Valence as a universal principle of binding and weighting

From valence electrons to cognition and ideology

Abstract

This work develops a unified theory of valence as a scale-spanning organizational principle from quantum chemistry to political ideology. Valence is defined as preferential stabilization - a mechanism that begins with energetic preferences in chemical bonds and continues through biochemical affinities and neuromodulatory signaling to cognitive evaluation processes. The central thesis states that ideological beliefs emerge and are stabilized through the same valence-based weighting mechanisms that modulate synaptic plasticity. This perspective explains the persistence and rigidity of political worldviews as natural consequences of neurochemical reinforcement systems, not as cognitive defects. The theory generates testable predictions for pharmacological, psychophysiological, and neuroimaging studies and has implications for therapeutic interventions in ideological rigidity as well as for the design of democratic institutions. In contrast to rationalistic approaches, valence theory emphasizes the fundamental role of emotional evaluation in all human cognition, offering a naturalistic alternative to normative ideals of rational discourse.

Keywords: Valence, Neuromodulation, Ideology, Cognitive Distortion, Three-Factor Learning, Political Cognition

Introduction and theoretical framework

The question of the fundamental mechanisms that give rise to order and structure in complex systems permeates all natural sciences. From quantum chemistry and biochemistry to neuroscience and social psychology, we encounter the same phenomenon over and over again: certain configurations prove to be more stable than others, certain connections form preferentially, and some structures persist over time while others decay. This universal tendency towards preferential stabilization can be conceptualized under the concept of valence – a principle that goes far beyond its original chemical meaning and can be understood as a fundamental organizing mechanism of the living.

The central thesis of this thesis is that valence represents a cross-scale principle that works from quantum chemical binding mechanisms to biochemical affinities and neuronal plasticity to cognitive and ideological structures. This is not a metaphorical transfer, but the manifestation of a uniform weighting principle on different organizational levels of matter and life. What begins at the atomic level as an energetic preference for certain electron configurations continues as biochemical selectivity, manifests as a neuromodulatory signature of synaptic plasticity, and finally culminates in the formation of cognitive and social attractors that shape our thinking and worldviews.

In order to avoid category errors, I differentiate between four uses of the concept of valence and introduce a common weighting theory: Chemical valence as the binding ability of atoms and molecules, based on valence electrons, orbital overlap and binding energy (Pauling, 1960; Atkins & de Paula, 2010). Biochemical affinity as selectivity between macromolecules, formalized via dissociation constants and free enthalpy (Michaelis & Menten, 1913; Monod, Wyman & Changeux, 1965). Neuronal valence as a neuromodulatorically signed signal that modulates synaptic plasticity in a directional way (Hebb, 1949; Schultz, Dayan & Montague, 1997). And finally, cognitive valence as evaluative weights for schemata, narratives and norms (Festinger, 1957; Kunda, 1990).

In all cases, the common denominator is preferential stabilization. Chemical bonding is the elementary form of this preference. Biochemical, neuronal and cognitive systems take this principle to higher scales, where it becomes visible as a weighting mechanism: pathways are signed strengthened or weakened, resulting in directed dynamics and attractor formation.

Quantum Chemical Foundations: Valence as an Energetic Preference

The term valence originally comes from chemistry, where it describes the bonding ability of atoms. However, this seemingly simple definition hides complex quantum mechanical processes that must be understood as the basis for all higher forms of valence. Linus Pauling revolutionized our understanding of chemical bonds by introducing the concept of hybridization, in which atomic orbitals rearrange themselves into new, more energetically favorable configurations (Pauling, 1960). This hybridization explains not only the geometry of molecules, but also their relative stability.

The quantum mechanical basis of valence lies in the overlap of electron wave functions between neighboring atoms. When atomic orbitals overlap, new molecular orbitals are formed, whose energy levels determine whether a bond is thermodynamically favorable. The binding energy, defined as the energy difference between the bound and separate states, represents the quantitative measure of this energetic preference (Atkins & de Paula, 2010). The characteristic pattern of valence is already evident at this elementary level: not all possible configurations are equally likely, but there are clear preferences that are determined by the underlying energetic conditions.

