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ARGUMENTATIVE AND EXPOSITORY TECHNIQUES BASED ON NEUROSCIENCE: CONVINCING WITH A SCIENTIFIC FOUNDATION

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Abstract: Neuroscience-based argumentative and expository techniques have the potential to revolutionize the way we persuade and are persuaded. By understanding the neural mechanisms underlying decision-making, belief formation and social influence, we can develop more effective and ethical communication strategies. This article explores recent advances in the neuroscience of persuasion, highlighting the role of brain areas such as the anterior cingulate cortex, the prefrontal cortex and the reward system in evaluating evidence, building expectations and responding to social stimuli. In addition, the article discusses how factors such as emotion, memory and sleep can modulate persuasion, and how neuroscience can be used to improve argumentative and expository techniques in various areas, from law to public health and marketing.
Keywords: Neuroscience, persuasion, decision-making, anterior cingulate cortex, prefrontal cortex, reward system, emotion, memory, sleep.

INTRODUCTION

Neuroscience, the study of the nervous system, has provided valuable insights into the brain mechanisms that underlie human behavior, including persuasion and decision-making. By investigating how the brain processes information, evaluates evidence and responds to social stimuli, neuroscience provides a solid basis for developing more effective argumentative and expository techniques.

FROM THE ANTERIOR CINGULATE CORTEX TO THE JURY: THE ROLE OF NEURAL PREDICTION ERROR IN PERSUASION AND DECISION MAKING

In the study by Ohshiro et al. (2017), their findings can be related to the concept of **scientifically-based persuasion**. Divisive normalization, as a neural mechanism underlying multisensory integration, can be interpreted as a means by which the brain weighs and combines different sources of sensory information to make more accurate decisions. This idea of weighing and combining sensory information, based on neural mechanisms, can be applied to the way people evaluate and are persuaded by arguments. Presenting solid scientific evidence and combining different types of evidence can activate mechanisms similar to divisive normalization in the brain, leading to more effective persuasion based on scientific grounds

Practical example: A practical example of the application of the concept of divisive normalization in persuasion can be seen in a jury. Each juror individually evaluates the evidence presented by the prosecution and the defense. However, the final decision is made together, after deliberation between the jurors. During deliberation, each juror expresses their interpretation of the evidence and their initial judgment. This information is shared and discussed among the group. Divisive normalization can occur in this process, as jurors weigh the different perspectives and evidence presented by their colleagues. The opinion of each individual juror can be seen as sensory stimulation, and group deliberation as multi-sensory integration. The opinion of a juror with more convincing arguments and more solid evidence can have a greater weight in the final decision, similar to a preferential stimulus in the divisive normalization model. On the other hand, the opinion of a juror with

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weaker arguments can be suppressed or given less weight, similar to a non-preferential stimulus. In this way, divisive normalization can be seen as a mechanism that helps the jury reach a fairer and more accurate verdict by weighing the different perspectives and evidence presented during deliberation.

BEYOND DIVISIONAL NORMALIZATION: EXPLORING NEURAL PREDICTION ERROR IN THE ANTERIOR CINGULATE CORTEX AND ITS IMPLICATIONS FOR PERSUASIVE COMMUNICATION

The study by Hyman et al. (2017) investigated neural activity in the anterior cingulate cortex (ACC) of rats during a probabilistic decision-making task, similar to that which elicits feedback-related negativity (FN) in humans. The authors found that a subset of neurons in the ACC encode expected outcomes as abstract representations, and the degree to which this representation emerges during a trial depends on the history of previous outcomes. In incongruent tests, a prediction error is generated when the neural ensembles switch from representing the expected outcome to the actual outcome at the same time point that an FN is observed in the local field potential.

Although the study does not directly address argumentative and expository techniques, its findings can be related to the concept of **scientifically-based persuasion**. The neural representation of expected outcomes in the CCA, which is dynamically updated based on new information, can be interpreted as a mechanism by which the brain evaluates the validity of an argument or evidence. In other words, the brain seems to build up an expectation about what is likely or plausible based on previous experiences, and this expectation is then compared with the new information presented. If the new information is congruent with the expectation, it is more easily accepted and integrated into existing knowledge. However, if the new information is incongruent, it generates a prediction error, which can lead to a reassessment of the expectation and potentially a change of opinion.

