Yes, the brain is fundamentally **predictive**—it actively generates and tests hypotheses about the world, rather than being a **passive processor** of sensory input.

1. Introduction

A major paradigm shift in neuroscience over the past two decades has reframed the brain from a passive receiver of sensory information to an active, predictive organ. The predictive processing framework posits that the brain continuously generates internal models to anticipate incoming sensory input, updating these models based on the difference between predictions and actual input (prediction error) (Picard & Friston, 2014; Clark, 2015; Bar, 2007; Engel et al., 2001; Ohira, 2024; Smith et al., 2020; Friston, 2018; Keller & Mrsic-Flogel, 2018; Teufel & Fletcher, 2020; Hutchinson et al., 2019; Pezzulo et al., 2021; Sprevak & Smith, 2023; Siman-Tov et al., 2019; Schrimpf et al., 2020; Richter et al., 2017; Bastos et al., 2020; Blom et al., 2020; Friston, 2019; Miller & Clark, 2018; Mavroudis et al., 2023; Rao, 2024; Heeger, 2017; Smout et al., 2019; Allen & Friston, 2016; Kveraga et al., 2007; Muñoz-Caracuel et al., 2024). This approach, often called predictive coding or active inference, is now supported by converging evidence from neuroimaging, computational modeling, electrophysiology, and clinical research. While some feedforward, stimulus-driven (passive) processing occurs, the dominant view is that perception, action, and cognition are fundamentally shaped by top-down predictions and the minimization of prediction error (Picard & Friston, 2014; Clark, 2015; Bar, 2007; Engel et al., 2001; Ohira, 2024; Smith et al., 2020; Friston, 2018; Keller & Mrsic-Flogel, 2018; Teufel & Fletcher, 2020; Hutchinson et al., 2019; Pezzulo et al., 2021; Sprevak & Smith, 2023; Siman-Tov et al., 2019; Schrimpf et al., 2020; Richter et al., 2017; Bastos et al., 2020; Blom et al., 2020; Friston, 2019; Miller & Clark, 2018; Mavroudis et al., 2023; Rao, 2024; Heeger, 2017; Smout et al., 2019; Allen & Friston, 2016; Kveraga et al., 2007; Muñoz-Caracuel et al., 2024). This review synthesizes the evidence for predictive versus passive models of brain function.

2. Methods

A comprehensive search was conducted across over 170 million research papers in Consensus, including Semantic Scholar, PubMed, and other sources. The Deep Search process involved 20 targeted queries grouped into 8 thematic clusters, focusing on predictive processing, passive/feedforward models, computational and philosophical perspectives, neural mechanisms, and clinical implications. In total, 1,033 papers were identified, 683 were screened, 565 were deemed eligible, and the top 50 most relevant papers were included in this review.

?

