introduction

People are constantly influenced by others, and persuasion is one of the main types of social influence. Persuasion is designed to produce changes in others' attitudes or behaviors, and it is quite relevant in many social entities involved in commerce, diplomatic/military projects, advertisement, and political and public health campaigns, among others. There is growing interest in research on the neural correlates of persuasion and its different effects on people, but a unified understanding of the underlying mechanisms of persuasion is still lacking (Spelt et al., 2022). Therefore, this study explores the efficacy of three different persuasive strategies used to draw attention to a nutrition-related topic, recorded through Event-Related Potentials (ERPs).

To change an attitude or behavior, it is crucial to capture people's attention. For this purpose, a commonly used strategy is framing, where some aspects of an issue are highlighted to connect the message's discourse to the recipient (Pan and Kosicki, 2005). The use of framing affects the individual's level of relevance or involvement, which influences the way the information is processed. To study the effectiveness of different frames, we chose three persuasive strategies: Ethos, Pathos, and Logos. They are based on Aristotelian rhetoric, and each has a particular perspective on how to address information. Ethos relies on the authority, expertise, and popularity of the source, and it adds reliability to what is said. Pathos appeals to the emotions and empathy of the audience to influence their rational judgment. Lastly, Logos relies on the logic of the argument, appealing mostly to rationality and critical thinking (Berlanga et al., 2013; Stucki and Sager, 2018).

Petty and Cacioppo (1986), in their Elaboration Likelihood Model, proposed that information processing takes one of two routes: central or peripheral. The central route requires more involvement and scrutiny and emphasizes the comprehension, learning, and retention of

the messages (Eagly, 1974; Petty et al., 1981). The peripheral route relies more on peripheral cues that distract the audience's attention from the content of the argument and make it seem more persuasive, without any issue-related thinking. Furthermore, because the recipient's level of argument elaboration is influenced by personal relevance or involvement, there is a tendency to scrutinize the arguments when a topic has high personal relevance. However, when personal relevance is low, the message's peripheral cues (e.g., source expertise) become more dominant (Petty et al., 1981).

Based on previous literature, the framing effect gains efficacy (i.e., more personal involvement and message elaboration) when it matches people's characteristics, such as their attitude functions (Petty and Wegener, 1998), orientations (Mayer, 2010), or stereotypes (Wheeler et al., 2008), among others. Based on this effect, we found it relevant to study the psychological trait of social dominance, given that this orientation is more likely to affect both the potential persuasive efficacy of the strategies (D'Errico, 2020) and the individual's susceptibility to being persuaded. Despite this, its study in relation to health communications is scarce.

In humans, as a social species, it is important to understand the functioning of social influences and the hierarchies in order to advance the health and well-being of the members. However, there is a gap in the general understanding of the way different factors work together to determine individuals' positions and influences in hierarchies (Dehnen et al., 2022). Social dominance orientation (SDO) has been described as a common characteristic of individuals or groups that encourages the maintenance of hierarchical orders (Tyler, 2006). This orientation is common in authoritative figures who want to legitimize their dominant status, for example, communicators who want to persuade the audience by appealing especially to their own power or authority. SDO is related to individuals' ideologies, attitudes toward social policies, and lifestyles (Ho et al., 2012). Recently, it has been studied as the basis of antiscientific and anti-

environmental attitudes that have emerged in relation to current topics such as vaccines or climate change (Azevedo and Jost, 2021; Kerr and Wilson, 2021). However, it is also relevant to study how the dominance orientation in the audience influences their susceptibility to being persuaded and, consequently, their social behavior. Furthermore, because SDO is considered a powerful predictor of intergroup attitudes and behavior, we found it relevant to study how this psychological orientation moderates the processing of health-related messages with different frames (i.e., Ethos, Pathos, and Logos).

In addition, we aimed to broaden the perspective by adding neurophysiological data that make it possible to explore the cognitive processing that underlies persuasion. In studies on persuasion, attitude or behavior changes have usually been assessed only by self-report measures, although more recently they have been complemented by neurophysiological measures (Benlamine et al., 2017; Kessels et al., 2011; Spelt, et al., 2018; 2019; 2022). These measures can help to better explain the variations in the attentional and motivational state of an individual. In Benlamine et al. (2017), the persuasive strategies of Ethos, Pathos, and Logos were used by a moderator to influence participants during a debate on certain topics, and electroencephalogram (EEG) recording was employed. Their results revealed that the Ethos and Pathos strategies induced more engagement, which can be interpreted as the subjects having transited the peripheral route because of the cues of source expertise and emotions, whereas the Logos strategy involved a greater workload. Based on this approach, we aimed to employ event-related potentials (ERPs) in the context of persuasion to enhance the understanding of the neural correlates of the persuasive attempts.

As mentioned above, we aimed to study the persuasiveness of the three different strategies in addressing nutrition-related topics related to limiting meat consumption. Currently, unhealthy nutrition is a public health issue due to the related diseases and high environmental impact of unhealthy-food industries. Poor dietary habits are a major risk factor

for cardiometabolic health, e.g., heart disease, stroke, or type 2 diabetes (Micha et al., 2017), and, hence, one of the main causes of death in modern society. Moreover, reducing the consumption of animal products, especially meat, is important in promoting a more sustainable diet (Macdiarmid et al., 2016; WHO, 2015; FAO, 2010). Meat consumption is a source of rich nutrients; however, processed meat had been classified as a definite cause of cancer, and red meat as a probable cause (IARC, 2015). In addition, livestock production harms GHG emissions, the water footprint, water pollution, and water scarcity (Farchi et al., 2017). Furthermore, meat consumption has been related to various culturally oriented values, such as superiority, strength, masculinity, and indulgence. Thus, the role of social values and orientations (e.g., the social dominance orientation) is worth studying in this context.

Based on the above, this research studied the efficacy of three different persuasive strategies (i.e., Ethos, Pathos, and Logos) in convincing and drawing attention to health education messages. Using a within-subject design, we aimed to identify which of the three strategies is considered more persuasive, attending to: the self-report assessment of the persuasive strategies (i.e., reported answers about how convincing each presented message is), attention capturing by means of the P300 ERP amplitude and latency, and the social dominance orientation (SDO). We formulated the following hypotheses: (1) Ethos and/or Pathos will be perceived as more persuasive on the self-report assessment and produce a larger P300 amplitude, in line with the Benlamine et al. (2017) results. (2) SDO will be positively related to the persuasiveness of Ethos because this strategy emphasizes the authority and expertise of the source.

Materials and Methods

Participants

The final sample was composed of thirty young undergraduate students (7 men and 23 women, mean age = 21.33 years) recruited from different bachelor's degree programs. The recruitment phase consisted of a personal visit to different classrooms where the research was introduced and details were provided about the type of data collected, the duration of the session, and the compensation they would receive if they participated. As a second recruitment strategy, several posters were displayed around the University. The recruitment was first carried out in the month of February 2020, but due to the emergence of the COVID-19 pandemic, the interested participants were not contacted until April 2021, when another round of recruitment took place.

The exclusion criteria were a history of alcohol or drug abuse; smoking more than 10 cigarettes a day; the presence of a neurological or psychiatric disorder; pregnancy; taking any medication that altered the nervous system (Picton et al., 2000); being a vegetarian; and, lastly, having had a fever, cough, and/or respiratory difficulties in the past 14 days (main Covid-19 symptoms). All the participants were right-handed according to the Edinburgh Handedness Inventory (Oldfield, 1971).

Procedure

The study consisted of one two-hour experimental session. Before the study, via email, participants were asked to maintain their sleep routine, avoid intense physical exercise and alcoholic drinks the day before, and not eat, smoke, or drink stimulant beverages such as coffee for at least two hours before the session. As participants arrived at the laboratory, the experimenter verified that the recommendations had been followed and then explained the content of the session. The study was performed according to the Declaration of Helsinki and

approved by the Ethical Committee of the University (register code: 1241475). All participants signed informed consent forms.

After a period of habituation to the laboratory, which included the control of the recommendations and the explanation of the study, there was a preparation period during which the experimenter measured the participant's head circumference for the EEG cap and cleaned the areas where the ECG electrodes would be placed. The EEG register started with two periods of resting EEG with three minutes of eyes-open and three minutes of eyes-closed. Next, the persuasion task was presented. After it, participants spent around thirty minutes answering a series of questionnaires. All participants received a USB memory pen in exchange for their participation in the study.

Persuasion task

The task consisted of three blocks of messages based on the Ethos, Pathos, and Logos persuasive strategies. At the beginning of the task, instructions were presented, followed by a 1-min river clip, then the three blocks, and after all the blocks, a 1-min acoustic startle. In each block, 20 messages promoting limited meat consumption were presented in the participants' native language (Spanish). After each message/question, there was a 1-s fixation point, and each block of messages was separated by a 1-min neutral river clip. Some examples of the messages presented are *Experts estimate that a vegetarian diet produces about 2.5 less GHG (Greenhouse Gas) emissions than a meat-based diet* (Ethos); *It is very unfortunate that still today 13% of pigs are conscious during the slaughter process* (Pathos); and *It is estimated that between 20-30% of the environmental impact in Western countries is due to the food industry* (Logos). Each message was followed by the question: 'How convincing is this message?', with a response range from (0) *not at all convincing* to (4) *very convincing*.

Block and message order was counterbalanced by E-Prime. The entire task lasted between 15-18 minutes (**Figure 1**).

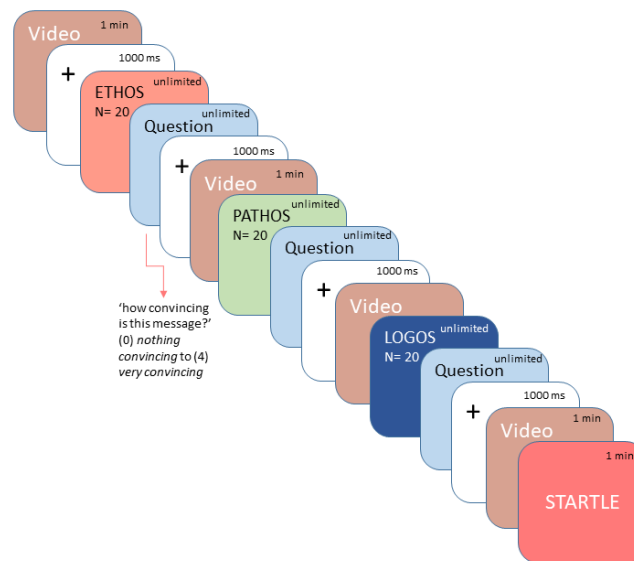


Figure 1. Visual representation of the experimental conditions.

Social Dominance Orientation (SDO)

We used the validated Spanish version of the Social Dominance Orientation Scale (Silván-Ferrero and Bustillos, 2007), based on the form designed by Pratto et al. (1994). The scale is composed of 16 items rated on a Likert scale ranging from (1) *totally disagree* to (7) *totally agree*. Participants respond to statements such as ‘*It’s probably a good thing that certain groups are at the top and other groups are at the bottom*’; or ‘*Some groups of people are just more worthy than others.*’ Items whose wording disagreed with dominance and inequality were reverse-scored. The total score was calculated; higher scores indicated a greater orientation toward social dominance. The Cronbach’s α was .85.

EEG recording and data analyses

Electroencephalogram (EEG) was recorded from 25 active electrodes using a Brain Vision Amplifier System (BrainProducts, Germany). The electrooculogram (EOG) was recorded from three of the total electrodes, one placed on the external canthus of each eye (HEOG+, HEOG-) and another on the supraorbitally of the right eye (VEOG+) to detect eye movements and remove blinks (Gratton et al., 1983). The ground electrode was placed on AFz and the reference on FCz. The remaining 20 electrodes (Fp1, Fp2, F7, F3, Fz, F4, F8, FC5, FC6, T7, Cz, T8, P7, Pz, P8, O1, Oz, O2, A1, and A2) were mounted on an elastic cap (Easycap, Falk Minow, Munich, Germany) according to the International 10-20 system. The electrode-to-skin impedances were lowered using electrolyte gel (SUPER-VISC High Viscosity Electrolyte-Gel) and kept below 5 K Ω throughout the recording.

The BrainVision Analyzer (BrainProducts, Germany) was used to analyze the EEG data. The signal was filtered through a 0.1-30 Hz offline bandpass. Epochs consisted of 1000ms, from 200 ms before the stimulus-response (corrected to baseline) to 800 ms after it. The baseline was set during the stimulus-response, i.e., when the participant presses the space button in response to having finished reading the message, just before the onset of the question ‘How convincing is this message?’.

The amplitude and latency of the ERP were analyzed for each participant and epoch. The different waveforms were detected by visual inspection and quantified by peak amplitude measures (μ V). The visual inspection showed clear peaks in the time window between 250-450 ms after the onset in the Fp1, Fp2, Fz, and Pz channels, which corresponds to the P300 component circuit pathway of neuroelectric activity between the frontal and temporal/parietal brain areas (Huang, Chen, and Zhang, 2015). Mean amplitudes were calculated using the Peak Detection Method through semiautomatic detection.

Statistical Analyses

An a priori power analysis for F tests with a medium-to-large effect size (Cohen, 1988) of $f = 0.30$ and $\alpha = 0.05$ with one group, two measurements, and .80 power in G*power indicated that a sample size of at least 24 participants should be sufficient for the aims of the study. We employed data from 30 participants.

To compare the assessment of the persuasive strategies (i.e., *how convincing* each message was) and reaction time (RT), repeated measures ANOVAs were performed. Likewise, to investigate the amplitude and latencies of the P300 component, we carried out rm-ANOVAs using Strategy (Ethos, Pathos, Logos) and Electrode (Fp1, Fp2, Fz, and Pz) as main factors. Analyses had a within-subject design. The relationships between the self-reported assessment of the persuasive messages and the SDO were studied through linear regression analyses.

All statistical analyses were performed with SPSS 26.0., and the level of significance was set at $p = 0.05$. *Post-hoc* comparisons were performed using Bonferroni adjustments for the p -values.

Results

Assessment of the persuasive strategies

We considered the responses to *how convincing* each message was and the reaction time (RT) in responding. Descriptive statistics are shown in **Table 1**. The Ethos strategy had the highest score on the ‘how convincing’ question (i.e., persuasiveness), and the Logos strategy had the longest RT. However, the ANOVA did not provide statistically significant differences ($p = 0.17$); the planned comparisons showed marginal differences between Ethos and Logos ($p = 0.06$), but not between Ethos and Pathos ($p = 1.0$) or between Pathos and Logos ($p = 0.90$).

Regarding the RT, the difference between strategies did not reach statistical significance ($p = 0.66$).

Table 1.

Mean Values for the Assessment of the Persuasion Strategies ($n = 30$).

	Persuasiveness		Reaction Time	
	Mean	SD	Mean	SD
Ethos	2.77	.4568	1670.2	910.85
Pathos	2.70	.5903	1780.0	884.01
Logos	2.58	.6184	1824.5	778.26

Event-Related Potentials

The mean amplitude (μV) and latency (ms) for the P300 component for the Ethos, Pathos, and Logos strategies are presented in **Table 2**.

Table 2.

Event-related potential (ERP) values for each persuasion strategy ($n = 30$).

P300	Ethos		Pathos		Logos	
Fp1	10,4 (14,6)	338 (98)	6.8 (9,2)	360 (103)	1,5 (3,2)	348 (99)
Fp2	10,7 (15,8)	337 (102)	7,4 (9,9)	378 (102)	1,5 (2,4)	353 (90)
Fz	3,5 (4,0)	377 (107)	2,1 (2,4)	370 (98)	1,7 (1,9)	356 (92)
Pz	5,2 (3,7)	356 (91)	4,6 (4,5)	363 (88)	3,6 (3,3)	330 (81)

Mean amplitude (μV) and latency (ms) for the Ethos, Pathos, and Logos strategies for the P300 component at the Fp1, Fp2, Fz, Pz electrodes. SDs are given in brackets.

For the P300 amplitudes, rm-ANOVA results showed significant effects of Strategy ($F(2, 58) = 9,87, p = 0.002, n^2 = .254$), Electrode ($F(3, 87) = 4,75, p = 0.03, n^2 = .141$), and the Strategy x Electrode interaction ($F(6, 174) = 5,90, p = 0.007, n^2 = .169$).