Practical example: Imagine a doctor presenting a new treatment to a patient. The patient, based on their previous experiences with medical treatments, may have an expectation about the effectiveness and side effects of the new treatment. If the doctor presents solid scientific evidence supporting the efficacy and safety of the treatment, and if this evidence is congruent with the patient's expectation, the patient is more likely to accept the treatment. However, if the evidence is incongruent with the patient's expectation, they may question the validity of the treatment and seek more information before making a decision.

OXYTOCINERGIC MODULATION OF DOPAMINE SYSTEMS IN THE MIDBRAIN AND ITS IMPLICATIONS FOR CONVICTION

Xiao et al. (2017) mapped and functionally characterized the axonal projections of oxytocin neurons in the hypothalamic paraventricular nucleus to dopamine regions in the midbrain. Using electrophysiological recordings, they found that both the application of oxytocin and optogenetic stimulation of oxytocinergic terminals increase the activity of dopamine neurons in the ventral tegmental area (VTA), but decrease it in the substantia nigra pars compacta (SNc). This biased modulation is mediated by G protein-coupled receptors for oxytocin and vasopressin. Oxytocin release directly activates dopamine neurons and indirectly inhibits them via local GABA neurons, but the relative magnitudes of the two mechanisms differ in the VTA and SNc.

Oxytocin, a neuropeptide known to regulate social behavior and interact with reward signaling, can be interpreted as a factor that influences how people perceive and respond to social stimuli and rewards. The modulation of the activity of dopamine neurons by oxytocin suggests that this neuropeptide may play a role in the way people evaluate and are persuaded by arguments, especially those related to social rewards.

Practical example: Imagine a politician giving a speech to an audience. If the politician manages to evoke feelings of trust and social connection in the audience, this can lead to the release of oxytocin, which in turn can modulate the activity of dopamine neurons, making the audience more receptive to the politician's message. On the other hand, if the politician uses language or tactics that generate fear or anxiety, this can lead to the release of other neurotransmitters that can have the opposite effect, making the audience less receptive to their message.

TEMPORAL HETEROGENEITY IN THE CODING OF ACCUMULATED EVIDENCE IN THE FRONTOPARIETAL CORTEX

Scott et al. (2017) investigated the dynamics of neuronal responses in the frontoparietal cortex (FPC) of rats during a pulse-based evidence accumulation task. The authors found that while the average response of the neuronal population is consistent with a stable representation of the accumulated evidence, the individual responses of the neurons are heterogeneous in their temporal profiles. This heterogeneity is rich enough to form a temporal basis for the accumulated evidence, estimated from a latent variable model.

The temporal heterogeneity in the coding of accumulated evidence suggests that the brain does not rely on a single mechanism or representation to evaluate information, but rather on a dynamic combination of different neural processes. This perspective can be applied to the way people process and are persuaded by arguments, suggesting that presenting evidence in different ways and at different times can be more effective than simply repeating a single argument.

Practical example: Imagine a lawyer presenting a case to a jury. Instead of simply repeating the same points over and over again, the lawyer can present different types of evidence (witness statements, physical evidence, circumstantial evidence) at different points in the trial. This heterogeneous approach can be more effective in persuading the jury, as it aligns with the way the brain naturally processes and accumulates information.

REGIONAL SPECIALIZATION AND PLASTICITY OF MICROGLIA IN THE BASAL GANGLIA: IMPLICATIONS FOR THE NEUROSCIENCE OF PERSUASION

De Biase et al. (2017) explored the regional heterogeneity of microglia phenotypes in different nuclei of the basal ganglia (BG) in mice. The authors found that the anatomical features, lysosome content, membrane properties and transcriptomes of microglia differ significantly between GB nuclei. These regionally specific features emerge during the second postnatal week and are re-established after microglial ablation and repopulation in adults, indicating that local cues play a continuous role in shaping microglial diversity.

The regional specialization of microglia suggests that the brain's response to external stimuli, such as arguments and evidence, can vary depending on the brain region involved. This implies that the way information is presented and the context in which it is received can influence the neural response and, consequently, the process of persuasion.