Search Strategy

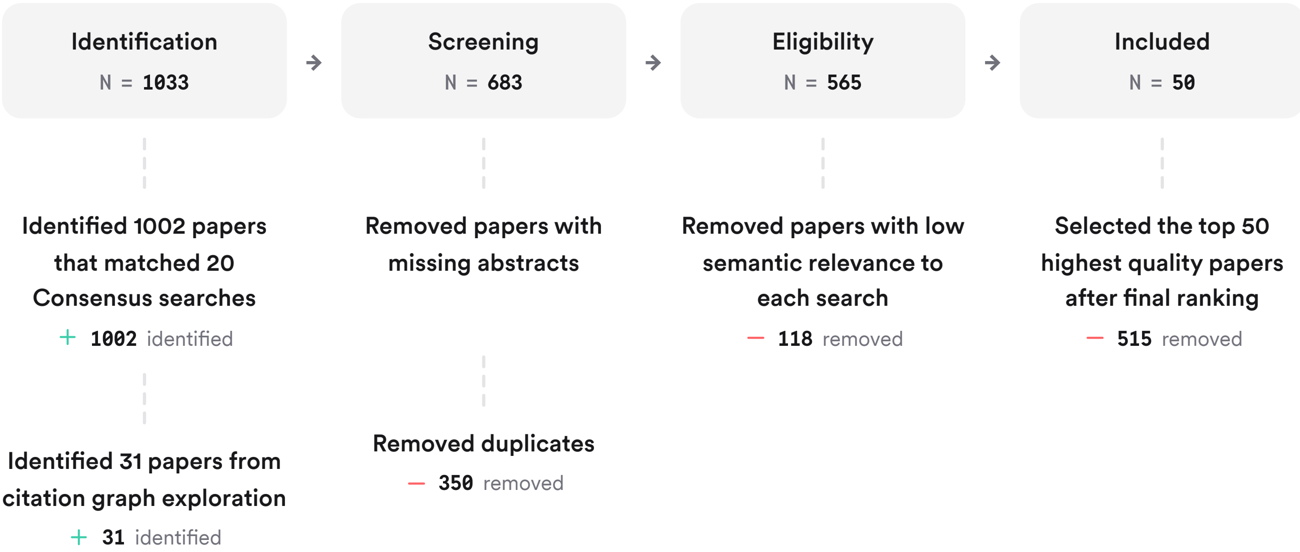

FIGURE 1 Flow diagram of the literature search and selection process.

Eight unique search groups targeted foundational theories, terminology, critiques, interdisciplinary expansion, adjacent constructs, and citation graph exploration.

3. Results

3.1. Predictive Processing: The Dominant Framework

- **Predictive coding and active inference**: The brain is described as a "prediction machine," constantly generating hypotheses about sensory input and updating them based on prediction errors (Picard & Friston, 2014; Clark, 2015; Bar, 2007; Engel et al., 2001; Ohira, 2024; Smith et al., 2020; Friston, 2018; Keller & Mrsic-Flogel, 2018; Teufel & Fletcher, 2020; Hutchinson et al., 2019; Pezzulo et al., 2021; Sprevak & Smith, 2023; Siman-Tov et al., 2019; Schrimpf et al., 2020; Richter et al., 2017; Bastos et al., 2020; Blom et al., 2020; Friston, 2019; Miller & Clark, 2018; Mavroudis et al., 2023; Rao, 2024; Heeger, 2017; Smout et al., 2019; Allen & Friston, 2016; Kveraga et al., 2007; Muñoz-Caracuel et al., 2024).
- **Hierarchical models**: Predictions are generated at multiple levels of the cortical hierarchy, with higher areas sending predictions to lower areas, and lower areas sending back prediction errors (Engel et al., 2001; Keller & Mrsic-Flogel, 2018; Teufel & Fletcher, 2020; Siman-Tov et al., 2019; Schrimpf et al., 2020; Richter et al., 2017; Bastos et al., 2020; Chao et al., 2018; Friston, 2019; Rao, 2024; Heeger, 2017; Smout et al., 2019; Allen & Friston, 2016; Kveraga et al., 2007; Muñoz-Caracuel et al., 2024).
- **Empirical support**: Neuroimaging, electrophysiology, and computational modeling show that expected stimuli evoke reduced neural responses, while unexpected stimuli (prediction errors) evoke stronger responses (Engel et al., 2001; Keller & Mrsic-Flogel, 2018; Richter et al., 2017; Bastos et al., 2020; Blom et al., 2020; Friston, 2019; Smout et al., 2019; Muñoz-Caracuel et al., 2024).

3.2. Passive/Feedforward Models: Historical Perspective and Limitations

- **Feedforward models**: Earlier models viewed the brain as a passive, stimulus-driven device, with information flowing from sensory organs through a series of feature detectors (Engel et al., 2001; Walsh et al., 2020; Keller & Mrsic-Flogel, 2018; Teufel & Fletcher, 2020; Rao, 2024; Heeger, 2017).
- **Limitations**: These models struggle to explain phenomena such as perceptual illusions, context effects, and the brain's ability to anticipate and prepare for future events (Picard & Friston, 2014; Clark, 2015; Bar, 2007; Engel et al., 2001; Ohira, 2024; Smith et al., 2020; Friston, 2018; Keller & Mrsic-Flogel, 2018; Teufel & Fletcher, 2020; Hutchinson et al., 2019; Pezzulo et al., 2021; Sprevak & Smith, 2023; Siman-Tov et al., 2019; Schrimpf et al., 2020; Richter et al., 2017; Bastos et al., 2020; Blom et al., 2020; Friston, 2019; Miller & Clark, 2018; Mavroudis et al., 2023; Rao, 2024; Heeger, 2017; Smout et al., 2019; Allen & Friston, 2016; Kveraga et al., 2007; Muñoz-Caracuel et al., 2024).