Post hoc tests revealed a significantly larger P300 amplitude effect for Ethos than for Logos ($p = 0.008$), and a marginal effect for Pathos ($p = 0.06$). In addition, the P300 amplitude was larger for Pathos than for Logos ($p = 0.01$). The Electrode effect showed that the amplitude was larger in Fp1 than in Fz ($p = 0.01$), larger in Fp2 than in Fz ($p = 0.02$), and larger in Pz than in Fz ($p = 0.02$), and the Fz channel had the smallest P300 amplitude. Lastly, regarding

the Strategy x Electrode interaction, post hoc tests revealed that the amplitude was larger for Ethos than for Logos in the Fp1 ($p = 0.01$), Fp2 ($p = 0.01$), and Pz ($p = 0.05$) electrodes, Pathos was larger than Logos in Fp1 ($p = 0.01$) and Fp2 ($p = 0.01$), and Ethos was larger than Pathos in Fz ($p = 0.03$). The largest P300 amplitude was for the Ethos strategy. Grand averages for the P300 component at the Fp1 electrode are presented in **Figure 2**.

No significant effects were found in the P300 latencies for Strategy ($p = 0.33$), Electrode ($p = 0.45$), or their interaction ($p = 0.49$).

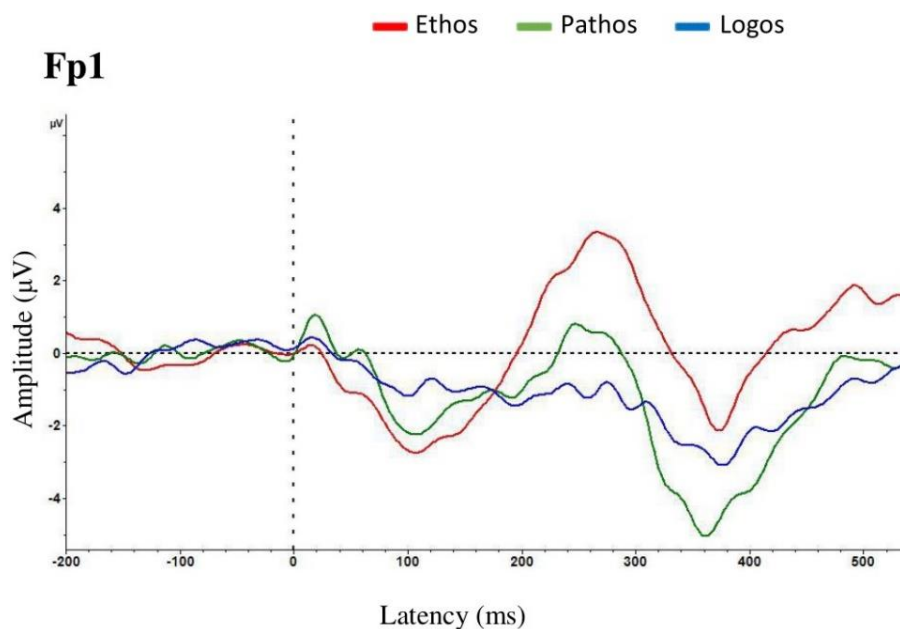


Figure 2. Grand averages of the P300 component at the Fp1 electrode for the three persuasive strategies (Ethos, Pathos, and Logos).

Relationship between SDO and persuasive strategies and ERP parameters

To verify our second hypothesis, linear regression analyses were performed. Results revealed that SDO was negatively associated with the perceived persuasiveness of the Pathos strategy ($R^2 = 0.313$, $B = -.034$, $p = 0.001$), whereas no relationship was found between SDO and Ethos ($p = 0.29$) or Logos ($p = 0.24$).

Furthermore, results showed a negative association between SDO and the P300 amplitude in the Pathos strategy for the Fp1 ($R^2 = 0.152$, $B = -.367$, $p = 0.03$), Fp2 ($R^2 = 0.158$, $B = -.404$, $p = 0.03$), and Fz ($R^2 = 0.196$, $B = -.109$, $p = 0.01$) electrodes, but no association was found with the Pz ($R^2 = 0.011$, $B = .048$, $p = 0.59$). In addition, SDO was positively related to the P300 latency in the Pathos strategy for the Fp1 ($R^2 = 0.144$, $B = 3.98$, $p = 0.03$) and Fp2 ($R^2 = 0.191$, $B = 4.55$, $p = 0.01$) electrodes, but it was not related to the Fz ($R^2 = 0.064$, $B = 2.51$, $p = 0.18$) or Pz ($R^2 = 0.021$, $B = -1.30$, $p = 0.45$). Lastly, no significant relationship was found between SDO and the amplitude or latency of the P300 for the Ethos or Logos strategies in any of the electrodes (all $p > 0.1$).

Discussion

The objectives of this study were, first, to examine which persuasive strategy (i.e., Ethos, Pathos, and Logos) seems more convincing to young people on a nutrition-related topic that is currently an object of social debate and explore the processing of these messages through ERPs. The second objective was to examine the predictive role of a personality trait that is relevant for social influence (SDO) in the processing of persuasive messages. To accomplish these aims, thirty young participants engaged in a computer task where they read messages about the benefits of limiting meat consumption. After each message, there was a question asking how convincing they thought the message was. Simultaneously, an EEG recording allowed us to measure the amplitude and latency of the P300 component. Participants also filled out the SDO scale.

Overall, we did not find statistically significant differences in the sample's assessment of the persuasiveness of the strategies. Although with a marginal significance in this study, the Ethos strategy (the one that relies on the authority of the source) had a higher score on the self-reported assessment, whereas Logos (the one that appeals to the rationality of the argument)

showed the longest RT on the task responses. It is worth noting that we found statistical significance confirming the assessment of the Ethos strategy as the most persuasive when studied in a larger sample of participants ($n = 310$) with different age groups, genders, and educational levels (Rodríguez-Hernández et al., unpublished data).

Regarding the electrophysiological results, the P300 amplitude was larger in the Ethos strategy than in the Logos strategy. No other significant effects of the strategy were observed. These results for the strategy's effect, where the P300 amplitude was larger in the Ethos strategy than in the Logos strategy and marginally larger in Ethos than in Pathos, partly support our first hypothesis. The Ethos strategy contained messages such as "*According to the WHO (World Health Organization), red meat is probably carcinogenic*". The appeal to the credibility and expertise of the source is a peripheral cue that distracts attention from the message's content and makes it seem more persuasive (Johnson et al., 2005; Petty and Cacioppo, 1986). The source's expertise makes the audience believe it should be trustworthy. This result suggests that most participants transited the peripheral route when processing the information. Some possible reasons would be that they had low involvement or were unmotivated by the topic, and so they relied on simple cues, as mentioned above, and/or the historical moment we were living through might have affected their responses. This study started in the first quarter of 2021, a period when people were saturated with health communications about the COVID-19 pandemic, and it was compulsory to obey the authorities. In any case, this result confirms the importance of transmitting messages framed in the expertise of the source.

Personal involvement (or personal relevance) has been considered a determinant of the information processing route (Petty et al., 1981). Under conditions of high personal relevance, people tend to be more influenced by the quality of the argument; however, under low relevance, people become more influenced by simple cues in the persuasion context (Petty and Cacioppo, 1986). Increasing personal involvement and people's engagement by presenting

an argument causes an increase in their processing and thinking about the issue. Although peripheral cues are effective in persuading individuals, the attitudes formed through high elaboration processing are better predictors of subsequent behavior than low elaboration processing caused by low motivation (Petty and Cacioppo, 1986; Cancela et al., 2021). In any case, the Ethos strategy could be an effective persuasive strategy.

As for the relationship between social dominance and the assessment of the persuasive strategies and the ERPs, our results confirmed a negative association. Higher SDO scores were related to a lower P300 amplitude and assessment of the Pathos strategy; that is, higher social dominance was related to a lower endorsement of messages framed with the intention to appeal to emotions or empathy. These results do not support our second hypothesis regarding the relationship between SDO and the Ethos strategy, but they clearly indicate the important role of the social dominance orientation in processing persuasive communications. Social dominance is an attitudinal orientation toward intergroup relations (Pratto et al., 1994) where an individual prefers hierarchical and unequal organizations. The SDO has been related to different social constructs, such as nationality, ethnicity, religion, and gender (Pratto et al., 2006), and it has also been related to environmentalism (Milfont et al., 2018) and human-nature relations. In this latter context, it is worth noting that, in order to contribute to solving environmental problems, individuals must have pro-environmental behaviors. Several studies have identified a negative association between SDO and the attempt to develop pro-environmental actions in society (Pratto et al., 1994), perhaps due to the belief in human dominance over nature (Kilbourne, 2006; Milfont et al., 2018). In line with this, higher SDO has also been associated with the belief that animals are inferior to humans (Dhont et al., 2014) and with more meat consumption (Allen et al., 2000). According to Allen et al. (2000), the consumption of meat has a symbolism related to human values of hierarchical domination,

which might contribute to explaining the negative association between SDO and the Pathos strategy found in our results.

The persuasive strategy of Pathos is mostly used to arouse emotions and appeal to the empathy of the audience (Stucki and Sager, 2018); however, SDO has been negatively related to empathy (Pratto et al., 1994; 2006). Empathy is an affective reaction in response to another individual's emotional state (Cikara et al., 2014), but there is also an emotional state of counter-empathetic responses, especially in out-group members (Hudson et al., 2019). In the Pathos strategy, there were messages such as "*It is very unfortunate that even today 13% of pigs are conscious during the slaughter process*". The aim of some of the messages framed according to this strategy was precisely to appeal to the empathy of the participants and make them feel involved. Furthermore, the Pathos strategy was effective in producing a longer P300 latency in individuals with higher SDO scores, which suggests that they took more time to evaluate the messages. A longer latency could also suggest greater scrutiny of the messages. However, individuals who scored high on SDO had a smaller P300 amplitude during the Pathos strategy, which suggests that the Pathos messages induced a lower workload. It could also indicate a defensive reaction of attentional avoidance due to opposition, as in the way people react to threatening information (Kessels et al., 2014). In any case, it is worth exploring further. In addition, the messages framed in the Pathos strategy were capable of reproducing (due to being considered less convincing) the previously identified attitudes in individuals with high SDO, such as the negative endorsement of social topics that promote greater equality, pro-environmental actions, and empathy, among others.

Our study is an attempt to examine the neurophysiological response to the processing of persuasive messages through ERPs. The neurophysiology of persuasion is a complex process to interpret but a promising research path to advance the understanding of the underlying elements of persuasion. Future studies in this line would allow us to know the relevance of our

results and combine them with other ways to present health messages, such as images. In addition, future research should expand the sociodemographic characteristics of the sample, the gender component, and the number of participants. We studied a reduced sample as a pilot ERP proposal, which could be the reason the assessment of the persuasive strategies did not reach statistical significance. In addition, participants were university students with high educational levels, which surely affected their susceptibility to being persuaded.

In conclusion, the results of this study suggest that the Ethos strategy was marginally perceived as the most convincing for health-related messages in young people with the characteristics of our sample. Moreover, Ethos was the most effective strategy for attracting attentional resources, observed in the P300 amplitude, which is related to a more controlled attention processing. Finally, and interestingly, we found that social dominance affects the processing of persuasive health messages, especially those that appeal to emotions and empathy (i.e., from the Pathos strategy). Lastly, it would be relevant to further examine this trait and explore other psychological orientations and compare the participants' pre- and post- attitudes toward relevant social topics.

CHAPTER V: Heart rate variability response to persuasive health messages: the importance of perceived stress and neuroticism³



³ Rodriguez-Hernandez, V., Batallas, D., Hidalgo, V., and Salvador, A. HRV response to persuasive health messages: the importance of perceived stress and neuroticism. [Manuscript under revision for publication].

Introduction

Persuasion is employed in health communications in an attempt to produce a change in a person's attitudes or behavior. Health communications are a major topic in both public and tailored health interventions. Public health campaigns are addressed to large audiences, usually to inform them about health risks and promote more sustainable lifestyles. Tailoring does the same thing, but in an effort to meet an individual's unique needs. Moreover, tailoring is used to enhance motivation to process information (Rimer and Kreuter, 2006), increasing the possibility that people will follow the recommended action. Persuasive efficacy is a central focus of interest in public health, but also in other enterprises such as social psychology, economics, politics, or commerce, among others, all of which use persuasion to influence a social norm or an individual's behavior. The most recent example is the use of persuasion during the COVID-19 pandemic, when health guidance (e.g., the use of masks or vaccinations) was abundant and official entities were aware of the difficulty of finding an effective strategy to deliver the communications (Svoboda, 2022).

The Elaboration Likelihood Model (ELM) theory (Petty and Cacioppo, 1986) explains two routes for processing persuasive information: central and peripheral. The central processing route involves systematic and analytical processing, whereas the peripheral route involves a heuristic, with no message scrutiny processing. Most of the variables that affect the type of route chosen are related to the source, the context, or the receiver, such as the source's expertise, the quality of the argument, and dispositional or situational factors of the person who receives the message. In this line, the efficacy of a persuasive message can be enhanced if the framing of the message (i.e., the strategy) matches the person's situational or dispositional state, such as their perceived stress or some personality characteristics. This matching/adjustment would enhance processing fluency (Lee and Aaker, 2004), message recognition (Lee and

Labroo, 2004; Mayer and Tormala, 2010), and involvement (Petty and Cacioppo, 1986), all of which would increase persuasive efficacy.

Literature on persuasion in health communications has focused on individual differences in age (McKay-Nesbit et al., 2011), affective and cognitive orientations (Haddock et al., 2008; Ryffel and Wirth, 2016), or susceptibility to persuasion (Spelt et al., 2022a). However, to our knowledge, the association between neuroticism and health communication processing has not been explored. Neuroticism is known to be related to psychological distress and negative affect. Individuals high in neuroticism are less capable of mitigating problematic events such as threats or frustration (Lahey, 2009). Previous research has found the neuroticism trait to be more susceptible to some of Cialdini's six persuasive principles, such as 'consensus' (Oyibo et al., 2017) and 'scarcity' (Alkis and Temizel, 2015). In addition, 'avoidant' framed messages have been found to be more appealing to people high in neuroticism (Blagov, 2021), although the evidence is scarce. Moreover, neuroticism has been suggested as the primary driver of perceived stress (Conard and Matthews, 2008).

Perceived stress is a subjective measure of the degree to which situations in one's life are considered stressful (Cohen et al., 1983). People with high levels of stress have difficulties processing threatening health information (Millar, 2005), and higher perceived stress is related to poorer recognition performance (Wiemers et al., 2019). For these reasons, investigating whether neuroticism and perceived stress predict the perceived persuasiveness of health communications would add relevant information to the literature on persuasive efficacy.

In this context, it is worth noting that the psychophysiology of persuasion is an emerging topic of research that is contributing insight into the processing and effectiveness of persuasion (Ewais, 2018; Spelt et al., 2022a). Traditionally, the efficacy of persuasive communication has been assessed through self-report measures, which have temporal

limitations (Falk et al., 2010) that make it difficult to accurately measure cognitive processing along with the persuasive attempt (Nisbett and Wilson, 1977). Physiological measures do not have this temporal limitation, and they can be applied simultaneously with the persuasive attempt.

In recent decades, the study of heart rate variability (HRV) has gained interest because of its power to clarify the relationship between different psychological and physiological processes (Berntson et al., 1997). HRV is the temporal variation between consecutive heartbeats and the result of the balance between sympathetic and parasympathetic mediators of the heart rate (HR) (Karim et al., 2011). Given that it reflects the mechanism of integration between the central nervous system (CNS) and the autonomic nervous system (ANS), it is considered a relevant index of self-regulation (Thayer and Lane, 2000). Previous research has reported the predictive value of HRV in aspects such as attentional control and emotional regulation. Higher levels of HRV are considered beneficial in mitigating problematic situations (Ode et al., 2010), whereas low HRV has been associated with impaired regulatory mechanisms, which in turn reduce the ability to cope with stressors. In sum, HRV is used as an indicator of psychological stress (Kim et al., 2017). Integrating trait and state characteristics with physiological reactivity would allow us to better predict the processing that underlies persuasion.

In this study, we aimed to evaluate the perceived persuasiveness of health messages related to limiting meat consumption, considering the presentation strategy: Ethos, Pathos, and Logos. Ethos focuses on factors associated with the source, such as authority or expertise on the subject matter. Pathos is a frame that appeals to the emotions and empathy of the audience. Lastly, Logos focuses on the logic of the argument. For this purpose, we explored the perceived persuasiveness through self-reports (i.e., how convincing each presented message was considered) of the three persuasive strategies and the physiological response captured by the

HRV recording. In addition, we aimed to study how neuroticism and perceived stress moderated the relationship between physiological reactivity and self-reports.