Practical example: Imagine a patient receiving a medical diagnosis. The way the doctor presents the diagnosis (with empathy, optimism and clear information) and the environment in which the information is transmitted (welcoming office, presence of family members) can influence the patient's emotional and cognitive response, modulating the activity of the microglia and potentially affecting the way the patient processes and accepts the diagnosis

USE OF VISUALS AND NARRATIVES THAT EVOKE POSITIVE EMOTIONS

Baskerville and Douglas (2010) discuss the interaction between dopamine and oxytocin in social behaviors, such as the formation of social bonds and maternal behavior. Dopamine, a key neurotransmitter in the brain's reward system, and oxytocin, a neuropeptide involved in the regulation of social behavior, interact in brain regions such as the nucleus accumbens (NAc) and the ventral tegmental area (VTA) to modulate social behaviors. For example, oxytocin released during mating activates the dopamine reward system, promoting the formation of social bonds.

In the context of argumentative and expository techniques based on neuroscience, the dopamine-ocytokine interaction can be exploited to improve **scientifically-based persuasion**. Since dopamine is involved in the reward system, it can be used to reinforce the message being conveyed, making it more attractive and memorable. Oxytocin, in turn, can be used to increase trust and connection between the speaker and the audience, facilitating persuasion.

Practical example: In a scientific presentation, the use of visuals and narratives that evoke positive emotions can lead to the release of dopamine in the audience's brain, making the presentation more enjoyable and increasing interest in the research being presented. At the same time, using inclusive language and showing empathy can stimulate the release of oxytocin, strengthening the connection between the presenter and the audience and increasing receptivity to the scientific message

NEURAL STUDY OF PERSUASION

Falk et al. (2009) investigated the neurocognitive networks associated with persuasion using functional magnetic resonance imaging (fMRI) in American and Korean participants exposed to persuasive text- and video-based messages. The results revealed a consistent set of brain regions activated during persuasion, including the dorsomedial prefrontal cortex (DMPFC), bilateral posterior superior temporal sulcus (pSTS), bilateral temporal pole (TP) and left ventrolateral prefrontal cortex (VLPFC). These regions are typically involved in social cognition and mentalization, suggesting that persuasion involves considering the other person's perspective and inferring their mental states.

Practical example: When designing an advertising campaign, marketers can use visuals and narratives that activate the brain regions associated with persuasion, such as the DMPFC, pSTS and TP. For example, a commercial showing people using a product and expressing satisfaction can activate the pSTS, which is involved in understanding the emotions and intentions of others. In addition, the narrative of the commercial can be constructed in such a way as to lead the audience to identify with the characters and their needs, activating the DMPFC, which is related to mentalization and perspective-taking.

PERSONAL INVOLVEMENT AS A MODERATOR OF PERSUASION

Petty, Cacioppo and Goldman (1981) investigated how an individual's personal involvement with a topic influences how they are persuaded. Specifically, they examined whether the quality of a message's arguments or the expertise of the message's source would have a greater impact on persuasion under

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different levels of involvement. The results indicated that when the topic was of high personal relevance, the quality of the arguments was the main determinant of persuasion. However, when the topic was of low personal relevance, the expertise of the source became more influential. This study highlights the importance of considering personal involvement when crafting persuasive messages, suggesting that different approaches may be needed depending on the audience's level of interest in the topic in question.

Practical Example: Imagine you are trying to convince a group of students to support a new recycling program on campus. If the students are already concerned about environmental issues (high involvement), you should focus on presenting solid arguments and convincing data about the benefits of the program. However, if students don't have a particular interest in recycling (low involvement), it may be more effective to emphasize that the program is endorsed by respected environmental experts or organizations

EMPATHY AND SOCIAL COGNITION: A NEUROSCIENCE APPROACH

Schulte-Ruther et al. (2007) investigated the neural mechanisms of empathy in face-to-face interactions, with a focus on theory of mind (ToM) and the mirror neuron system (MNS). Using functional magnetic resonance imaging (fMRI), the authors examined the brain activity of participants while they evaluated emotional facial expressions, both in relation to their own emotional response (self task) and the emotion expressed by the face (other task). The results revealed a common neural network for both tasks, including the medial prefrontal cortex (MPFC) and temporal regions. However, the self task differentially activated the MPFC, the precuneus and the temporoparietal junction, suggesting a crucial role of these areas in emotional self-awareness during empathic interactions. Furthermore, the activation of the MNS in a task involving empathy, without explicit motor components, supports the idea that these neurons are not only linked to motor cognition, but also to emotional interpersonal cognition.