The decisive factor here is the realization that chemical valence is not only a static property, but a dynamic process of continuous optimization. Molecules are in constant thermal motion, and their bonds are constantly formed and broken. Nevertheless, characteristic equilibria are established over longer periods of time, which are determined by the relative bond strengths. This dynamic between flexibility and stability, between exploration and exploitation, can be found at all higher levels of organization.

The thermodynamic laws that determine chemical reactions already lead to a form of "memory" at the molecular level. Catalysts lower activation barriers and make certain reaction pathways more likely than others. Autocatalytic reactions, in which a product promotes its own formation, generate positive feedbacks that can lead to exponential growth processes. This already shows the principle that is later formulated in neural networks as Hebb's rule: "What fires together, wires together" – what is active together reinforces each other.

Biochemical Emergence: From Affinities to Dissipative Structures

The transition from chemistry to biochemistry marks a decisive leap in complexity, in which highly specific molecular recognition systems emerge from simple energetic preferences. Michaelis-Menten kinetics describes how enzymes bind their substrates with characteristic affinity constants (Michaelis & Menten, 1913). These affinities, quantified by dissociation constants (Kd) and free enthalpies (ΔG), represent a refinement of the chemical valence concept. While chemical valence is often non-specific, biochemical valence is characterized by its exquisite selectivity.

Allostery, as described by Jacques Monod and his colleagues, introduces the concept of contextual modulation (Monod, Wyman, & Changeux, 1965). Allosteric proteins can switch between different conformational states, with the binding of a ligand at one site altering the binding properties at other sites. This principle of remote modulation is later implemented in neuronal systems by neuromodulators that are not directly involved in synaptic transmission, but influence its efficiency and plasticity.

Manfred Eigen's work on the self-organization of chemical systems showed how complex, self-replicating structures can emerge from simple autocatalytic reactions (Eigen, 1971). These hypercyclic systems already exhibit all the characteristics that later recur in cognitive and social systems: self-reinforcement, competition for resources, and the emergence of stable attractors in state space. Ilya Prigogine and Grégoire Nicolis extended these insights with their theory of dissipative structures, which shows how systems far from thermodynamic equilibrium can spontaneously form order (Prigogine & Nicolis, 1977).

Stuart Kauffman's concept of "autocatalytic sets" generalizes these principles into a theory of self-organization in biochemical networks (Kauffman, 1993). In such networks, each element catalyzes the formation of other elements, forming self-sustaining cycles. These cycles function as primitive forms of memory and information, as they stabilize certain molecular configurations over time. The crucial point is that this stabilization does not occur through external control, but arises as an emergent property of network dynamics.

Biochemical valence is also manifested in the compartmentalization of cellular processes. Membranes create spatially separated reaction spaces with different chemical milieus, enabling complex signaling cascades. Second messenger systems such as cAMP or calcium signaling transmit information over long distances and coordinate cellular responses. These signaling systems already implement rudimentary forms of evaluation and decision-making: certain signals are amplified, others are attenuated, and the resulting cellular responses reflect this weighted integration of multiple input signals.

Neural valence: neuromodulation and three-factor learning

The transition from biochemical to neuronal systems entails a further qualitative transformation of the valence concept. While biochemical valence is primarily based on molecular specificity, neuronal valence operates via spatially and temporally extended modulation systems. Donald Hebb's famous formulation of associative plasticity – "cells that fire together, wire together" – captured the basic logic of neuronal valence as early as 1949, even if the underlying mechanisms were not understood until decades later (Hebb, 1949).

Modern neuroscience has shown that Hebb's plasticity alone is not sufficient to explain stable memory structures. Pure correlation between pre- and postsynaptic activity would lead to an uncontrolled amplification of all temporally correlated inputs, which would destabilize the system. Instead, three-factor learning rules have proven to be fundamental, in which synaptic plasticity only occurs when a third, modulatory signal is present in addition to pre- and postsynaptic activity (Frémaux & Gerstner, 2016).