Regarding these aims, we expected the Ethos strategy to be perceived as more persuasive than the Pathos or Logos strategies, in line with previous results obtained in our laboratory with another sample (Rodríguez-Hernández et al., unpublished data), and elicit higher reactivity (Spelt et al., 2019). Regarding neuroticism and perceived stress, we hypothesized they would moderate the direction and magnitude of the relationship between the persuasiveness and the cardiovascular response, such that the higher the neuroticism and/or perceived stress, the greater the perception of persuasiveness (for the Ethos and Pathos strategies). This hypothesis is based on previous literature that has shown a negative correlation between neuroticism (Johansson and Ölund, 2017) and stress (Zerna et al., 2023) and the level of the need for cognition. Individuals with a low need for cognition focus more on peripheral cues such as the credibility of the source. Therefore, we expected that those who were high in neuroticism and/or perceived stress would find Ethos more persuasive.

Materials and Methods

Participants and procedure

The total sample in this study was composed of 58 volunteers (46 women, 12 men; mean age: 21.74; SD= 3.22). Participants were recruited from different bachelor's degree programs at the University of Valencia. The recruitment phase involved a personal visit to different classrooms where information was provided about the type of data collected, the duration of the session, and the compensation (i.e., USB memory) they would receive if they participated. The study consisted of one 2-h experimental session in the Laboratory of Social Cognitive Neuroscience at the University of Valencia.

Upon arrival at the laboratory, participants received verbal and written information about the study and gave their written informed consent. After that, there was a preparation period when the experimenter cleaned the area where the electrodes would be placed and attached the ECG device while the participant was sitting in front of a computer. Then, the *persuasion task* was presented. After that, participants spent around thirty minutes answering a series of questionnaires, such as the Perceived Stress Scale (PSS) and the Neuroticism subscale derived from the NEO Five-Factor Inventory (NEO-FFI), among others that are not included in this study. All the questionnaires were completed through the online survey tool LimeSurvey. The persuasive task procedure was administered using E-Prime 2.0 (Psychology Software Tools, Pittsburgh, PA).

The exclusion criteria were history of alcohol or drug abuse; smoking more than 10 cigarettes a day; the presence of a neurological or psychiatric disorder; pregnancy; taking any medication that altered the nervous system; being a vegetarian; and lastly, having had a fever, cough, and/or respiratory difficulties in the past 14 days (main Covid-19 symptoms). The study was approved by the Ethical Committee of the University of Valencia (register code: 1241475).

Measurements

Self-report measures

Neuroticism

We used the Spanish version (Costa and McCrae, 1999) of the NEO Five-Factor Inventory (NEO-FFI; Costa and McCrae, 1992) to measure the neuroticism trait. This questionnaire consists of 60 items that measure the Big Five personality traits, with 12 items for each (neuroticism, conscientiousness, extraversion, openness, and agreeableness). On a 5-point Likert scale, participants respond from 0 (*Totally disagree*) to 4 (*Totally agree*). The Neuroticism subscale has a Cronbach's $\alpha = .83$.

Perceived Stress Scale (PSS)

For this research, we used the validated Spanish version (Remor, 2006) of the PSS (Cohen et al., 1983; Cohen and Williamson, 1988). Participants respond on a 5-point Likert scale from 0 (*Never*) to 4 (*Very often*) to the PSS-4 (Items 2, 6, 7, and 14 from the original PSS-14). Items 6 and 7 were reverse-scored. Higher scores indicate higher levels of perceived psychological stress during the past month. The Cronbach's α for the scale was .74.

Persuasion task

The study task consisted of six blocks: one baseline neutral clip lasting 1-min, three blocks of messages (each based on one of the persuasive strategies: Ethos, Pathos, and Logos), and a 1-min acoustic tone to elicit a startle physiological response. For each block, 20 messages promoting limited meat consumption were presented in the participants' native language (Spanish). Some examples of the messages presented are: '*According to WHO (World Health Organization), red meat is probably carcinogenic*' (Ethos); '*The consumption of meat condemns those animals to a live a life full of suffering*' (Pathos); and '*Diets with a reduced or null meat consumption are associated with a 20-26% reduction in heart diseases*' (Logos). Each message was followed by the question: 'How convincing is this message?' with a range from 0 (*Nothing convincing*) to 4 (*Very convincing*). Between the messages/questions, there was a 1-s fixation point, and each block was separated by a 1-min neutral river clip. The block and message order were counterbalanced by E-Prime. The mean duration of the entire task was 16.5 minutes.

Cardiovascular data

Electrocardiography (ECG) recordings were collected in a sitting position during the entire task. Three Kendall H124SG disposable electrodes and three Lead110 electrodes with clips measured ECG, one on the right side below the collarbone, one on the left side below the collarbone as a ground electrode, and one on the left side under the ribs. The BIOPAC ECG100C amplifier (Biopac Systems, Inc.) was used for data acquisition, with a band-pass filter of 35 Hz and 1.0 Hz sampling at 1000 Hz. Moreover, a 50 Hz notch filter was applied to reduce the noise from interfering signals.

The total ECG measure was divided into baseline, three separate message blocks, and the startle tone, in a total of 5 blocks. Each block was manually marked during the recording using the data acquisition software *Acknowledge*. From the ECG signal, HRV was calculated using the root mean square of successive differences (RMSSD). To analyze HRV and apply artifact corrections, Kubios software (Biomedical Signal Analysis Group, University of Kuopio, Finland) was used. A medium-level automatic artifact correction was applied. The HRV was calculated from a 1-minute recording from each of the 5 blocks of the task. In the 3 blocks of messages, the central minute was assessed. In healthy individuals, RMSSD can be recorded in ultra-short terms (Shaffer and Ginsberg, 2017), and it has been found to correlate with the standard 5-minute ECG (Nussinovitch et al., 2011).

Statistical analyses

An a priori power analysis for F tests with a medium-to-large effect size (Cohen, 1988) of $f^2=0.25$ and $\alpha=0.05$ with one group, three predictors, and .80 power in G*power (Faul et al., 2007) indicated that a sample size of 48 participants should be sufficient for the study's aims.

To evaluate the perceived persuasiveness of the messages, a repeated-measures ANOVA was performed with Strategy (Ethos, Pathos, Logos) as a within-subject variable. To explore

the differences in RMSSD between the experimental blocks, rm-ANOVAs were conducted with the Block as a within-subject factor (Baseline, Ethos, Pathos, Logos, Startle tone). The cardiac data were log-transformed to bring them closer to normal distribution.

Finally, to explore the possible moderation of PSS and Neuroticism in the relationship between the persuasive strategies and cardiac reactivity, several moderation analyses were carried out with HRV (RMSSD parameter) as the independent variable, each persuasive strategy separately as the dependent variable, and PSS and Neuroticism separately as moderating variables. Moderated regression analysis and bootstrapped bias-corrected 95% confidence intervals of the interaction effect were computed using Hayes' PROCESS macro model number 1 (Hayes, 2017) with 5000 bootstrap iterations.

All statistical analyses were performed with SPSS 26.0 (IBM Corporation, Armonk, NY, USA). *Post-hoc* comparisons were carried out using Bonferroni adjustments for the *p*-values, and the level of significance was set at $p < .05$.

Results

Self-report data

For the self-report data, two participants were eliminated due to technical problems; therefore, 56 participants completed the PSS and NEO-FFI. For the rest of the measures, the sample contained 58 participants. For Neuroticism, the mean score was 22.5 (SD = 7.90), and for PSS-4, the mean score was 6.09 (SD = 2.70). Pearson's bivariate correlation revealed a positive relationship between Neuroticism and PSS ($r = .530, p = <.001$).

Persuasiveness of the strategies

Results revealed a significant effect of the Strategy factor ($F(2, 114) = 15.04, p < .001, n_p^2 = .209$). Thus, the Ethos strategy had a significantly higher score on the ‘how convincing’ question ($M = 3.0, SD = .46$), compared to Pathos and Logos (both $p < .001$), whereas there was no difference between Pathos ($M = 2.7, SD = .66$) and Logos ($M = 2.6, SD = .62$) ($p = 0.95$).

Cardiovascular data

Regarding the RMSSD, results indicated a significant difference between blocks ($F(4, 228) = 22.37, p < .001, n_p^2 = .282$). The RMSSD was significantly different and higher during the baseline and startle tone blocks, compared to each of the three blocks of messages (all $p < .001$), whereas there was no difference between baseline and the startle tone ($p > 0.99$). No differences in HRV were found between the three blocks of persuasive messages (all $p > 0.99$).

Results are presented in **Figure 1**.

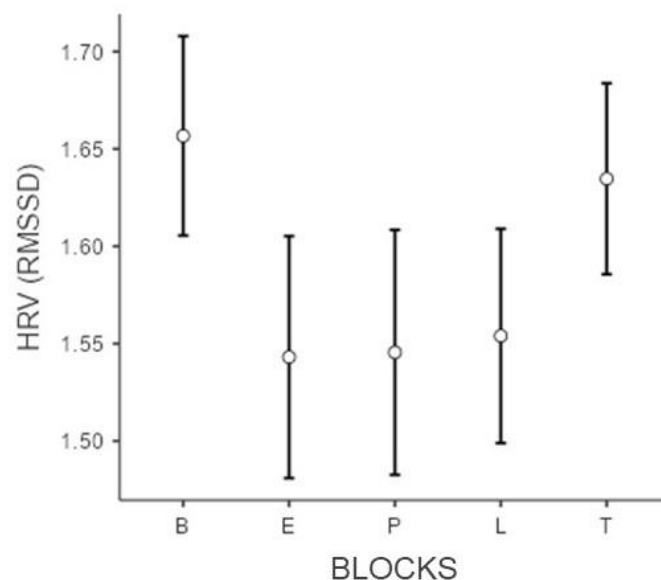


Figure 1. Means and standard errors of HRV (RMSSD) during the five blocks.

Moderation analysis: the role of Neuroticism

No moderation effect of Neuroticism was found in the relationship between RMSSD and the Ethos ($p = 0.896$), Pathos ($p = 0.362$), or Logos ($p = 0.212$) strategies. Therefore, Neuroticism did not moderate the relationship between HRV reactivity and any of the three persuasive strategies.

Moderation analysis: the role of PSS

For the Logos strategy, the moderation analysis revealed a significant interaction between PSS and HRV (RMSSD) ($p = 0.015$). When participants were high in PSS, a significant negative relationship was observed between RMSSD and the perceived persuasiveness of the Logos strategy ($B = -1.435, p = 0.034$), but this result was not significant at low ($p = 0.385$) or medium ($p = 0.409$) levels of PSS. For the Pathos strategy, the same interaction between PSS and RMSSD was marginally significant ($p = 0.073$). When subjects were high in PSS, there was a negative relationship between RMSSD and the Pathos assessment ($B = -1.349, p = 0.017$); however, this was not significant when individuals scored low ($p = 0.801$) or average ($p = 0.102$) on PSS. The interaction was not statistically significant for the Ethos strategy ($p = 0.600$). Results are presented in **Table 1**.

Table 1. Conditional effect of HRV on the persuasive strategies for different values of PSS

Moderator variable (W): PSS

Independent variable (X): RMSSD_L

Dependent variable (Y): Logos strategy

 ΔR^2 interaction $F = 6.301$ $p = .015$
 $= .107$

PSS	Effect	SE	<i>t</i>	<i>p</i>	LLCI	ULCI
4,000	.3905	.4462	.8753	.3854	-.5048	1.285
6,000	-.3399	.4086	-.8320	.4092	-1.159	.4800
9,000	-1.435	.6606	-2.173	.0343	-2.761	-.1101

Moderator variable (W): PSS

Independent variable (X): RMSSD_P

Dependent variable (Y): Pathos strategy

 ΔR^2 interaction $F = 3.335$ $p = .074$
 $= .057$

PSS	Effect	SE	<i>t</i>	<i>p</i>	LLCI	ULCI
4,000	-.1142	.4525	-.2523	.8018	-1.022	.7939
6,000	-.6081	.3662	-1.660	.1029	-1.343	.1268
9,000	-1.349	.5500	-2.452	.0176	-2.452	-.2454

Moderator variable (W): PSS

Independent variable (X): RMSSD_E

Dependent variable (Y): Ethos strategy

 ΔR^2 interaction $F = .277$ $p = .601$
 $= .005$

PSS	Effect	SE	<i>t</i>	<i>p</i>	LLCI	ULCI
4,000	-.0078	.3051	-.0255	.9797	-.6200	.6044
6,000	-.1098	.2804	-.3917	.6969	-.6726	.4529
9,000	-.2629	.4448	-.5911	.5570	-1.155	.6297

Discussion

Currently, it is more common to tailor health information in order to match it to the characteristics of each person and, thus, have a stronger effect on the behavioral outcome of interest (Kreuter et al., 2020). For this reason, the optimization of the use of persuasion in health communication gains relevance. Studying the psychophysiological reactions and individual characteristics that underlie the processing of persuasion increases the understanding and efficacy of tailored interventions. In this line, the present study aimed to explore the role of cardiovascular reactivity as a physiological measure, perceived stress as a situational factor, and Neuroticism as a psychological trait in the processing of health communications framed in three different persuasive strategies in young individuals. To accomplish this, participants completed a task with messages about limiting meat consumption framed in three different persuasive strategies. Simultaneously, an ECG device was recording their cardiovascular activity. These data were related to participants' perceived stress and neuroticism trait in a within-subject design.

Results provided partial support for our hypotheses because the Ethos strategy was assessed as the most convincing. Moreover, the cardiovascular reactivity was higher during the exposure to the persuasive messages than during the baseline or startle tone blocks, although there was no distinction between the three different strategies. The HRV parameter did not predict the outcome of the assessment of the task. However, PSS moderated the interaction between cardiac reactivity and the messages' assessment, particularly when the Logos strategy was used.

According to the ELM, there are peripheral cues in a persuasive attempt that may affect a person's attitudes when the elaboration of the communication is low or absent (Petty and Cacioppo, 1986). Some of the most common cues are related to the source, such as its

attractiveness or expertise, and the emotional content of the messages (Petty and Briñol, 2015). Our results suggest that participants mostly transited a peripheral processing route in which the source expertise cue prevailed in their opinion about the persuasiveness of the different strategies, given that the Ethos strategy was considered significantly more convincing than Pathos or Logos. The Ethos strategy highlights the source's expertise and authority, which makes it seem more reliable and convincing. Moreover, the assessment of the persuasive strategies did not coincide with the physiological response because no differences in HRV arousal between the strategies were found.

At the physiological level, the results show a different HRV reactivity between baseline and exposure to the messages. HRV decreased during the presentation of the messages, suggesting that there was higher sympathetic arousal during the persuasive health communication. HRV is an index of vagal activity and a marker of emotion and stress regulation. It decreases in stressful situations and increases with rest (Karim et al., 2011). The results suggest that the processing of the messages was to some extent physiologically perceived as stressful. This result is in line with Spelt et al. (2022a; 2022b), who found more physiological arousal when processing persuasive messages than in a resting state. In our study, the messages presented were mostly informative, but somehow alarming, due to the negative consequences for health and the environment if meat consumption behaviors do not change, which may be the reason for the elicited arousal. Regarding the startle tone block, the intended aim was not achieved because it did not elicit a startle response. On the contrary, during the tone, cardiac reactivity decreased, acting as a recuperation phase, which suggests that the tone was not alarming enough.

We found that PSS moderated the interaction between HRV and the assessment of the Logos strategy, and it marginally moderated the relationship between HRV and the Pathos strategy. These results revealed that, in individuals with high levels of PSS, a low HRV was

associated with a better assessment of the Logos strategy. This finding suggests that the situational factor of subjective stress is related to cardiovascular reactivity, which in turn is related to the perceived persuasiveness of health communications.