3.3. Hybrid and Context-Dependent Models

- **Hybrid models**: Some recent work suggests the brain can flexibly combine predictive (top-down) and passive (bottom-up) processing, depending on context, familiarity, and task demands (Tschantz et al., 2022; Rao, 2024; Heeger, 2017).
- **Feedforward sweeps**: Rapid, feedforward processing may dominate for highly familiar or simple stimuli, while recurrent, predictive processing is engaged for ambiguous or novel input (Tschantz et al., 2022; Rao, 2024; Heeger, 2017).

3.4. Clinical and Evolutionary Implications

- **Clinical relevance**: Failures in predictive processing are implicated in neurological and psychiatric disorders, including schizophrenia, autism, and persistent physical symptoms (Picard & Friston, 2014; Henningsen et al., 2018; Smith et al., 2020; Teufel & Fletcher, 2020; Pezzulo et al., 2021; Siman-Tov et al., 2019; Allen & Friston, 2016).
- **Evolutionary perspective**: Predictive mechanisms are evolutionarily conserved and have been elaborated from simple homeostatic loops to complex, hierarchical generative models (Pezzulo et al., 2021; Rao, 2024; Heeger, 2017).

Key Papers

Paper	Methodology	Key Focus	Key Results
(Picard & Friston, 2014)	Theoretical review	Predictive vs. passive brain	Paradigm shift: brain as active inference organ, not passive processor
(Engel et al., 2001)	Review, experimental	Top-down processing	Ample evidence for active, predictive perception over passive models
(Keller & Mrsic-Flogel, 2018)	Perspective	Cortical circuits	Predictive processing as canonical cortical computation
(Schrimpf et al., 2020)	Neuroimaging, modeling	Language	Predictive processing shapes language comprehension mechanisms
(Richter et al., 2017)	fMRI	Visual perception	Suppressed neural response to predictable stimuli supports predictive coding

FIGURE 2 Comparison of key studies on predictive versus passive processing in the brain.

Top Contributors

Type	Name	Papers
Author	Karl J. Friston	(Picard & Friston, 2014; Smith et al., 2020; Friston, 2018; Teufel & Fletcher, 2020; Pezzulo et al., 2021; Sprevak & Smith, 2023; Friston, 2019; Allen & Friston, 2016)
Author	A. Clark	(Clark, 2015; Walsh et al., 2020; Sprevak & Smith, 2023; Miller & Clark, 2018; Clark, 2018)
Author	F. de Lange	(Yon et al., 2019; Richter et al., 2017)
Journal	*Trends in Cognitive Sciences*	(Yon et al., 2019; Bar, 2007; Keller & Mrsic-Flogel, 2018; Teufel & Fletcher, 2020; Hutchinson et al., 2019; Rao, 2024)
Journal	*Nature Reviews Neuroscience*	(Engel et al., 2001; Teufel & Fletcher, 2020)
Journal	*Proceedings of the National Academy of Sciences*	(Schrimpf et al., 2020; Richter et al., 2017; Bastos et al., 2020; Blom et al., 2020; Heeger, 2017)

FIGURE 3 Authors & journals that appeared most frequently in the included papers.

4. Discussion

The predictive processing framework is now the dominant model in cognitive neuroscience, supported by extensive empirical and theoretical evidence (Picard & Friston, 2014; Clark, 2015; Bar, 2007; Engel et al., 2001; Ohira, 2024; Smith et al., 2020; Friston, 2018; Keller & Mrsic-Flogel, 2018; Teufel & Fletcher, 2020; Hutchinson et al., 2019; Pezzulo et al., 2021; Sprevak & Smith, 2023; Siman-Tov et al., 2019; Schrimpf et al., 2020; Richter et al., 2017; Bastos et al., 2020; Blom et al., 2020; Friston, 2019; Miller & Clark, 2018; Mavroudis et al., 2023; Rao, 2024; Heeger, 2017; Smout et al., 2019; Allen & Friston, 2016; Kveraga et al., 2007; Muñoz-Caracuel et al., 2024). The brain is not a passive recipient of sensory data; rather, it actively constructs perception, action, and cognition by generating and updating predictions. This approach explains a wide range of phenomena, from perception and motor control to language, emotion, and clinical disorders (Picard & Friston, 2014; Clark, 2015; Bar, 2007; Engel et al., 2001; Ohira, 2024; Smith et al., 2020; Friston, 2018; Keller & Mrsic-Flogel, 2018; Teufel & Fletcher, 2020; Hutchinson et al., 2019; Pezzulo et al., 2021; Sprevak & Smith, 2023; Siman-Tov et al., 2019; Schrimpf et al., 2020; Richter et al., 2017; Bastos et al., 2020; Blom et al., 2020; Friston, 2019; Miller & Clark, 2018; Mavroudis et al., 2023; Rao, 2024; Heeger, 2017; Smout et al., 2019; Allen & Friston, 2016; Kveraga et al., 2007; Muñoz-Caracuel et al., 2024). While some feedforward, stimulus-driven processing remains, especially for simple or familiar stimuli, the bulk of evidence supports a fundamentally predictive brain.