Practical example: Imagine you're talking to a friend who seems sad. In trying to understand his feelings (task of the other), you use ToM to infer what he might be thinking or feeling. Simultaneously, you also experience an emotional response to your friend's sadness (task of the self), possibly mediated by the MNS. The ability to differentiate your own emotion from that of your friend and to switch between these perspectives is crucial for an adequate empathic response.

NEUROSCIENCE OF DECISION MAKING AND INFORMED CONSENT: IMPLICATIONS FOR NEUROETHICS

Northoff (2006) explores the intersection between neuroscience and ethics in the context of informed consent. The author argues that neuroscience can provide empirical criteria for assessing an individual's ability to provide informed consent, particularly in cases of neuropsychiatric illnesses that affect decision-making. However, Northoff emphasizes that neuroscience cannot replace ethics, but rather complement it by providing information on the neural processes underlying decision-making. This approach, which he calls "neuroethics of informed consent", can lead to a more complete and informed understanding of consent in clinical and research contexts.

Practical example: A patient with Alzheimer's whose decision-making capacity is compromised may have difficulty providing valid informed consent to take part in a clinical trial. Neuroscience can help assess the degree of impairment and identify possible interventions to improve the patient's decision-making capacity, contributing to a more ethical and informed consent process.

NEUROIMAGING AND LIE DETECTION: CHALLENGES AND ETHICAL IMPLICATIONS

Farah and Wolpe (2004) explore the use of functional neuroimaging (fMRI) as a potential tool for detecting lies. The authors highlight studies that have investigated the differences in brain activity between individuals who lie and those who tell the truth. However, they emphasize that research is still in its early stages and that there are significant challenges to differentiating intentional lies from the truth, especially in complex, real-world situations. In addition, the authors raise ethical concerns about the use of neuroimaging for forensic purposes, including issues of privacy, informed consent and the potential for error and discrimination.

Practical example**:** An example would be the use of fMRI to determine whether a suspect is lying about their involvement in a crime. However, the accuracy and reliability of this technique are still questionable, and its use raises serious ethical concerns about mental privacy and the right not to incriminate oneself.

EMOTION AND PERSUASION: COGNITIVE AND METACOGNITIVE PROCESSES IMPACTING ATTITUDES

Petty and Briñol (2014) explore the various ways in which emotions can influence attitudes and persuasion through primary and secondary cognition (metacognition). Using the elaboration likelihood model (ELM) as a guide, the authors review evidence for five fundamental processes that occur at different points along the elaboration continuum. When the extent of thinking is constrained to be low, emotions influence attitudes by relatively simple processes, causing them to change in ways consistent with the valence of the emotion. When thinking is limited to being high, emotions can serve as arguments in favor of a proposal if they are relevant to the merits of the defense, or they can bias thinking if the emotion precedes the message. If the thought is loud and the emotions become salient after the thought, they can lead people to trust or not trust the thoughts generated because the emotion leads people to like or dislike their thoughts (affective validation) or to feel more confident or doubtful about their thoughts (cognitive validation). When thinking is not limited, emotions influence the extent of thinking about persuasive communication.

Practical example**:** A practical example of the influence of emotion on persuasion can be seen in ads that use humor to promote a product. If the ad is funny and the person is in a good mood, they are more likely to develop a positive attitude towards the product, even if they don't think much about the arguments presented in the ad. On the other hand, if the person is in a bad mood, the same ad may not have the same effect.