One possible reason that high levels of PSS moderated the relationship between HRV and the Logos strategy can be found in the distinction made by Millar and Millar (1993) between health communications about disease detection and those about health promotion behaviors. Health communications about disease detection are designed to detect physical pathologies (e.g., blood pressure check), whereas communications about health promotion have the purpose of promoting behaviors that directly improve health (e.g., limiting meat consumption). Stress affects the processing of information; in particular, it makes it more difficult to process threatening health information (Millar, 2005), as in disease detection approaches. The detection of a disease requires the person to cope with a health problem, which produces more anxiety and, consequently, disrupts the processing of the given information. In contrast, health promotion communications inform about ways to improve health, which probably facilitates information processing. Regarding our result, in individuals with high levels of PSS, their HRV was negatively related to the Logos message assessment. The messages in the Logos block were assessed as more convincing because this type of strategy appeals mostly to logic and has a more informative and promotional tone, which may have led to greater agreement and processing fluency. This result goes beyond Millar's (2005) results, which showed that participants with high levels of perceived stress were not persuaded by messages about promotion behaviors and agreed even less with messages about disease detection.

Neuroticism did not moderate the relationship between cardiovascular activity and the persuasiveness of the messages; nor was it associated independently with HRV or persuasion. This result is contrary to previous research (Oyibo and Vassileva, 2019) that found individuals

high in neuroticism to be more susceptible to social influences. However, neuroticism positively correlated with perceived stress, which indicates that behind the high PSS that moderates the association between HRV and Logos, there could be a characteristic similar to neuroticism affecting the way the communication is processed.

In conclusion, our findings have important implications because people who experience high levels of perceived stress make up a large and important target group in the health field. For this reason, and according to our results, the construction of health messages for individuals with high levels of perceived stress should appeal to logic and have a more informative approach, rather than using fear or disadvantage frames that increase anxiety (Worsdale and Liu, 2023). This is relevant for public health communications and medical adherence to treatments. As a limitation, and for future exploration, this research should address the gender and age of the population. In addition, our results replicate previous studies where the physiological arousal is different during persuasive messages compared to a baseline or resting state, a topic that should be studied further. To our knowledge, this is the first study to investigate the interaction between PSS, Neuroticism, and HRV reactivity in relation to the perceived persuasiveness of health messages framed in three different persuasive strategies.

CHAPTER VI: Need for Cognition role in EEG resting state and the Recall and Recognition of Persuasive Messages



Introduction

Cognition is intrinsic to human behavior, and many research studies have been done on EEG oscillations to find out brain patterns associated with it (e.g., memory performance: Brokaw et al., 2016; Decay, 2005; Jacobs et al., 2006; Klimesch et al., 2000; Klimesch, 1996). Understanding individual characteristics in brain oscillations is relevant as it helps to predict cognitive performance. Contradictory results have arisen from research that aims to decode personality traits from resting state EEG (rsEEG) (Balconi et al., 2016; Korjus et al., 2015; Kuper et al., 2019). However, to our knowledge, no study has related rsEEG to the individual tendency for the *need for cognition* (NFC). This is a stable tendency to engage in and enjoy effortful cognitive activities (Cacioppo et al., 1996).

Several studies have evidenced that individuals high in NFC are more likely to engage in greater information processing, scrutiny, and thoughtful judgments (Cacioppo et al., 1996). In this line, Mussel et al. (2016) found evidence that supports the hypothesis that EEG theta oscillation reflects cognitive processes related to mental effort that are part of the personality trait of epistemic motivation, which is a stable individual characteristic very similar to the NFC component. Moreover, Mussel et al. (2016) found that NFC predicts a more positive slope of theta power in response to cognitive demands.

In addition to general cognitive performance, brain oscillations have been widely studied in relation to memory performance. Most of the literature relates theta and alpha power bands with memory, in particular, there is a hypothesis that relates the alpha band with semantic memory and theta band with episodic memory (Decay, 2005; Herweg et al., 2020; Klimesch et al., 2006; Klimesch et al., 1994). Episodic memory refers to the ability to recall past events (Ranganath, 2022). The ability to recall or accurately recognize communications previously seen or heard is part of the episodic memory. In this line, some studies have found that

individuals high in NFC are better at recall, and that is due to their tendency to engage in more extensive thinking (Lassiter et al., 1991). As both, brain oscillations and the NFC, have supporting evidence about their ability to predict cognitive achievements, we choose to investigate both factors concerning memory on persuasive information.

Persuasion is a form of social influence that intend to change another's persons beliefs, attitudes, or behavior by providing information. In the persuasion literature, memory has been studied separately from attitude change. According to Cacioppo et al. (2018), the thoughts people generate in response to persuasive messages are more important determinants of attitude change than learning and memory per se. However, as Braun-Latour and Zaltman (2006) stated, persuasion is more likely to occur when the information becomes internalized, which is possible through a reconstructive memory process. This means contrasting their prior beliefs and the ones following the persuasive attempt, resulting in a new belief or attitude from the new information.

Even though the intact retrieval of advertising or persuasive communication does not guarantee an attitude change, an enhanced recognition of information suggests a deeper processing of information (Haddock et al., 2008). Besides, regarding persuasive health messages, it becomes even more relevant that the recipient encodes, stores, and eventually retrieves the communication when necessary to make an important decision or perform a healthy behavior (Clayton, 2022; Lang, 2006).

In addition, NFC is one of the main individual characteristics studied in the persuasion literature (Appel and Maleckar, 2012; Aquino et al., 2020; Briñol et al., 2007; Haddock et al., 2008; McKay-Nesbitt et al., 2011). As part of the Elaboration Likelihood Model (ELM) proposed by Petty and Cacioppo (1986), the NFC is an individual factor that influences message processing and in consequence, persuasion. The ELM states that there are two distinct

routes to persuasion: the central route, which is transited by a thoughtful person who scrutinizes the arguments of a persuasive attempt; and the peripheral route, which is transited by a person who relies on simple cues (e.g., an attractive source) to process the information (Petty and Cacioppo, 1986). In this line, individuals high in NFC tend to consider the quality of arguments and transit the central route, whereas individuals low in NFC are more influenced by peripheral cues (Cacioppo et al., 1996).

In sum, we have the following objectives: (1) to explore how the spectral power of low-frequency bands (i.e., delta, theta, and alpha) using EEG recording with eyes-open (EO) and eyes-closed (EC) differs based on the level of NFC, (2) determine if there is a predictive value of the spectral power on the memory performance (free recall, and recognition), on the low and high NFC groups separately, and (3) to explore if there is a difference in which persuasion strategy (i.e., ethos, pathos, or logos) is better recalled and recognized comparing groups (low vs. high NFC).

Following those objectives, we tested three main hypotheses: (1) individual differences in NFC would be reflected differently in the delta and theta rhythms (Masullo et al., 2022; Mussel et al., 2016). (2) Theta power band would positively predict memory performance (Finnigan and Robertson, 2011; Jacobs et al., 2006), in the individuals high in NFC, whereas the alpha power would do it negatively. Lastly, (3) individuals high in NFC would better recall and/or recognize the messages in the Logos strategy. In contrast, the low NFC group would recall and/or recognize better the Ethos or Pathos strategies, because of the peripheral cues (Cacioppo et al., 1996).

Methods

Participants

Fifty-five young adults (43 women, 12 men; mean age: 21.49) participated in this study. The sample was recruited through personal visits to classrooms from different bachelor's degrees at the University of Valencia. In the recruitment talk, we explained the topic of the research, the type of data collected, the duration of the session, and the compensation (i.e., USB memory) they would receive if they participated. Participants were distributed into two groups according to their scores on the NFC scale. Visual binning by equal width intervals divided the sample into high ($n=26$) and low ($n=29$) NFC groups.

The exclusion criteria were as follows: a history of alcohol or drug abuse; smoking more than 10 cigarettes a day; the presence of a neurological or psychiatric disorder; pregnant women; taking any medication that altered the nervous system (Picton et al., 2000); and, lastly, having had a fever, cough, and/or respiratory difficulties in the past 14 days (main Covid-19 symptoms). All the participants were right-handed according to the Edinburgh Handedness Inventory (Oldfield, 1971). The study was performed according to the Declaration of Helsinki and the Ethical Committee of the university (register code: 1241475).

Procedure

The study consisted of one 2-h experimental session in the Laboratory of Social Cognitive Neuroscience at the University of Valencia. Sessions were in the morning between 10h and 12h, based on the participant's availability. Before the study, via email, participants were asked to maintain their sleep routine, avoid intense physical exercise and alcoholic drinks the day before, and not eat, smoke, or drink stimulant beverages such as coffee for at least two hours

before the session. Upon arrival at the laboratory, participants received verbal and written information about the study and signed informed consent.

After the first control, there was a preparation period during which the experimenter measured the participant's head circumference for the EEG cap. Participants were asked to sit in front of a computer quietly with their hands resting on their lap. The EEG register started with two periods of rsEEG with three minutes of eyes-open (EO) and three minutes of eyes-closed (EC). During the EO period, they looked at a fixation cross at the center of the computer screen.

After the resting EEG recording, participants completed a task consisting of reading messages framed with three different persuasive strategies. Immediately after the task, participants completed a free recall task where they had to write as many of the messages they had read during the task, for 5 minutes. Then, thirty minutes after the task, participants carried out a recognition task where 60 messages (30 new and 30 old) were presented, and they had to respond "yes" or "no" to indicate if they have seen the message in the previous task or not. In between the two memory tasks, several questionnaires were completed including the NFC scale. All participants received a USB memory pen in exchange for their participation in the study.

Psychological measure

Need for Cognition (NFC)

We used the validated Spanish version of the Need for Cognition Scale (Falces et al., 2001), based on the version formulated by Cacioppo and Petty (1982). The scale uses 18 items rated on a Likert scale ranging from 1 (*nothing characteristic of me*) to 5 (*very characteristic of me*), with nine items written in a positive sense and nine in a negative sense. Items written in a

negative sense were reverse scored so that higher scores indicate a greater tendency to engage in and enjoy thinking. Cronbach's α was = .84.

Memory assessment

Persuasion task

It consisted of six blocks: one baseline neutral clip lasting 1-min, three blocks of messages (each based on one of the persuasive strategies: Ethos, Pathos, and Logos), and a 1-min acoustic tone to elicit a startle physiological response. For each block, 20 messages promoting limited meat consumption were presented in the participants' native language (Spanish). The block and message order were counterbalanced by E-Prime.

Regarding the persuasive strategies, Ethos focuses on factors associated with the source, such as authority or expertise. Pathos is a frame that appeals to the emotions and empathy of the audience. Lastly, Logos focuses on the logic of the argument.

Free recall

In the free recall task, participants were instructed to recall as many messages as possible from the previous task, for 5 minutes. As mentioned above, the previous task consisted of three blocks of 20 messages (each based on one of the persuasive strategies), for a total of 60 messages. Immediately after this task, the recall task began.

Recognition memory

The recognition memory task consisted of three blocks of messages, as the persuasion task, each block based on one of the persuasive strategies Ethos, Pathos, and Logos. Per block, 20 messages were presented, 10 were new and 10 were old (i.e., repeated from the persuasion task), for a total of 60 messages. Some examples of the messages presented are: '*According to*

WHO (World Health Organization), red meat is probably carcinogenic' (Ethos/ Old) and '*In 2015, WHO (World Health Organization) recommended the consumption of meat exceptionally'* (Ethos/ New). Each message contained the question: *Do you remember to have read this message before?* to assess the recognition accuracy, they had to answer yes or no. Results were calculated as the difference between the percentage of hits (total number of messages correctly recognized) and the percentage of false alarms (total number of messages incorrectly recognized). Messages order per block were randomized by E-Prime.

EEG resting state recording and spectral analysis

EEG was recorded from 25 active electrodes according to the International 10-20 System (Fp1, Fp2, F7, F3, Fz, F4, F8, FC5, FC6, T7, Cz, T8, P7, Pz, P8, O1, Oz, O2, A1, and A2), mounted on an elastic cap (EasyCap, Falk Minow, Munich, Germany), and using the Brain Vision Amplifier System (BrainProducts, Germany), digitized at 500 Hz. The ground electrode was placed on AFz and the reference on FCz. In addition, electrooculogram (EOG) was recorded from three of the electrodes, one placed on the external canthus of each eye (HEOG+, HEOG) and another on the supraorbitally of the right eye (VEOG+) to detect eye movements and remove blinks (Gratton et al., 1983). The electrode-to-skin impedances were lowered using electrolyte gel (SUPER-VISC High Viscosity Electrolyte-Gel) and kept below 5 K Ω throughout the recording. The resting state was recorded for 3-minutes in each of the EO and EC conditions. The recording started with the EO condition with the participant seated in front of a computer looking at a fixation cross, followed by the EC condition after the experimenter instructed the change.

The EEG data was analyzed using the BrainVision Analyzer (BrainProducts, Germany). The preprocessing steps were to re-reference the signals obtained to a common average of the electrodes, to use a 100 Hz high-pass filtering and a 50 Hz notch filter to remove noise, and to

use the ICA method to remove eye-movement artifacts. A formula evaluator was used to group the electrodes in five regions of interest (ROI): frontal (F3, Fz, F4), central (FC5, Cz, FC6), parietal (P7, Pz, P8), occipital (O1, O2), and temporal (T7, T8). Each 3-minute condition was segmented into adjacent intervals of 2s. A power spectral analysis was performed through the Fast Fourier Transform (FFT). The frequency bands analyzed were delta (0.5-4 Hz), theta (4-8 Hz), and alpha (8-12 Hz). Finally, all the signals were log-transformed.

Statistical Analysis

For the first objective (i.e., to explore how the spectral power of low-frequency bands using EEG recording with EO and EC differs depending on the level of NFC) separate mixed-ANOVAs for each power band were employed with *ROI* (frontal, central, parietal, occipital, and temporal) and *Condition* (EO and EC) as the within-subject factors, whereas the *NFC* (low or high) was the between-subject factor.

To examine the second objective (i.e., determine if there is a predictive value of the rsEEG frequency bands on the memory performance (free recall, and recognition) on each NFC group), multiple linear regressions were performed with Frequency band/ROI/Condition as the independent variables and the total outcome on the recall and recognition tasks separately as the dependent variable, independently for the low and high NFC groups. Lastly, to examine the third objective (i.e., to explore if there is a difference in which persuasion strategy (i.e., Ethos, Pathos, or Logos) is better recalled and recognized comparing NFC groups, a one-way ANOVA was executed with the scores on the memory tasks but considering the total of messages recall and recognized per strategy on each NFC groups.

All statistical analyses were performed with SPSS 26.0., and the level of significance was set at $p = 0.05$. *Post-hoc* comparisons were performed using Bonferroni adjustments for the p -values.

Results

Spectral power

For the delta power, a mixed ANOVA revealed no significant effect of Condition * NFC ($F(1, 53) = 1.96, p = .167, \eta^2 = .036$), ROI * NFC ($F(4, 212) = .579, p = .619, \eta^2 = .011$), or Condition * ROI * NFC ($F(4, 212) = .257, p = .830, \eta^2 = .005$) interactions. However, a further exploration of the post-hoc pairwise comparisons revealed an interaction effect of Condition * ROI * NFC, where in the EC condition statistically significant differences were observed between low and high NFC in the frontal ($p = 0.075$), central ($p = 0.029$), and temporal ($p = 0.036$) regions. A higher mean of delta power was found in the low NFC group.

Similarly, for the alpha power, no significant effect of Condition * NFC ($F(1, 53) = 1.58, p = .214, \eta^2 = .029$), ROI * NFC ($F(4, 212) = .283, p = .817, \eta^2 = .005$), or Condition * ROI * NFC ($F(4, 212) = .574, p = .634, \eta^2 = .011$) interactions were found. However, the exploration of the post-hoc pairwise comparison revealed an interaction effect of Condition * ROI * NFC with marginal significant differences in the EO condition between low and high NFC in the frontal ($p = 0.063$) and central ($p = 0.057$) regions. A higher alpha power was found in the high NFC group.

Lastly, no significant effects were found for any of the interactions in the theta power (all $p > 0.200$).

Predictive value of spectral power on memory performance

For the low NFC group, no significant relationship was found between delta, theta, or alpha power bands in any of the EC/EO conditions and the recall or recognition tasks (all $p > 0.10$). As for the high NFC group, the delta power in the EC condition and the frontal ($p = 0.011$), central ($p = 0.044$), and parietal ($p = 0.035$) regions negatively predicted the recognition

performance. However, the alpha power also in the EC condition and the frontal ($p = 0.029$), central ($p = 0.038$), parietal ($p = 0.054$), and occipital ($p = 0.049$) regions positively predicted the recognition performance. Lastly, the theta power in the EO condition and the central ($p = 0.058$) and occipital ($p = 0.010$) regions positively predicted the free recall performance, but not the recognition.