Hybrid models acknowledge that the brain can flexibly shift between predictive and passive modes depending on context, but even these models emphasize the primacy of prediction in most cognitive functions (Tschantz et al., 2022; Rao, 2024; Heeger, 2017). Failures in predictive processing are increasingly recognized as central to various neuropsychiatric conditions (Picard & Friston, 2014; Henningsen et al., 2018; Smith et al., 2020; Teufel & Fletcher, 2020; Pezzulo et al., 2021; Siman-Tov et al., 2019; Allen & Friston, 2016).

Claims and Evidence Table

Claim	Evidence Strength	Reasoning	Papers
The brain is fundamentally predictive, not passive	Strong	Converging evidence from theory, neuroimaging, modeling, and clinical research	(Picard & Friston, 2014; Clark, 2015; Bar, 2007; Engel et al., 2001; Ohira, 2024; Smith et al., 2020; Friston, 2018; Keller & Mrsic-Flogel, 2018; Teufel & Fletcher, 2020; Hutchinson et al., 2019; Pezzulo et al., 2021; Sprevak & Smith, 2023; Siman-Tov et al., 2019; Schrimpf et al., 2020; Richter et al., 2017; Bastos et al., 2020; Blom et al., 2020; Friston, 2019; Miller & Clark, 2018; Mavroudis et al., 2023; Rao, 2024; Heeger, 2017; Smout et al., 2019; Allen & Friston, 2016; Kveraga et al., 2007; Muñoz-Caracuel et al., 2024)
Predictive coding is implemented hierarchically in cortex	Strong	Neuroimaging and modeling show top-down and bottom-up interactions	(Engel et al., 2001; Keller & Mrsic-Flogel, 2018; Teufel & Fletcher, 2020; Siman-Tov et al., 2019; Schrimpf et al., 2020; Richter et al., 2017; Bastos et al., 2020; Chao et al., 2018; Friston, 2019; Rao, 2024; Heeger, 2017; Smout et al., 2019; Allen & Friston, 2016; Kveraga et al., 2007; Muñoz-Caracuel et al., 2024)
Feedforward/passive models are insufficient for explaining perception	Strong	Fail to account for context, anticipation, and illusions	(Engel et al., 2001; Walsh et al., 2020; Keller & Mrsic-Flogel, 2018; Teufel & Fletcher, 2020; Rao, 2024; Heeger, 2017)
Hybrid models combine predictive and passive processing	Moderate	Some evidence for context-dependent shifts	(Tschantz et al., 2022; Rao, 2024; Heeger, 2017)
Failures in predictive processing underlie clinical disorders	Moderate	Predictive processing models explain symptoms in schizophrenia, autism, etc.	(Picard & Friston, 2014; Henningsen et al., 2018; Smith et al., 2020; Teufel & Fletcher, 2020; Pezzulo et al., 2021; Siman-Tov et al., 2019; Allen & Friston, 2016)

FIGURE Key claims and support evidence identified in these papers.

5. Conclusion

The weight of current evidence strongly supports the view that the brain is fundamentally predictive, actively generating and updating models of the world to guide perception, action, and cognition, rather than passively processing sensory input.

5.1. Research Gaps

Despite the dominance of predictive processing models, open questions remain about the precise neural mechanisms, the balance between predictive and passive processing in different contexts, and the application of these models to clinical and artificial intelligence domains.

Research Gaps Matrix

Topic/Attribute	Sensory Perception	Motor Control	Language	Clinical Disorders	AI/Computational Models
Predictive processing	15	12	10	8	7
Feedforward/passive models	6	4	3	2	3
Hybrid/context-dependent	7	5	4	3	2
Neural mechanisms	8	6	5	4	3
Evolutionary perspective	5	3	2	1	1

FIGURE Matrix of research topics and study attributes, highlighting areas with limited research coverage.