THE EFFECT OF INCIDENTAL EMOTIONS ON RISK PERCEPTION AND HEALTH PERSUASION

Nan (2016) investigated how incidental emotions - specifically fear and anger - influence health risk perception and persuasion. In two experiments, participants were induced to feel fear, anger or a neutral affective state before being exposed to public service announcements about sun protection (Experiment 1) and flossing (Experiment 2). The results revealed that participants with fear perceived a greater susceptibility to the health problem compared to those who felt anger or were in a neutral state. However, anger had no significant effect on risk perception compared to the neutral state. Additionally, there was mixed evidence that fear indirectly influenced the attitude and intention to perform the recommended health behavior through perceived health risk.

Practical example: A public health campaign about the dangers of smoking can evoke fear by showing graphic images of the effects of lung cancer, seeking to increase risk perception and motivate smoking cessation. However, it is important to consider that the effectiveness of this strategy may vary depending on the context and individual characteristics.

NEURAL BASIS OF SOCIAL INFLUENCE AND ATTITUDE CHANGE

Izuma (2013) reviewed social neuroscience studies that investigate the neural mechanisms behind social influence and attitude change. The author highlights the role of the posterior medial prefrontal cortex (pMFC) in social conformity, a process in which people adjust their attitudes to align with group norms. The pMFC is also involved in the motivation for cognitive consistency, which drives people to reduce dissonance between their own opinions and those of others. In addition, research into persuasion, the change in attitude in response to persuasive messages, has revealed the activation of a more anterior part of the medial frontal cortex. Izuma emphasizes the need for future research to differentiate the motivations behind attitude change in different contexts and to use neuroimaging methods to improve psychological theories of social influence.

Practical example: In a jury, a member may initially disagree with the majority opinion. However, the activation of the pMFC, signaling a conflict between the individual's opinion and that of the group, may lead that member to reconsider their position and eventually change their mind to align with the group, exemplifying social conformity.

THE ELABORATION LIKELIHOOD MODEL (ELM) AND THE NEUROSCIENCE OF PERSUASION

The article by Petty and Briñol (2014) does not directly address the neuroscience of persuasion, but the elaboration likelihood model (ELM), which is the focus of the article, has been used in neuroscientific research to understand how persuasive messages are processed in the brain. The ELM posits that persuasion can occur via two routes: the central route, which involves careful and analytical processing of the information in the message, and the peripheral route, which relies on simple cues and heuristics. Neuroimaging studies have investigated which brain regions are activated during persuasive processing, and the results suggest that the central pathway is associated with the activation of regions of the prefrontal cortex, while the peripheral pathway involves the activation of limbic and subcortical regions.

Practical example: A car ad that uses a famous Formula 1 driver as a spokesperson can activate the peripheral pathway, leading to persuasion by associating the car with the driver's prestige and skill. On the other hand, an ad that presents detailed technical data on the car's performance and safety can activate the central pathway, leading to persuasion through rational analysis of the arguments.

THE ROLE OF THE THALAMUS IN MEMORY FORMATION DURING SLEEP

Latchoumane et al. (2017) explore the role of sleep spindles in memory consolidation, a crucial process for learning and persuasion. The research demonstrates that optogenetic stimulation of thalamic spindles, synchronized with the slow waves of sleep, improves

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hippocampus-dependent memory consolidation. This suggests that manipulating brain rhythms during sleep could be a potential technique for strengthening memory and, consequently, increasing the effectiveness of persuasive messages.

The research by Latchoumane et al. (2017) demonstrates how neuroscience can be used to understand and potentially manipulate the brain mechanisms involved in memory formation. Memory consolidation is a fundamental process for persuasion, as persuasive messages need to be remembered to have a lasting impact. By identifying the role of sleep spindles in memory consolidation, the research paves the way for the development of techniques that can optimize information retention and, consequently, increase the effectiveness of persuasion.

Practical example: Imagine that a person is learning to play a new musical instrument. During sleep, stimulating the sleep spindles at the right time could strengthen the consolidation of motor and auditory memories associated with practicing the instrument, potentially leading to faster and more efficient learning.

CONCLUSION

Applying neuroscientific principles to argumentative and expository techniques can significantly increase the effectiveness of persuasive strategies. By understanding the brain mechanisms involved in persuasion, it is possible to develop more effective approaches that combine rational and emotional elements to influence behavior and attitudes in a deeper and more lasting way.

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