Memory performance: the role of NFC

Free recall

Participants recalled a mean of 5.8 (SD= 1.8) of the messages, from a total of 60 messages that were presented during the persuasion task. Distinguishing by persuasive strategy, Logos was the most recalled (M= 2.25, SD= 1.28) of the strategies, followed by Pathos (M= 2.07, SD= 1.36), and lastly, Ethos (M= 1.51, SD= 1.15). In addition, significant differences between NFC groups were observed in the recalled of Pathos ($p = .005$) and Logos ($p = .047$), but no differences were found in the recalled of Ethos ($p = .775$). The group low in NFC recalled better the messages in the Pathos strategy, whereas the individuals high in NFC recalled better the messages in the Logos strategy (**Figure 1**).

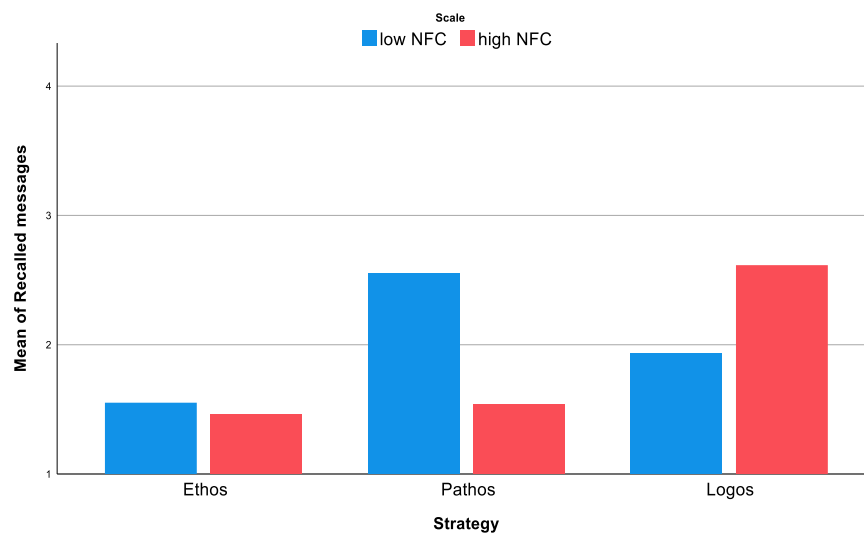


Figure 1. Comparison by group of the mean messages recalled per each strategy.

Recognition

Results revealed that a mean of 37.3 (SD= 7.5) of the messages were accurately recognized. Considering strategy, Pathos was significantly more recognized ($M= 15.4$, $SD= 3.0$) than Ethos ($M= 11.9$, $SD= 2.7$) ($p < .001$) and Logos ($M= 9.9$, $SD= 4.4$) ($p < .001$), whereas the Ethos strategy was better recognized than Logos ($p = .007$). However, no differences between groups were found in the recognition of any of the strategies (all $p > .300$) (**Figure 2**).

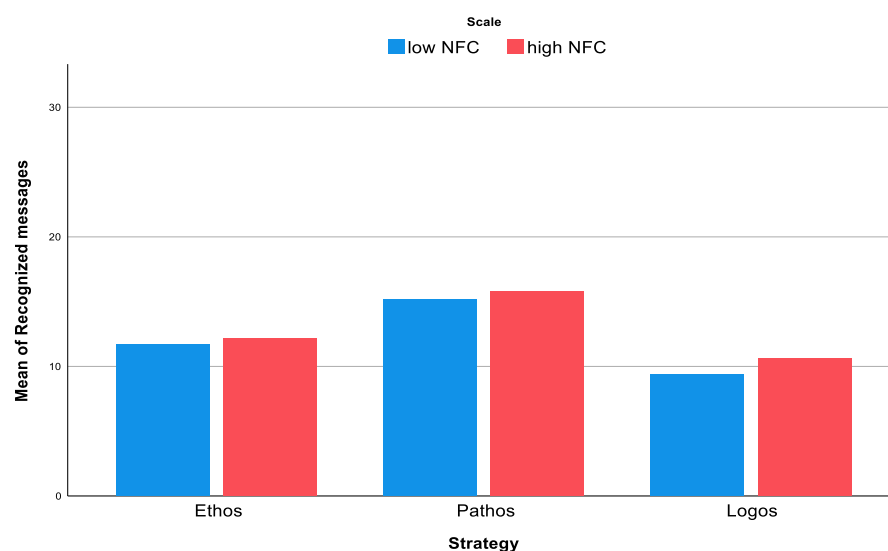


Figure 2. Comparison by group of the mean messages recognized per each strategy.

Discussion

In the present study, we examined, attending to the NFC of individuals, the EEG oscillations in resting state, the predictive value of spectral power on memory performance, and which persuasion strategy is better recalled and recognized.

Regarding our first hypothesis (i.e., delta and theta power activity would be sensible to stable individual differences), results partly support it since the spectral power of delta was sensible to the NFC, but not the theta power. Moreover, and not expected the differences between groups also influenced the alpha power. The main findings were an increased power in delta in individuals low in NFC compared to those high, but a marginally higher alpha power in the high NFC group compared to the low one. No differences were found between groups for the theta spectral power in any of the conditions in the resting state.

There is not much evidence about the role of individual differences in the delta spectral power and no evidence at all about the possible reflection of NFC in delta patterns. Opposite results arise in the literature (Harmony et al., 2013; Liu et al., 2008; Vlahou et al., 2014) about the role of slow wave oscillations in cognition and their implication in healthy or pathological aging. Jann et al. (2010) studied five different resting state networks (RSNs) and their results revealed a positive association between higher cognitive functions and high EEG rhythms (e.g., alpha), while a negative association between the cognitive functions and slow oscillations (e.g., delta) was found. In this line, delta power has been negatively related to cognitive functions such as self-reflection, attention, working memory, and language (Jann et al., 2010). In this way, the higher delta power in the group of low NFC reflects a tendency for lower cognitive functions, whereas the lower delta power in the group of high NFC reflects the domain of higher cognitive functions.

In addition, an increase in delta power and a decrease in alpha power have been related to the construct of the Need for Cognitive Closure (NCC), which is the desire for predictability and unambiguity (Massullo et al., 2022). The NCC characteristic differs from the NFC, being the latter one a tendency to seek new information and to have a higher level of tolerance for dealing with ambiguity and conflict (Fortier and Burkell, 2015; Mussel et al., 2016). Our results point out a novel result that needs to be further studied to have stronger evidence about the possible sensibility of delta power to individual differences in an individual's NFC on frontal, central, and temporal regions.

As for the second hypothesis (i.e., theta power band would positively predict episodic memory performance in the individuals high in NFC, whereas the alpha power would do it negatively), it was partly supported. As expected, resting state theta power positively predicted memory performance (i.e., free recall task), however the spectral power of alpha also predicted memory performance positively but for the recognition task. In addition, results revealed that delta power had a negative association with memory performance, in a way that individuals with lower delta power had a better recognition performance, as is the case of the group high in NFC. In line with the interpretation of the results on the first objective, lower power in delta oscillations benefited the cognitive function of memory.

Regarding theta and alpha power, both have been associated with memory processes (López Zunini et al., 2013). There is evidence about the resting state theta power capacity to predict recall performance, in addition to being sensitive to individual differences and being related to mental effort (Mussel et al., 2016). Moreover, some studies have pointed out theta oscillations as an EEG index of healthy cognitive functions such as memory and attention (Finnigan and Robertson, 2011; Mitchell et al., 2008). As for the alpha power, there is evidence that the resting state alpha band can predict memory performance and response accuracy in working memory tasks (López Zunini et al., 2013), as is the case of the recognition task of this

study. In sum, the results obtained regarding theta and alpha bands are widely supported by the literature. No interactions were found between the EEG resting state and the memory performance for the low NFC group.

Concerning the role of NFC in memory performance distinguished by persuasive strategy, individuals in the low NFC group better recalled the Pathos messages. In contrast, the individuals in the high NFC group better recalled the Logos messages. No differential effects were observed on the recognition performance based on the NFC. This result supports our third hypothesis (i.e., individuals with low NFC would recall and/or recognize better the Ethos or Pathos strategies than the Logos strategy) and the Cacioppo et al. (1996) proposal about the individual differences in people's tendency to enjoy effortful cognitive activity, which was conceptualized in a single factor called the NFC. This trait influences how people make sense of their world, in a way that individuals high in NFC prefer more likely stimuli or tasks that require reasoning, whereas individuals low in NFC rely on cognitive heuristics (e.g., experts, or emotions). In the persuasive task of this study, the strategies of Ethos (authority) and Pathos (emotions) used peripheral cues to deliver the messages. In contrast, the strategy of Logos (logic) used a more logical and reasonable presentation of the health messages. The differences between groups in our young sample were not in the ability to recall but in the type of messages recalled, with the low NFC recalling the weaker messages.

Limitations

Some limitations of the study are regarding the sample, such as the gender factor that could not be studied since it is very unbalanced (43 women, 12 men). In addition, the total of the sample was composed of young university students, which makes it difficult to generalize the results. Concerning the variables studied, there are contradictory results regarding the possibility of decoding personality traits from the rsEEG, however, our results support the notion that delta

and alpha rhythms are sensible to the NFC tendency. This is something that would benefit from a replication of the study.

Conclusions

To conclude, the results obtained in this study suggest that EEG resting state oscillatory patterns are informative and contribute to cognitive performance. In addition, it revealed that the slow-frequency power of delta and alpha differs based on the psychological tendency for NFC and that delta, theta, and alpha power bands predict memory performance differently depending on the NFC. Lastly, the level of NFC trait demonstrates to affect differently the capacity to recall and recognize messages with different persuasive strategies. These results are relevant for the field of health communication and persuasion since EEG is an accessible and objective measure sensible to individual differences and capable of predicting subsequent memory performance.

CHAPTER VII: General Discussion



General Discussion

This Doctoral Thesis aimed to investigate the role of individual characteristics and physiological reactivity to the processing of persuasive health messages. In addition, it aimed to contribute to the understanding of the psycho- and neurophysiology of persuasion. More specifically, we investigated through a self-reported assessment which persuasive strategy (i.e., Ethos, Pathos, and Logos) seems more convincing to a general sample. We also investigated how individual characteristics such as psychological traits (social dominance orientation (SDO) and neuroticism) and states (perceived stress, PSS), affected the processing and perceived persuasiveness of health messages. Moreover, we explored the physiological (heart rate variability, HRV) and neurophysiological (event-related potentials, ERPs) responses to the different persuasive strategies in a sample of young people. Finally, this Thesis explored, based on a psychological tendency (need for cognition, NFC) of individuals, the cerebral activity in resting state (EEG resting state, rsEEG), how rsEEG predicts memory performance, and lastly, which persuasive strategy is better recalled and recognize.

In this chapter will be presented a summary of the main results and a discussion of them. Also, a reflection of the main limitations, strengths, and future directions of this Doctoral Thesis will be stated.

Overview of the Main Findings

The *first objective* of this Thesis was to explore which strategy (i.e., Ethos, Pathos, and Logos) was considered more persuasive through self-report assessment. The topic of the messages was the limit of meat consumption, with an expanded focus on the consequences of it on a health, environmental, and animal abuse level. The task was conducted during the COVID-19

pandemic confinement (the online study) and post-confinement period (the experimental session), a delicate moment due to the saturation of health messages.

The results were consistent in both the young in-person sample and the general sample of the online study, the Ethos strategy (the one that relies on the authority of the source) was considered the most persuasive. In the young in-person sample, the Ethos strategy was followed by Pathos (the one that appeals to emotions and empathy) and lastly, Logos (the one that appeals to the rationality of the argument) in persuasiveness. In the online study the Ethos strategy was followed by Logos and lastly, Pathos. This result suggests that the authority of the source continues to be an element of power in persuasive communication due to the credibility and trust it generates in the audience. The characteristics of the source, such as its attractiveness (Chaiken, 1979) or expertise (Cialdini, 1993; Johnson et al., 2005), have been studied for long a time with consistent results about its persuasive power. However, the historical and sanitary moment these studies were conducted adds relevant insight.

The source's expertise serves as a peripheral cue (Elaboration likelihood model, ELM; Petty and Cacioppo, 1986) or a shortcut to influence attitudes without issue-relevant thinking about the arguments. For example, the source expertise operates through the audience's belief that experts can be trusted (Chaiken, 1987; Johnson et al., 2005). However, the extent to which a peripheral cue affects the persuasion elaboration relies on other factors such as personal motivation (or involvement) and individual tendencies (or personalities), among others, of the receptor. In this line, the *second objective* of the Thesis was to evaluate how psychological traits and states of individuals affect the processing and perceived persuasiveness of the strategies.

In the fourth chapter, SDO was explored, and results revealed a negative association between SDO and the Pathos strategy, in the self-report assessment and the neurophysiological response (i.e., ERP P300 parameter). Higher SDO was related to a lower endorsement of the

messages framed to appeal to emotions or empathy (i.e., the Pathos strategy). Although the hypothesis about the association between the Ethos strategy and SDO due to the preference for hierarchical order was not met, the results are legitimate and important as they reveal the importance of this characteristic in persuasion elaboration. SDO is a psychological orientation toward hierarchical organizations (Pratto et al., 1994). It had been mostly studied concerning political and ideological topics, however, we found it relevant to investigate an individual characteristic in the receptor that may affect the processing of persuasive communication, specifically regarding a topic that impacts health, environment, and animal abuse. The Pathos strategy is mostly used to arouse emotions and appeal to the empathy of the audience (Stucki and Sager, 2018). In contrast, SDO has been negatively related to empathy (Pratto et al., 1994; 2006), which clarifies the low assessment given to the Pathos messages and the low attentional resources provided (through a lower P300 amplitude).

In the fifth chapter, the personality traits of neuroticism and the psychological state of perceived stress were explored as possible moderators of the relationship between the persuasive strategies and cardiac reactivity. Neuroticism is known as a primary driver of perceived stress (Conard and Matthews, 2008), and individuals high on it are less capable of mitigating problematic events such as threats or frustrations (Lahey, 2009). Perceived stress is a subjective measure of the degree to which situations in one's life are considered stressful (Cohen et al., 1983). Results in study 3 revealed no effect of neuroticism, while perceived stress moderated the cardiovascular response to the Logos strategy. In individuals with high levels of perceived stress, a low HRV (greater reactivity) was associated with a better assessment of the Logos strategy.

The Logos strategy appeals to the logic and rationality of the argument, without peripheral cues. As the results of the first objective revealed, it was perceived as the least persuasive strategy for the young sample. However, for the group of youths with higher levels

of PSS, the way the messages were delivered through the Logos strategy seemed more effective. In line with Millar and Millar (1993), health communications can be distinguished into those about disease detection and those about health promotion. High levels of stress and physiological reactivity affect the processing of threatening health information (i.e., disease detection) (Millar, 2005), however, the messages framed in the Logos strategy had a more informative and promotional tone, which led to greater agreement and processing fluency. This result is especially relevant in this Doctoral Thesis, since people with high levels of PSS make up a large and important target group in the health field, so to know which persuasive strategy is more effective to deliver the communication is very pertinent. In addition, it contrasts with the literature that still points out fear appeals as more effective in engaging individuals to follow recommendations (Das et al., 2003).

The *third objective* was to explore the psycho- and neurophysiological responses during persuasion elaboration, through the measures of ERPs and HRV. In the fourth chapter, we evaluate the P300 component's amplitude and latency. Results revealed a statistically significant effect of Strategy, where the P300 amplitude was larger for the Ethos strategy than for Pathos or Logos, specifically in the prefrontal, frontal, and parietal regions. The amplitude index indicates the magnitude of the neural activity (Friedman et al., 2001) and is sensitive to the amount of attentional resources allocated (Polich, 2007). This result supports the assessment of the participants where the Ethos strategy was reported as the most persuasive and, in addition, the strategy with more attentional resources received. As mentioned in the result of the first objective, the authority and expertise of the source continue to be a strong peripheral cue in persuasion. Maybe even more in a historical context such as a global pandemic. These results suggest that in our sample of young students, more attention allocated meant more perceived persuasiveness and vice versa (evidenced also in one of the results of the second objective where the Pathos strategy was assessed as less persuasive and evoke a

lower P300 amplitude). Few research has studied ERPs in the context of persuasion and high-order stimuli that require cognitive processing (Kessels et al., 2011; 2014), however, we conducted this analysis as an exploratory study to add insight into the neuroscience of persuasion.