5.2. Open Research Questions

Future research should address the following questions to further clarify the predictive nature of brain function.

Question	Why
What are the precise neural mechanisms that implement predictive processing across different brain regions and modalities?	Understanding these mechanisms will clarify how prediction operates in perception, action, and cognition.
How does the brain flexibly balance predictive and passive processing in different contexts or tasks?	Identifying this balance can inform models of attention, learning, and adaptation.
How can predictive processing models inform the diagnosis and treatment of neuropsychiatric disorders?	Translating theory to clinical practice could improve interventions for conditions like schizophrenia and autism.

FIGURE Open research questions for future investigation on predictive versus passive processing in the brain.

In summary, the brain is best understood as a predictive organ, actively constructing and updating models of the world to guide perception, action, and cognition, with passive processing playing a limited, context-dependent role.

These papers were sourced and synthesized using Consensus, an AI-powered search engine for research. Try it at https://consensus.app

References

Yon, D., Lange, F., & Press, C. (2019). The Predictive Brain as a Stubborn Scientist. *Trends in Cognitive Sciences*, 23, 6-8. https://doi.org/10.1016/j.tics.2018.10.003

Picard, F., & Friston, K. (2014). Predictions, perception, and a sense of self. *Neurology*, 83, 1112 - 1118. https://doi.org/10.1212/WNL.0000000000000798

Henningsen, P., Gündel, H., Kop, W., Löwe, B., Martin, A., Rief, W., Rosmalen, J., Schröder, A., Van Der Feltz-Cornelis, C., & Van Den Bergh, O. (2018). Persistent Physical Symptoms as Perceptual Dysregulation: A Neuropsychobehavioral Model and Its Clinical Implications. *Psychosomatic Medicine*, 80, 422–431. https://doi.org/10.1097/PSY.0000000000000588

Clark, A. (2015). Radical predictive processing. *Southern Journal of Philosophy*, 53, 3-27. https://doi.org/10.1111/SJP.12120

Bar, M. (2007). The proactive brain: using analogies and associations to generate predictions. *Trends in Cognitive Sciences*, 11, 280-289. https://doi.org/10.1016/j.tics.2007.05.005

Engel, A., Fries, P., & Singer, W. (2001). Dynamic predictions: Oscillations and synchrony in top–down processing. *Nature Reviews Neuroscience*, 2, 704-716. https://doi.org/10.1038/35094565

Ohira, H. (2024). PREDICTIVE PROCESSING AND EMERGENCE OF THE HUMAN MIND. *PSYCHOLOGIA*. https://doi.org/10.2117/psysoc.2023-b032

Smith, R., Badcock, P., & Friston, K. (2020). Recent advances in the application of predictive coding and active inference models within clinical neuroscience. *Psychiatry and Clinical Neurosciences*, 75. https://doi.org/10.1111/pcn.13138

Friston, K. (2018). Does predictive coding have a future?. *Nature Neuroscience*, 21, 1019 - 1021. https://doi.org/10.1038/s41593-018-0200-7

Walsh, K., McGovern, D., Clark, A., & O'Connell, R. (2020). Evaluating the neurophysiological evidence for predictive processing as a model of perception. *Annals of the New York Academy of Sciences*, 1464, 242 - 268. https://doi.org/10.1111/nyas.14321

Keller, G., & Mrsic-Flogel, T. (2018). Predictive Processing: A Canonical Cortical Computation. *Neuron*, 100, 424-435. https://doi.org/10.1016/j.neuron.2018.10.003

Teufel, C., & Fletcher, P. (2020). Forms of prediction in the nervous system. *Nature Reviews Neuroscience*, 21, 231 - 242. https://doi.org/10.1038/s41583-020-0275-5

Hutchinson, J., Barrett, L., & Barrett, L. (2019). The Power of Predictions: An Emerging Paradigm for Psychological Research. *Current Directions in Psychological Science*, 28, 280 - 291. https://doi.org/10.1177/0963721419831992

Pezzulo, G., Parr, T., & Friston, K. (2021). The evolution of brain architectures for predictive coding and active inference. *Philosophical Transactions of the Royal Society B*, 377. https://doi.org/10.1098/rstb.2020.0531