In the fifth chapter, the HRV was measured as an index of physiological reactivity in response to persuasive health messages. Higher HRV is considered beneficial in mitigating problematic situations (Ode et al., 2010). In contrast, low HRV has been associated with impaired regulatory mechanisms, which in turn reduce the ability to cope with stressors. Results in this study revealed a lower HRV response during the exposure to the messages, regardless of the type of strategy compared to the blocks of baseline and startle tone in the task. This result suggests a higher sympathetic arousal during persuasion, which can be interpreted as the messages being somehow stressful or as a reactance state. According to some studies (Clayton, 2022; Spelt et al., 2022), a reactance response suggests there is a perceived threat to freedom or a misalignment between the person's current behaviors and the persuasive attempt. Considering that meat consumption is a contemporary controversial topic, is plausible that the participants perceived the health messages as a threat.

Another relevant result was a negative association between HRV and the Logos strategy, specifically in the group of individuals with high perceived stress. So, those more stressed (subjectively and physiologically), assessed the messages framed in a more logical and informative tone as more persuasive. As discussed in the second objective, some health messages can be more threatening while others are more promotive, and even though the messages of the task seem to be perceived as a threat, for those more stressed the Logos strategy was less threatening and more persuasive.

The results found in response to the third objective of this Doctoral Thesis are relevant in the psychophysiology of persuasion. The increase of evidence about the effect of persuasion on a person's motivational state taking into consideration individual characteristics such as traits and states, is a relevant contribution to many fields such as health, advertising, politics, economics, and social issues; all of which use persuasion to try to change attitudes or behaviors. In addition, studying neurophysiological responses to persuasion (i.e., ERPs) besides the most common psychophysiological measures (e.g., ECG, EDA, EMG), goes a step further in the understanding of the underlying mechanisms of persuasion that typically encounter studying the reactance state and not the response to persuasion solely (with or without reactance).

Lastly, the *fourth objective* of the project was to study how cerebral activity in a resting state differentiates based on the psychological tendency in NFC. In addition, we aimed to explore if the spectral power of the bands in rsEEG are predictors of memory performance in each group separately (low and high in NFC), and lastly, to determine if there is a difference in which persuasion strategy (i.e., ethos, pathos, or logos) is better recalled and recognized, comparing NFC groups. Results revealed a higher delta power in a resting state brain activity of individuals low in NFC compared to the group high in NFC in the EC condition on the frontal, central, and temporal regions. In contrast, individuals high in NFC had marginally higher alpha power in the frontal and central regions on the EO conditions, compared to the low NFC group. No effect was found in the theta power band. Delta power has been negatively related to several cognitive functions such as attention and working memory, so a lower delta power in the group of high in NFC may contribute to the tendency for higher cognitive functions and may explain the results found regarding memory performance.

Concerning memory, in the group of individuals high in NFC, delta power had a negative association with the recognition performance, in a way that individuals with lower delta power had a better recognition performance. In addition, theta and alpha power bands

positively predicted the memory performance, the theta power for the free recall task, and the alpha power for the recognition task. There is extensive evidence about the role of both theta and alpha power in memory processes (López Zunini et al., 2013). Moreover, theta oscillations have been considered as an EEG index of healthy cognitive functions such as memory and attention (Finnigan and Robertson, 2011; Mitchell et al., 2008). As for the alpha power, studies have evidenced its capacity to predict memory performance and response accuracy in working memory tasks (López Zunini et al., 2013). In the case of theta and alpha power bands, there is extensive evidence about their implications for cognitive functions. In contrast, the delta power still produces opposite results about its positive or negative effects on cognition, so further studies are needed.

Lastly, individuals high in NFC demonstrated enhanced recall for messages employing the Logos strategy, whereas individuals low in NFC exhibited better recall for messages of the Pathos strategy. These results align with the ELM processing routes (Petty and Cacioppo, 1986). Specifically, individuals low in NFC tend to transit a peripheral route, wherein arguments with peripheral cues are more persuasive. Conversely, individuals high in NFC tend to transit the central route in which the argument content is more scrutinized. Despite the absence of a direct link between memory and persuasive efficacy, is an interesting result that sheds light on the way a psychological tendency such as NFC affects the recall of persuasive messages.

In general, this Doctoral Thesis adds evidence to the psychophysiology of persuasion research area, which is still in its infancy. In addition, it adds relevant insights about the processing of persuasive health messages considering unexplored individual characteristics in the research area such as SDO, besides perceived stress, neuroticism, and the NFC. We found that the source's authority is a very important factor in persuasion, which points out the relevance that the source takes care of their trustworthiness on one side and on the other side

that the receptor has the cleverness to scrutinize an argument regardless of the expertise or attractiveness of the source. Individual characteristics play a significant role in the perception of how persuasive is an argument, which is a result consistent in the literature as is demonstrated in the systematic review presented and in addition reconfirmed in the results of this project. The SDO level affects the processing of messages that appeal to emotions and empathy, whereas messages that appeal to logic and rationality are more effective when the level of perceived stress is high. In addition, the NFC predicts the subsequent recall and recognition of the messages, whereas neuroticism does not necessarily interact with the persuasive attempt. Finally, the evidence about the physiological response to persuasion is promising and gives the possibility to understand the motivational states of an individual or to discriminate individual differences by their resting state EEG, and consequently be more effective in the delivery of communication, specifically concerning health.

Limitations, Strengths, and Future Directions

In each study of the project, the specific limitations were described. The main limitation was the impossibility of exploring the variables of age and gender. This limitation, particularly the age one, is because the experimental phase was conducted amidst the COVID-19 pandemic, so the safety protocols were very strict, and the recruitment of old people was not possible. In this line, the homogeneity of the sample (healthy young university students) makes it difficult to generalize the results. In the fourth chapter, ERPs were explored in response to the processing and self-reported assessment of how convincing each message was considered. ERPs are fast neurophysiological processes and are more commonly studied in response to an image or a sound. However, in line with the research of ERPs in Psycholinguistics, we proposed this study with an exploratory and promising approach in the field of persuasion.

Concerning the strengths of this Doctoral Thesis, it is worth pointing out the relevance of persuasion in the health field. In this way, the contribution to an emerging research area such as the psychophysiology of persuasion is also a contribution to health-related concerns such as adherence to treatments. In addition, the neuroscience of persuasion is also an emerging research area relying more on brain imaging techniques, so the study of both psycho- and neurophysiological techniques such as HRV, EEG, and ERPs allows to broaden the insights into the underlying mechanisms of persuasion. In this line, is important to highlight the rigor for the collection, treatment, and analysis of complex data and techniques. Lastly, regarding the psychological factors, we include several variables, some of them novel in the persuasion literature.

The result of this Doctoral Thesis adds evidence to the body of research on persuasion but also introduces a new research path with the potential to advance the understanding of the underlying mechanisms of persuasion. Future research on the ERPs' response to health-related stimuli could be interesting, either with messages, images, or videos. Also, a larger and more heterogeneous sample could increase the generalization of the results and permit the differentiation of the psychological and physiological variables by age and gender. Finally, it would also be interesting to replicate the study design with other persuasive strategies and other health-related topics.

To conclude with a reflection, the development of personalized persuasive strategies and technologies serves many beneficial aims such as the promotion of healthier behaviours or social changes, among others aims, however, its ethical application is fundamental to not serve many other ill aims such as manipulation or deception.

CHAPTER VIII: Main Conclusions



Main Conclusions

1. The Ethos strategy (the one that relies on the authority of the source) was assessed as the most persuasive by both the general online sample and the young in-person sample.
2. SDO was negatively related to the messages that appeal to emotions and empathy, both in the self-reported assessment and P300 amplitudes. Individuals high in SDO did not engage with the messages from the Pathos strategy.
3. The trait of neuroticism did not moderate the relationship between HRV and the perceived persuasiveness of the strategies.
4. For youths with higher perceived stress, a lower HRV was associated with a better assessment of the Logos strategy. This suggests that the messages framed in a more informative and promotional tone, led to greater agreement and processing fluency, particularly for stressed individuals.
5. Young people showed larger P300 amplitude in the processing of messages from an authority source (i.e., Ethos strategy), compared to more emotional (Pathos) or logical (Logos) messages. This suggests a more controlled attention processing to the messages due to the source that emits them.
6. A lower HRV during the exposure to the messages was found, regardless of the type of strategy, compared to the blocks of baseline and startle tone.

7. Brain activity in a resting state differs based on the NFC. Individuals high in NFC are characterized by lower delta power and higher alpha power than individuals low in NFC. No differences were found in the theta power between NFC groups.
8. For the high NFC group, delta power negatively predicted the recognition of the messages, whereas alpha power did it positively. In addition, theta power positively predicted free recall. No effect was found for the low NFC group.
9. The NFC predicted the recall of messages from the Pathos and Logos strategies. Individuals high in NFC better recalled messages that appeal to the logic of the argument, whereas those low in NFC better recalled messages that appeal to emotions. These results are in line with the ELM.

CHAPTER IX: General summary in Spanish



Introducción general

Influencia social: Persuasión

La influencia social se define como el acto intencional o no de cambiar la opinión o comportamiento de otro individuo (Gass, 2015), algo común en diversas especies de animales sociales. La persuasión, uno de los principales tipos de influencia social, es exclusivo de los seres humanos. Se trata del intento deliberado de un individuo, grupo o entidad social de modificar las creencias, actitudes o conductas de otra persona, mediante la provisión de información relevante sobre un tema en específico (Cacioppo et al., 2018). La persuasión es un tema principal en diversos ámbitos como la política, economía, salud pública, marketing, y milicia, entre otros, donde el objetivo y beneficio es ejercer influencia sobre las personas. Además, a nivel individual, los seres humanos influyen unos sobre otros en distintas situaciones. Por ejemplo, alguien que intenta persuadir a un ser querido para que deje de fumar, o que comience a ejercitarse, un proveedor de salud que intenta convencer a las personas de realizarse exámenes de salud, o un candidato político que apela a sus votantes a través de su agenda política.

La persuasión se ha convertido en un tema principal en la psicología social, pero su estudio se remonta a los filósofos griegos. Aristóteles, en su renombrado tratado *Retórica*, expuso que la eficacia de la persuasión depende del carácter del orador, el estado emocional de la audiencia, y del argumento en sí (Johnson et al., 2015). Ahora bien, el estudio científico y organizado de la persuasión se inició durante la Segunda Guerra Mundial apoyado por el ejército estadounidense, utilizando técnicas de propaganda y medios de comunicación masivas para influir sobre los soldados y los asuntos ideológicos detrás de la guerra (Hovland et al., 1949).

Desde entonces, este campo de la investigación ha dedicado considerables esfuerzos a comprender los elementos claves que conforman una comunicación persuasiva: la fuente, el destinatario, el mensaje y los factores contextuales (Wagner y Petty, 2022). Entre los factores mencionados, algunos de los más estudiados son, por ejemplo, la experiencia o credibilidad de la fuente, la necesidad de cognición del destinatario, la fuerza del argumento, y el contexto de la comunicación, ya sea en forma escrita o verbal.

Además, el emisor (o fuente) de la comunicación puede emplear diferentes estrategias persuasivas para aumentar la eficacia. Entre varias estrategias o principios de persuasión, para esta tesis, elegimos estudiar tres estrategias basadas en la retórica aristotélica y con perspectivas bien diferenciadas: Ethos, Pathos y Logos. Estas estrategias influyen de manera diferente según su perspectiva sobre cómo abordar la información y según las características individuales de los destinatarios del mensaje. Ethos se centra en factores asociados con la fuente, como la autoridad, la experiencia y la popularidad. Pathos apela a las emociones y la empatía de la audiencia. Por último, Logos se basa en la lógica del argumento, apelando principalmente a la racionalidad y al pensamiento crítico (Berlanga et al., 2013; Stucki and Sager, 2018).

Sin embargo, en un momento dado, hubo muchas teorías de la persuasión sin llegar a un consenso claro sobre los principales factores que realmente generaban un cambio de actitud (Petty y Cacioppo, 1986). Fue en este período cuando surgieron los modelos teóricos en la persuasión de proceso dual (p.e., Modelo de Probabilidad de Elaboración), los cuales se inspiraron en la antigua dicotomía entre emoción y razón. Pero en este caso, con la intención de organizar los hallazgos de la investigación en una misma visión que reconociera la existencia de dos rutas distintas en el procesamiento de la persuasión: central y periférica.

Modelo de Probabilidad de Elaboración

El Modelo de Probabilidad de Elaboración (ELM, por sus siglas en inglés) postula la existencia de un continuo de elaboración que es determinado por la motivación de un individuo para profundizar en el procesamiento de un mensaje. Cuando la motivación de una persona y su capacidad de generar pensamientos relevantes sobre un tema son altas, es más probable que asigne más recursos cognitivos al mismo, y de esta manera transite la ruta central. Mientras que, cuando la motivación y/o capacidad de pensar de una persona es baja, es más probable que se base en señales simples que le permitan procesar la información con un mínimo esfuerzo, lo que se sería transitar por la ruta periférica.

Los elementos clave del ELM sobre cómo una variable puede afectar la cantidad y dirección de un cambio de actitud son a través de la calidad del argumento, las señales periféricas y el nivel de elaboración por parte del destinatario (Petty and Cacioppo, 1986). Para afectar el nivel de elaboración del argumento por parte del destinatario, es necesario determinar la implicación del individuo en el procesamiento del mensaje y su actividad cognitiva, lo cual es posible a través de autoinformes, medidas psicofisiológicas o teniendo en cuenta las diferencias individuales, entre otras formas. Las diferencias individuales más estudiadas han sido la motivación, la personalidad, la necesidad de cognición, la consistencia o ambivalencia psicológica, y las emociones (Wagner y Petty, 2022).

Características individuales

Rasgos psicológicos

La eficacia de la persuasión varía entre individuos según características individuales como los rasgos psicológicos o estados situacionales. En la literatura sobre persuasión, se ha estudiado ampliamente el efecto de ajustar el contenido del mensaje a las actitudes de una persona (Petty y Wegener, 1998), obteniendo resultados positivos. En esta línea, algunos de los métodos más

comunes son el enmarcado (“framing”) o el ajuste a medida (“tailoring”), a través de los cuales se construye un mensaje basado en las características del destinatario, resaltando ciertos aspectos con el fin de aumentar la influencia.

La adaptación de un mensaje según la personalidad del destinatario, más allá de sus características demográficas, aumenta la posibilidad de un cambio de actitud (Oyibo y Vassileva, 2019). La tecnología persuasiva está creciendo rápidamente, y los investigadores señalan la necesidad de personalizar los sistemas tomando en consideración los rasgos de personalidad, ya que los individuos responden de manera diferente según sus características. La noción de “one-size-fits-all” ha demostrado no ser adecuada, especialmente en el campo de la salud.

Algunas de las características estudiadas en relación con la persuasión son: los Cinco Grandes rasgos de personalidad (apertura, responsabilidad, extraversión, amabilidad y neuroticismo) (Alkis y Temizel, 2015), la Susceptibilidad a la Persuasión (STPS, por sus siglas en inglés) (Kaptein, 2012), las diferencias individuales en la activación de los sistemas motivacionales de Inhibición (BIS, por sus siglas en inglés) y Activación (BAS, por sus siglas en inglés) conductual (Shen, 2007), y la Necesidad de Cognición (NC) (Cacioppo y Petty, 1982).

La NC es una diferencia individual ampliamente estudiada en la literatura de la persuasión y en relación con el modelo teórico de ELM, debido a su capacidad para explicar el nivel de motivación de un individuo para procesar y elaborar una información dada. Se define como la tendencia a participar y disfrutar de esfuerzos cognitivos. En el capítulo seis de esta Tesis, elegimos investigar cómo el nivel de NC afecta de manera diferente el EEG en estado de reposo y el desempeño de la memoria.

Por otro lado, la personalidad de un ser humano es una gama de rasgos más complejos que abarcan características más propensas a ser persuadidas, mientras que otras, por el contrario, están más asociadas con la resistencia a la persuasión (Wall et al., 2019). La Orientación a la Dominancia Social (SDO, por sus siglas en inglés) es una orientación hacia relaciones intergrupales jerárquicas y desiguales (Pratto et al., 1994). Hasta donde sabemos, solo un artículo (D'Errico, 2020) ha estudiado esta característica en el receptor de un mensaje persuasivo. Sin embargo, en relación con temas sociales, ideológicos y/o políticos que buscan el uso de la persuasión, es relevante considerar el nivel de SDO del destinatario, ya que esta característica afectará su nivel de elaboración en temas que promuevan propuestas igualitarias y razonables. En esta línea, en esta tesis doctoral se ha investigado la relación entre la SDO y la respuesta a la persuasión a través de autoinformes y potenciales evocados (ERPs, por sus siglas en inglés).

Estados situacionales

Una de las premisas del ELM es que las variaciones en la elaboración de un mensaje por parte de una persona se deben a factores individuales y situacionales (Petty y Cacioppo, 1986). Cuando la elaboración es alta, se asignan más recursos cognitivos que promueven un procesamiento adecuado de los argumentos persuasivos. Por el contrario, cuando la elaboración es baja, hay una falta de procesamiento reflexivo que resulta en un cambio de actitud producido por señales periféricas. Algunos de los factores situacionales más estudiados en la literatura sobre persuasión que afectan el nivel de elaboración son la relevancia personal, la motivación, la responsabilidad, la repetición del mensaje (Petty y Cacioppo, 1986), y la confianza en el propio pensamiento (Petty et al., 2002). Sin embargo, hay otros factores situacionales y psicológicos escasamente abordados en la literatura sobre persuasión que son muy relevantes, como la ansiedad y el estrés percibido. En relación con esta Tesis Doctoral y nuestro interés en

el estudio de la persuasión en el ámbito de la salud, consideramos especialmente relevante tener en cuenta estos factores situacionales del receptor del mensaje. Una persona con un alto estrés percibido experimentará más dificultades en el procesamiento de mensajes, especialmente si son amenazantes, lo que se podría percibir de cualquier mensaje de salud (Millar, 2005). Por esta razón, estudiamos la relación entre el estrés percibido, la respuesta cardiovascular y la persuasión de los mensajes.

Psicofisiología de la Persuasión

Sistema Nervioso Periférico

La psicofisiología de la persuasión tiene como objetivo estudiar los correlatos fisiológicos del procesamiento emocional y cognitivo de la comunicación persuasiva. Los estudios sobre persuasión han utilizado tradicionalmente medidas conductuales y autoinformes, sin embargo, las limitaciones de los autoinformes introspectivos y la incapacidad de las tareas conductuales para evaluar el procesamiento cognitivo simultáneamente al intento persuasivo han llevado al crecimiento de las medidas psico-y neurofisiológicas en el campo. Las medidas fisiológicas periféricas más comúnmente exploradas como mecanismos subyacentes de la persuasión son la frecuencia cardíaca (FC), la variabilidad de la frecuencia cardíaca (VFC), la actividad electrodermal (AED), y la electromiografía facial (EMGf). Los principales resultados de la literatura sobre la psicofisiología de la persuasión están presentados al inicio de esta Tesis Doctoral, a través de la revisión sistemática realizada. Además, hemos investigado la respuesta de la VFC a la persuasión.

Variabilidad de la Frecuencia Cardíaca

La VFC es la variación temporal entre latidos cardíacos, y es el resultado del equilibrio entre los sistemas simpático y parasimpático en la frecuencia cardíaca (Karim et al., 2011). La VFC

representa la capacidad del corazón para responder a estímulos fisiológicos y ambientales. Una baja VFC se asocia con una autorregulación deficiente, lo que reduce la capacidad del organismo para hacer frente a estresores internos y externos (Kim et al., 2018), lo que ha llevado al uso de la VFC como indicador de estrés. La evidencia científica señala esta medida como una herramienta eficaz para explicar la relación entre procesos psicológicos y fisiológicos (Berntson et al., 1997). Por esta razón, elegimos la VFC como índice psicofisiológico a estudiar en relación con la persuasión, además de la medida de estrés percibido, ya que los mensajes persuasivos de salud pueden ser potencialmente estresantes.

Sistema Nervioso Central

La neurociencia de la persuasión es un área de investigación en crecimiento, especialmente con la integración de técnicas de neuroimagen (p.e., la resonancia magnética funcional y la electroencefalografía) (Cacioppo et al., 2018) y la identificación de una red de regiones en el cerebro asociadas con la persuasión (es decir, la corteza prefrontal dorsomedial, la cisura temporal superior posterior, el polo temporal y la corteza prefrontal ventrolateral), una red común con la cognición social y la mentalización (Falk et al., 2010). En esta Tesis Doctoral nos centramos en el uso de la electroencefalografía (EEG). El EEG consiste en el registro de la actividad eléctrica a lo largo del cuero cabelludo de manera directa, no invasiva y en tiempo real, desde donde se pueden estudiar diferentes bandas de frecuencia y potenciales evocados. Las bandas de frecuencia van desde las más lentas, delta (0.5-4 Hz) y theta (4-8 Hz), hasta las más rápidas como alpha (8-12 Hz), beta (13-30 Hz) y gamma (> 30 Hz). A partir de las bandas de frecuencia, algunos de los índices extraídos que se han estudiado en la literatura sobre persuasión son: el índice de compromiso mental (Benlamine et al., 2015; Berka et al., 2007; Correa et al., 2015; Pope et al., 1995; Villata et al., 2018), el índice de carga de trabajo

(Chaouachi and Frasson, 2011) y la asimetría frontal de Alpha (Borawska et al., 2020), entre otros.

Además del análisis de las ondas cerebrales, el estado de reposo de la persona es una medida ampliamente estudiada. Sin embargo, hasta donde sabemos no se han realizado estudios que investiguen cómo las diferencias individuales en la actividad cerebral durante el estado de reposo se asocian con el procesamiento de la persuasión y el rendimiento de la memoria en el reconocimiento y recuperación de los mensajes después de haber sido expuestos a ellos.

EEG en Estado de Reposo y Potenciales Evocados

Las oscilaciones cerebrales en estado de reposo (rsEEG, por sus siglas en inglés) se registran durante un breve período de tiempo en condiciones de ojos cerrados y abiertos. Estas reflejan la actividad neurofisiológica basal de una persona. Los hallazgos científicos sugieren que la señal rsEEG tiene el potencial de predecir de manera precisa el rendimiento cognitivo (Wan et al., 2023). Por este motivo, en esta Tesis se exploró cómo el rsEEG predice el reconocimiento y recuperación posterior de mensajes persuasivos. Específicamente, comparamos cómo los individuos con un nivel de Necesidad de Cognición (NFC) alto vs. bajo difieren en su estado de reposo y en el rendimiento de la memoria.

Los Potenciales Evocados (ERPs, por sus siglas en inglés) son respuestas neurales a eventos sensoriales, cognitivos y/o motores específicos. Son descargas eléctricas relacionadas con eventos específicos. Los ERPs se originan a partir de potenciales postsinápticos que ocurren cuando los neurotransmisores se unen a los receptores y cambian el flujo de iones. Los ERPs proporcionan una medida de la actividad neural instantánea, con una resolución de milisegundos (Luck, 2014). Además de los índices de EEG, estudiar los ERPs en el contexto de la persuasión puede mejorar nuestra comprensión sobre la respuesta neural a intentos

persuasivos específicos. Aunque no hay componentes de ERPs explícitamente provocados por la atención, varios componentes varían sus amplitudes cuando se atiende un estímulo (Coull, 1998).

Los parámetros generalmente estudiados de los ERP son su amplitud y latencia. La amplitud indica la magnitud de la actividad neural (Friedman et al., 2001) y permite estimar la cantidad de recursos atencionales, mientras que la latencia indica el tiempo que toma detectar y evaluar el estímulo. Algunos de los componentes más estudiados en la literatura de persuasión son el N100 y P300. El N100 es un componente negativo relacionado con un procesamiento atencional temprano, el cual tiene un pico máximo alrededor de 100 ms después de la aparición de un estímulo. Su amplitud aumenta cuando el estímulo es atendido, mostrando un mayor procesamiento del estímulo atendido en comparación con cualquier otro estímulo no atendido. El P300 es un componente positivo tardío, que alcanza su pico máximo alrededor de 300 ms después de la aparición del estímulo. Se asocia con el procesamiento de estímulos nuevos que requieren una actualización en la memoria de trabajo (Polich, 2007), y también se relaciona con un procesamiento atencional más controlado. Cabe mencionar que muy pocos estudios han relacionado la medida de ERPs con el procesamiento atencional a mensajes persuasivos (Kessels et al., 2011; 2014).

Objetivos e hipótesis

El objetivo general de esta Tesis Doctoral ha sido ampliar la evidencia sobre la psico- y neurofisiología de la persuasión tomando en consideración características individuales, con el fin de aumentar la eficiencia de las comunicaciones en salud y la adherencia a posibles tratamientos. A partir de este objetivo general, se han abordado los siguientes objetivos específicos:

1. Evaluar, a través de una valoración autoinformada, qué estrategia persuasiva (es decir, Ethos, Pathos, y Logos) resulta más convincente. Este objetivo se aborda en los capítulos tres, cuatro y cinco. Hipotetizamos que Ethos (debido a la señal periférica de la experiencia de la fuente; ELM) y/o Pathos serán percibidos como más persuasivos que Logos.
2. Explorar cómo algunas características individuales (rasgos: orientación a la dominancia social (SDO) y neuroticismo; estado: estrés percibido) afectan el procesamiento de mensajes de salud y su persuasión percibida. Este objetivo se investiga en los capítulos cuatro y cinco. En primer lugar, con respecto a SDO, planteamos que estará positivamente relacionado con la estrategia de Ethos, ya que esta enfatiza la autoridad y experiencia de la fuente, mientras la característica de SDO propicia las relaciones jerárquicas. En segundo lugar, en cuanto al neuroticismo y estrés percibido, planteamos la hipótesis de que moderarán la dirección y magnitud de la relación entre la persuasión y la respuesta cardiovascular, de tal manera que un mayor neuroticismo y/o estrés percibido se asociará con una mayor percepción de persuasión (particularmente de las estrategias Ethos y Pathos) y una mayor reactividad cardiovascular.
3. Explorar las respuestas fisiológicas (variabilidad de la frecuencia cardíaca, VFC) y neurofisiológicas (potenciales evocados, ERPs) a diferentes estrategias persuasivas en la comunicación de aspectos relacionados con la salud. Este objetivo se aborda en los capítulos cuatro y cinco de la presente Tesis. Con respecto a la VFC, al igual que en el segundo objetivo, planteamos que habrá una mayor reactividad cardiovascular (menor VFC) cuanto mayor sea el estrés percibido y neuroticismo en el individuo. En cuanto a

los ERPs, esperamos una mayor amplitud de P300 en respuesta a la estrategia que sea considerada más persuasiva (objetivo 1).

4. Examinar cómo un biomarcador de estado (EEG en estado de reposo, rsEEG por sus siglas en inglés) difiere según una característica individual (NC), determinar si la potencia espectral de las bandas en rsEEG predice el rendimiento de la memoria (explorando por separado los grupos de NC bajo y alto), y explorar si hay una diferencia en cuál estrategia persuasiva (es decir, ethos, pathos o logos) se recuerda y reconoce mejor según el nivel de NC (bajo vs. alto). Este cuarto objetivo se aborda en el capítulo seis de la Tesis. En primer lugar, planteamos la hipótesis de que las diferencias individuales en NC se reflejarían de manera diferente en los ritmos delta y theta. En segundo lugar, hipotetizamos que la potencia theta predeciría positivamente el rendimiento de la memoria en individuos con NC alta, mientras que la potencia alfa lo haría de manera negativa. Por último, hipotetizamos que las personas con NC alta recordarían y/o reconocerían mejor los mensajes en la estrategia Logos. En contraste, el grupo con NC baja recordaría y/o reconocería mejor las estrategias Ethos o Pathos, debido a las señales periféricas.

Metodología

A continuación, se presenta una breve descripción de los participantes, del procedimiento e instrumentos empleados.

Participantes

Respecto a la muestra del estudio en línea, el total fue de 422 voluntarios que participaron de la encuesta en línea. Sin embargo, 112 entradas estuvieron incompletas, de modo que la muestra final analizada fue de 310 sujetos (227 mujeres y 83 hombres) con una edad media de 40.8 años (DE: 15.9). Estos participantes fueron reclutados a través del contacto directo con conocidos, familiares, estudiantes y colegas, entre otros. La encuesta se difundió durante el confinamiento del COVID-19, entre los meses de abril y junio de 2020. No hubo criterios de exclusión respecto a edad, sexo, o país de residencia.

La muestra total de la fase experimental presencial fue de 66 participantes (50 mujeres y 16 hombres) de entre 18 y 35 años. Estos participantes fueron reclutados de diferentes grados y másteres de la Universidad de Valencia. En relación con cada estudio, el número de sujetos varió dependiendo de las variables estudiadas. La fase experimental se llevó a cabo entre marzo y diciembre de 2021 en el Laboratorio de Neurociencia Social de la Universidad de Valencia.

En relación con la fase experimental, los criterios de exclusión fueron: antecedentes de abuso de alcohol o drogas; fumar más de 10 cigarrillos al día, presencia de problemas severos de visión o audición o alguna enfermedad que implique una alteración del sistema nervioso; padecer un trastorno neurológico o psiquiátrico; tomar alguna medicación que altere el sistema nervioso; estar embarazada; ser vegetariano/a; y por último, tener fiebre, tos y/o alguna dificultad respiratorio en los 14 días previos al día de la sesión (principales síntomas del COVID-19). Todos los participantes eran diestros.

Procedimiento

Revisión sistemática

En primer lugar, se realizó una revisión sistemática siguiendo las Pautas de Informe para Revisiones Sistemáticas y Metaanálisis (PRISMA, por sus siglas en inglés) (Moher et al.,

2009). La búsqueda se realizó en las siguientes bases de datos: Web of Science, Scopus, Embase, PsycINFO y PubMed, en artículos publicados hasta septiembre de 2023. Se utilizaron las siguientes palabras clave en la búsqueda: (argumentation* OR persuasion) AND cognition* AND emotions*; and: persuasion* AND (psychophysiology* OR psychobiology*). Luego del proceso de selección, se incluyeron en la revisión un total de 28 artículos.

Los datos extraídos de los estudios elegibles se clasificaron en cuatro categorías: 1) estudios que examinan los efectos de las emociones en el procesamiento de la información, 2) estudios que evalúan el efecto moderador de las orientaciones basadas en afecto y cognición en el procesamiento de la información, 3) artículos que examinan los efectos del enmarcado ('framing') en el procesamiento de la información, y 4) estudios que exploran la psicofisiología de la persuasión.

Encuesta en línea

La encuesta en línea estuvo conformada por preguntas demográficas, cuestionarios psicológicos y la tarea de persuasión. Esta última consistió en 30 mensajes, 10 mensajes por cada una de las tres estrategias de persuasión (Ethos, Pathos y Logos). La encuesta completa tuvo una duración de entre 15 y 20 minutos. La presentación y contrabalanceo de los bloques y mensajes se hizo a través de la plataforma de encuestas en línea LimeSurvey.

Fase experimental

El procedimiento del estudio consistió en una sesión experimental de dos horas. El día previo a la sesión, los participantes debían mantener una rutina de buen descanso, sin consumo de alcohol ni actividad física intensa. Además, dos horas previas a la sesión debían evitar bebidas estimulantes. Una vez en el laboratorio, se les explicaba en detalle el estudio y se les entregaba un consentimiento informado. Las sesiones se realizaron en el turno de mañana (entre 10:00 y

12:00). Todo el estudio se llevó a cabo según la Declaración Helsinki y con la aprobación del Comité de ética de la Universidad de Valencia (código #1241475).

Después de un período de habituación en la sala, había un período de preparación donde se medía la circunferencia de la cabeza para el gorro del EEG y se limpiaban las zonas donde se colocarían los electrodos del ECG. El estudio se iniciaba con el registro de EEG en estado de reposo con dos períodos de tres minutos, uno con ojos-abiertos y el siguiente con ojos-cerrados. A continuación, se presentaba la tarea de persuasión en el ordenador. Simultáneamente a la tarea, se hacía el registro de EEG y ECG. Después de la tarea, con una duración de 15-18 minutos, los participantes debían completar una prueba de memoria de recuerdo libre durante 5 minutos. Tras esto, durante 30 minutos respondían cuestionarios psicológicos. Finalmente, se les presentaba una tarea de memoria de reconocimiento.