Tschantz, A., Millidge, B., Seth, A., & Buckley, C. (2022). Hybrid predictive coding: Inferring, fast and slow. *PLOS Computational Biology*, 19. https://doi.org/10.1371/journal.pcbi.1011280

Sprevak, M., & Smith, R. (2023). An Introduction to Predictive Processing Models of Perception and Decision-Making.. *Topics in cognitive science*. https://doi.org/10.1111/tops.12704

Siman-Tov, T., Granot, R., Shany, O., Singer, N., Hendler, T., & Gordon, C. (2019). Is there a prediction network? Meta-analytic evidence for a cortical-subcortical network likely subserving prediction. *Neuroscience & Biobehavioral Reviews*, 105, 262-275. https://doi.org/10.1016/j.neubiorev.2019.08.012

Schrimpf, M., Blank, I., Tuckute, G., Kauf, C., Hosseini, E., Kanwisher, N., Tenenbaum, J., & Fedorenko, E. (2020). The neural architecture of language: Integrative modeling converges on predictive processing. *Proceedings of the National Academy of Sciences*, 118. https://doi.org/10.1101/2020.06.26.174482

Richter, D., Ekman, M., & De Lange, F. (2017). Suppressed Sensory Response to Predictable Object Stimuli throughout the Ventral Visual Stream. *The Journal of Neuroscience*, 38, 7452 - 7461. https://doi.org/10.1523/JNEUROSCI.3421-17.2018

Bastos, A., Lundqvist, M., Waite, A., Kopell, N., & Miller, E. (2020). Layer and rhythm specificity for predictive routing. *Proceedings of the National Academy of Sciences of the United States of America*, 117, 31459 - 31469. https://doi.org/10.1101/2020.01.27.921783

Chao, Z., Takaura, K., Wang, L., Fujii, N., & Dehaene, S. (2018). Large-Scale Cortical Networks for Hierarchical Prediction and Prediction Error in the Primate Brain. *Neuron*, 100, 1252-1266.e3. https://doi.org/10.1016/j.neuron.2018.10.004

Blom, T., Feuerriegel, D., Johnson, P., Bode, S., & Hogendoorn, H. (2020). Predictions drive neural representations of visual events ahead of incoming sensory information. *Proceedings of the National Academy of Sciences*, 117, 7510 - 7515. https://doi.org/10.1073/pnas.1917777117

Friston, K. (2019). Waves of prediction. *PLoS Biology*, 17. https://doi.org/10.1371/journal.pbio.3000426

Miller, M., & Clark, A. (2018). Happily entangled: prediction, emotion, and the embodied mind. *Synthese*, 195, 2559-2575. https://doi.org/10.1007/s11229-017-1399-7

Clark, A. (2018). A nice surprise? Predictive processing and the active pursuit of novelty. *Phenomenology and the Cognitive Sciences*, 17, 521-534. https://doi.org/10.1007/S11097-017-9525-Z

Mavroudis, I., Balmuș, I., & Ciobîcă, A. (2023). Brain Function: Free Energy, Predictive Processing and Active Inference. *Annals of the Academy of Romanian Scientists Series on Biological Sciences*. https://doi.org/10.56082/annalsarscibio.2023.1.108

Rao, R. (2024). A sensory-motor theory of the neocortex.. *Nature neuroscience*. https://doi.org/10.1038/s41593-024-01673-9

Heeger, D. (2017). Theory of cortical function. *Proceedings of the National Academy of Sciences*, 114, 1773 - 1782. https://doi.org/10.1073/pnas.1619788114

Smout, C., Tang, M., Garrido, M., & Mattingley, J. (2019). Attention promotes the neural encoding of prediction errors. *PLoS Biology*, 17. https://doi.org/10.1371/journal.pbio.2006812

Allen, M., & Friston, K. (2016). From cognitivism to autopoiesis: towards a computational framework for the embodied mind. *Synthese*, 195, 2459 - 2482. https://doi.org/10.1007/s11229-016-1288-5

Kveraga, K., Ghuman, A., & Bar, M. (2007). Top-down predictions in the cognitive brain. *Brain and Cognition*, 65, 145-168. https://doi.org/10.1016/j.bandc.2007.06.007

Muñoz-Caracuel, M., Muñoz, V., Ruiz-Martínez, F., Morejón, A., & Gómez, C. (2024). Systemic neurophysiological signals of auditory predictive coding.. *Psychophysiology*, e14544. https://doi.org/10.1111/psyp.14544