Tarea de persuasión

La tarea consistió en tres bloques de mensajes basados en las estrategias de persuasión: Ethos, Pathos y Logos. Al comienzo de la tarea, aparecían las instrucciones, seguidas de un vídeo de 1-minuto de contenido neutral, luego los tres bloques, y al final un tono acústico de 1-minuto. En cada bloque, aparecían 20 mensajes sobre el límite en el consumo de carne. Después de cada mensaje, aparecía la pregunta ‘¿Cuán convincente es este mensaje?’, a la que debían responder con un rango de 0 (nada convincente) a 4 (muy convincente). Después de cada mensaje/pregunta, había un punto de fijación de 1-segundo, y entre cada bloque había un vídeo neutral de 1-minuto. Algunos ejemplos de los mensajes presentados son: ‘Según la OMS (Organización Mundial de la Salud) la carne roja es probablemente cancerígena’ (Ethos); ‘Es muy lamentable que aún el 13% de los cerdos estén conscientes durante el proceso de sacrificio’ (Pathos); y ‘Se estima que entre el 20-30% del impacto ambiental en los países occidentales se debe a la industria alimentaria’ (Logos).

Variables

Variables psicológicas

El **estrés percibido** fue evaluado mediante la adaptación al español (Remor, 2006) de la Escala de Estrés Percibido (PSS, por sus siglas en inglés) (Cohen et al., 1983). Los participantes respondieron en una escala tipo Likert del 0 (*Nunca*) al 4 (*Muy a menudo*) al PSS-4 (ítems 2, 6, 7 y 14 del PSS-14 original). Los ítems 6 y 7 se puntuaron de forma inversa. Las puntuaciones más altas indican niveles más altos de estrés psicológico percibido durante el último mes.

Los **rasgos de personalidad** se evaluaron mediante la adaptación al español (Costa and McCrae, 1999) del Inventario de los Cinco Factores (NEO-FFI, por sus siglas en inglés) (Costa and McCrae, 1992). Este cuestionario consta de 60 ítems que miden los cinco grandes rasgos de personalidad, con 12 ítems para cada uno (neuroticismo, responsabilidad, extraversión, apertura y amabilidad).

La **orientación a la dominancia social** se evaluó a través de la adaptación al español (Silván-Ferrero and Bustillos, 2007) de la versión original diseñada por Pratto et al. (1994). La escala está compuesta por 16 ítems, y aquellos redactados en desacuerdo con la dominancia y la desigualdad se puntuaron de forma inversa. Puntuaciones más altas indican mayor orientación hacia la dominancia social.

La **necesidad de cognición** fue evaluada con la versión en español (Falces et al., 2001) de la escala original diseñada por Cacioppo y Petty (1982). La escala consta de 18 ítems, y evalúa la tendencia a participar y disfrutar de pensar.

Las **estrategias de afrontamiento** se examinaron mediante la adaptación al español (Morán et al., 2010) del inventario corto para evaluar las estrategias de afrontamiento (Brief-

Coping Orientation to Problems Experienced Inventory, Brief-COPE, por sus siglas en inglés) (Carver, 1997). Los participantes respondieron a 28 ítems relacionados con las diferentes formas en las que afrontan el estrés. Estos 28 ítems corresponden a 14 subescalas compuestas por 2 ítems cada una.

Variables fisiológicas

Variabilidad de la frecuencia cardíaca

El registro ECG se recopiló a través de tres electrodos desechables Kendall H124SG y tres electrodos Lead 110, uno en el lado derecho debajo de la clavícula, otro en el lado izquierdo debajo de la clavícula como electrodo tierra, y otro en el lado izquierdo debajo de las costillas. Se utilizó el amplificador BIOPAC ECG100C (Biopac Systems, Inc.) para la adquisición de datos, con un filtro de paso de banda de 35 Hz y 1000 Hz. Además, se aplicó un filtro ‘notch’ de 50 Hz para reducir el ruido de las señales interferentes.

A partir de la señal de ECG, se calculó la variabilidad de la frecuencia cardíaca (VFC) utilizando la raíz cuadrada de las diferencias sucesivas (RMSSD). Para analizar la VFC y aplicar correcciones de artefactos, se utilizó el software Kubios (Biomedical Signal Analysis Group, University of Kuopio, Finlandia). La VFC se calculó a partir de períodos de 1 minuto en cada uno de los 5 bloques de la tarea (período basal, tres bloques de mensajes separados y tono de sobresalto). En los tres bloques de mensajes, se evaluó el minuto central.

Potenciales evocados

El registro EEG se obtuvo a través de 25 electrodos activos utilizando el sistema de amplificación BrainVision (Brain Products, Alemania). El electrooculograma (EOG) se registró a partir de tres electrodos, uno colocado en el canto externo de cada ojo (HEOG+, HEOG-) y otro en la región supraorbitaria del ojo derecho (VEOG+) para detectar movimientos

oculares y eliminar parpadeos (Gratton et al., 1983). El electrodo tierra se colocó en el AFz y la referencia en el FCz. Los restantes 20 electrodos activos (Fp1, Fp2, F7, F3, Fz, F4, F8, FC5, FC6, T7, Cz, T8, P7, Pz, P8, O1, Oz, O2, A1, and A2) se montaron en un gorro elástico (EasyCap, Falk Minow, Munich, Alemania) según el sistema internacional 10-20.

El componente de P300 se midió en los electrodos Fp1, Fp2, Fz y Pz dentro de la ventana temporal de 250-450 ms después del estímulo. El estímulo fue seleccionado como el momento en que el participante finalizaba de leer un mensaje y pasaba a la pregunta ‘¿Cuán convincente es este mensaje?’. De modo que el componente podía responder al procesamiento del mensaje.

EEG en estado de reposo

El registro en estado de reposo siguió la misma metodología que los potenciales evocados en cuanto a montaje y número de electrodos activos. En cuanto al registro, este se realizó a través de dos períodos de tres minutos, uno con ojos-abiertos y otro con ojos-cerrados. Para el análisis, las bandas de frecuencia estudiadas fueron: delta (0.5-4 Hz), theta (4-8 Hz), alpha (8-12 Hz) y beta (13-30 Hz). El análisis de poder espectral se realizó aplicando una transformada rápida de Fourier (FFT, por sus siglas en inglés). Las regiones de interés exploradas fueron: frontal (F3, Fz, F4), central (FC5, Cz, FC6), parietal (P7, Pz, P8), occipital (O1, O2) y temporal (T7, T8).

Resultados principales

El *primer objetivo* de esta Tesis fue evaluar a través de una valoración auto informada qué estrategia persuasiva (es decir, Ethos, Pathos, y Logos) resultaba más convincente. Este objetivo se examinó en los capítulos tres, cuatro y cinco. Los resultados fueron consistentes tanto en la muestra general evaluada en línea como en la muestra de jóvenes en la tarea presencial. La estrategia de Ethos fue considerada la más persuasiva. En el estudio en línea, la

estrategia de Ethos fue seguida de Logos, y como última, Pathos. En los capítulos cuatro y cinco, la persuasión percibida de Pathos fue mayor que la de Logos.

Dicho resultado sugiere que la autoridad de la fuente sigue siendo un elemento de poder en la comunicación persuasiva debido a la credibilidad y confianza que genera en la audiencia receptora. Según el ELM, la fuente es una de las claves más utilizadas como señal periférica para influir en las actitudes de una persona cuando su elaboración de la información es baja o ausente (Petty y Cacioppo, 1986). Es relevante mencionar que este estudio se llevó a cabo durante la pandemia de COVID-19: el estudio en línea durante el confinamiento (abril-junio 2020) y la fase experimental durante el período post-confinamiento (abril-diciembre 2021), de modo que había una saturación de mensajes de salud y aquellos que provenían de fuentes de autoridad destacaban como los más confiables.

El *segundo objetivo* de esta Tesis era explorar cómo algunas características individuales (rasgos: orientación a la dominancia social (SDO) y neuroticismo, estado: estrés percibido) afectan el procesamiento de mensajes de salud y su persuasión percibida. En el estudio 2, la orientación a la dominancia social se relacionó de manera negativa con la estrategia de Pathos, tanto en la respuesta autoinformada como en los correlatos neurales (potenciales evocados). A pesar de no cumplirse la hipótesis sobre la relación entre el SDO y la estrategia de Ethos por la preferencia por el orden jerárquico, el resultado es justificable y revela la importancia de esta característica en el procesamiento de información persuasiva. La SDO es una orientación hacia las organizaciones desiguales en contextos sociales, como la nacionalidad, religión, género, e incluso en temas del medio ambiente. La estrategia de Pathos, por su parte, es utilizada para apelar a las emociones y empatía de la audiencia. Por el contrario, la SDO se ha asociado negativamente con la empatía (Pratto et al., 1994; 2006), lo que justifica el resultado obtenido, donde aquellos individuos con niveles de SDO más altos evaluaron los mensajes de salud en la estrategia de Pathos como menos convincentes. Conviene recordar que el tema de la tarea

era el límite del consumo de carne por su impacto negativo en la salud, medio ambiente y maltrato animal.

En el capítulo cinco, se evaluó el rasgo de personalidad de neuroticismo y el estrés percibido. No hubo efectos relacionados con el neuroticismo. Sin embargo, el estrés percibido moderó la relación entre la VFC y la estrategia de Logos. En el grupo de individuos con un alto nivel de estrés percibido, hubo una mayor reactividad cardiovascular (menor VFC) en relación con una mayor percepción de persuasión en los mensajes enmarcados en Logos. De modo que, para aquellos más estresados (subjettiva y fisiológicamente), los mensajes enmarcados en un tono más lógico e informativo fueron considerados como más persuasivos. Esto es un resultado especialmente relevante, dado que, en relación con los mensajes de salud, la población estresada es una diana importante, de modo que conocer cuál es la manera más efectiva de enmarcar un mensaje de salud es importante. Además, dicho resultado contradice la literatura que aún señala a las apelaciones al miedo como más efectivas para persuadir a las personas a seguir alguna recomendación (Das et al., 2003).

El *tercer objetivo* de la Tesis era explorar respuestas fisiológicas (variabilidad de la frecuencia cardíaca, VFC) y neurofisiológicas (potenciales evocados, ERPs) durante la exposición a los mensajes de salud. Los hallazgos del capítulo cuatro revelaron un efecto de Estrategia, en la cual hubo una mayor amplitud de P300 ante los mensajes de Ethos en comparación con las estrategias de Pathos o Logos, particularmente en las regiones prefrontal, frontal y parietal. La amplitud es un índice que indica la magnitud de la actividad neural (Friedman et al., 2001), y es sensible a la cantidad de recursos atencionales prestados a un estímulo. Este resultado respalda la respuesta autoinformada de los participantes quienes evaluaron la estrategia de Ethos como la más persuasiva. Según se mencionó en el resultado del primer objetivo, se destaca que la autoridad de la fuente continúa siendo una clave periférica efectiva para persuadir, más aún en el contexto de una pandemia de salud global.

Además, la VFC se exploró como un indicador de la reactividad fisiológica en respuesta a los mensajes persuasivos. Niveles más altos de VFC se consideran beneficiosos para enfrentar situaciones problemáticas (Ode et al., 2010), mientras que niveles bajos de VFC se asocian con mecanismos de regulación deficientes, disminuyendo así las habilidades para enfrentar factores de estrés. Los resultados obtenidos revelaron una respuesta de VFC más baja durante la exposición a los mensajes, independientemente del tipo de estrategia, en comparación con los bloques de línea base y tono de sobresalto. Este resultado sugiere que hubo una mayor excitación simpática durante la persuasión, indicando posiblemente que los mensajes fueron percibidos como estresantes o provocaron una respuesta de reactancia.

Estos resultados son relevantes en el área de la psicofisiología de la persuasión. Aumentar la evidencia sobre el efecto de la persuasión en el estado motivacional de las personas y además considerar sus características individuales, es una contribución relevante para muchas áreas como la salud, la política, economía, entre otros campos de interés social, todos los cuales utilizan la persuasión para generar un cambio de actitud o conducta en las personas.

Finalmente, el *cuarto objetivo* fue examinar cómo un biomarcador de estado (EEG en estado de reposo) se diferencia según una característica individual (necesidad de cognición, NC), determinar si la potencia espectral de las bandas en estado de reposo predice el rendimiento de la memoria (explorando por separado los grupos de NC bajo y alto), y explorar si hay una diferencia en cuál estrategia persuasiva (es decir, ethos, pathos o logos) se recuerda y reconoce mejor según el nivel de NC (bajo vs. alto). El EEG en estado de reposo se diferenció por grupo (NC) en la potencia de las bandas delta y alpha. Los sujetos bajos en NC tuvieron más potencia delta en las regiones frontal, central y temporal, aunque menos potencia alpha en las regiones frontal y central. La banda delta se ha relacionado negativamente con funciones cognitivas como la atención o la memoria de trabajo (Jann et al., 2010), de modo que una menor

potencia delta en el grupo de individuos altos en NC puede contribuir a la tendencia hacia funciones cognitivas superiores, y puede explicar en parte los resultados hallados en el desempeño de memoria.

En relación con el desempeño en la memoria, el estado de reposo se relacionó con la tarea de reconocimiento en el grupo de altos en NC, pero no en el grupo de baja NC, en las potencias de delta, alpha y theta. Una menor potencia de delta en las regiones frontal, central y parietal predijo un mejor desempeño en reconocimiento en individuos altos en NC. Mientras que la potencia de alpha predijo de manera positiva el desempeño en la tarea de reconocimiento, y la potencia de theta el desempeño en la tarea de recuerdo libre. Hay extensa evidencia de la implicación de ambas bandas en las funciones de la memoria.

Finalmente, hubo diferencias de grupo (NC) en la tarea de recuerdo libre, pero no en la de reconocimiento. Los mensajes enmarcados en la estrategia de Pathos fueron mejor recordados por los participantes bajos en NC, mientras que los mensajes de Logos lo fueron por los sujetos altos en NC. Este último resultado va en línea con nuestra hipótesis de que los individuos bajos en NC recordarían mejor los mensajes de Ethos o Pathos, debido a las claves periféricas. Pero más allá de esto, el hecho de que los mensajes de Logos sean mejor recordados por los altos en NC sugiere que transitaron por una ruta central de acuerdo con el ELM, lo que reafirma la relevancia de esta característica individual en el procesamiento de información persuasiva.

Principales Conclusiones

1. La estrategia de Ethos, la que se basa en la autoridad de la fuente, fue percibida como la más persuasiva tanto por la muestra general en línea como por la muestra presencial de jóvenes.

2. La SDO se correlacionó negativamente con los mensajes que apelan a las emociones y la empatía, tanto en la evaluación autoinformada como en la amplitud de P300. Las personas con una SDO alta tuvieron una menor conexión con los mensajes de la estrategia de Pathos.
3. El rasgo de neuroticismo no moderó la relación entre la HRV y la persuasión percibida de las estrategias.
4. Para los jóvenes con un mayor estrés percibido, una menor HRV se asoció con una mejor evaluación de la estrategia de Logos. Esto sugiere que los mensajes enmarcados de manera más informativa y promocional generaron una mayor aceptación y fluidez de procesamiento, especialmente en los individuos más estresados.
5. Los jóvenes mostraron una mayor amplitud de P300 al procesar mensajes de una fuente de autoridad (es decir, la estrategia de Ethos), en comparación con mensajes más emocionales (Pathos) o lógicos (Logos). Esto sugiere un procesamiento de atención más controlado hacia los mensajes debido a la fuente que los emite.
6. Hubo una menor HRV durante la exposición a los mensajes, independientemente del tipo de estrategia, en comparación con los bloques de línea base y tono de sobresalto.
7. La actividad cerebral en estado de reposo se diferenció según la NC. Las personas con alta NC presentaron una menor potencia en la banda delta y una mayor potencia en la banda alfa en comparación con aquellos con baja NC. No se observaron diferencias en la potencia de la banda theta entre los grupos.

8. En el grupo con alta NC, la banda delta predijo negativamente el reconocimiento de los mensajes, mientras que la banda alfa lo predijo positivamente. Además, la potencia en la banda theta predijo positivamente el recuerdo libre. No se encontraron efectos para el grupo con baja NC.
9. La NC predijo el recuerdo de los mensajes de las estrategias de Pathos y Logos. Las personas con alta NC recordaron mejor los mensajes que apelaban a la lógica del argumento (Logos), mientras que aquellos con baja NC recordaron mejor los mensajes que apelaban a las emociones (Pathos).

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Valerie N Rodríguez-Hernández

PhD in Neurosciences