This third signal is provided by various neuromodulatory systems: dopamine signals reward prediction errors, norepinephrine marks surprise and attention, serotonin modulates patience and persistence, and acetylcholine regulates the balance between exploration and exploitation. These neuromodulators do not act as punctual signals, but as diffuse fields that affect entire brain regions at the same time (Sara, 2009). This creates system-wide biases that determine which neural pathways are preferentially recruited and reinforced.

Wolfram Schultz and his colleagues revolutionized our understanding of dopaminergic modulation by discovering that dopamine neurons do not encode reward per se, but prediction errors – the difference between expected and actual reward (Schultz, Dayan & Montague, 1997). This Reward Prediction Error (RPE) serves as a teacher signal for reinforcement learning and explains how organisms learn to predict future rewards and adjust their behavior accordingly. Crucially, the RPE determines not only the direction of learning (positive or negative), but also its intensity.

The formalization of these findings led to the development of elegant mathematical models of synaptic plasticity. The basic equation for three-factor learning is: $\Delta wij = \eta \cdot M(t) \cdot eij(t) - \lambda wij$, where Δwij is the change in synaptic strength, η the learning rate, $M(t)$ is the modulatory signal, $eij(t)$ is the eligibility trace (a measure of the temporally correlated activity of pre- and postsynaptic neurons), and λwij is a forgetting term. This equation captures the essence of neuronal valence: synapses are only permanently altered when their activation coincides with an evaluative signal.

The effect of neuronal valence is particularly elegant in the temporal dynamics of learning. Eligibility traces mark synaptic connections as "eligible" for plasticity, but only for a limited period of time. If a modulatory signal arrives within this critical time window, the synaptic strength is modified according to the valence of the signal (Yagishita et al., 2014). This temporal coupling between activity and evaluation implements a form of causal attribution: synapses that were active shortly before an important event are considered potentially causative and are correspondingly strengthened or weakened.

The spatial organization of neuromodulatory systems reflects the hierarchy of cognitive processes. While local interneurons modulate specific circuits, the large modulatory nuclei – the substantia nigra and ventral tegmental area (dopamine), locus coeruleus (norepinephrine), raphe nuclei (serotonin), and basal forebrain (acetylcholine) – project diffusely into wide areas of the brain (Sara, 2009). This architecture allows global assessments to influence local learning processes, allowing coherent behavioral adaptations to be coordinated across multiple brain regions.

Cognitive valence: emotion as a weighting operator

The transition from neuronal to cognitive valence marks another qualitative transformation, in which neurochemical modulation signals become conscious evaluations and emotions. For a long time, cognitive science has held the idea that emotion and cognition are separate and often antagonistic systems. However, this dichotomy has been refuted by a wealth of empirical evidence showing that emotional valence is an integral part of all cognitive processes.

Luiz Pessoa's influential work on emotion-cognition integration demonstrates that the traditional separation between limbic and cortical systems is neuroscientifically untenable (Pessoa, 2008, 2017). Instead, imaging studies show a massive interconnectedness between brain regions traditionally classified as "emotional" or "cognitive". The amygdala, long thought of as a purely emotional center, turns out to be a complex information processing node that evaluates sensory cues as well as modulates attention and memory (McGaugh, 2004).

James McGaugh's research on the emotional modulation of memory paradigmatically shows how valence influences cognitive processes. Emotionally arousing events are not only remembered better, but also processed differently: They activate the amygdala, which increases consolidation in the hippocampus and cortex via noradrenergic projections. This reinforcement is not unspecific, but selectively affects those aspects of the experience that are considered causally relevant for emotional arousal. In this way, the brain implements a form of causal-correlative filtering, which ensures that behaviorally relevant information is preferentially stored.

The effects of emotional valence on cognition are diverse and systematic. Alice Isen and her colleagues documented how positive affects increase cognitive flexibility, promote creative problem-solving, and increase willingness to cooperate (Ashby, Isen & Turken, 1999). Negative affects, on the other hand, focus attention, increase the thoroughness of information processing, but at the same time reduce flexibility. These differential effects can be understood as adaptive specializations: positive affects signal safe environments in which exploration is worthwhile, while negative affects indicate threats that require focused attention and conservative strategies.

Norbert Schwarz and Gerald Clore's "affect-as-information" theory formalizes how emotional states serve as heuristic signals for cognitive evaluations (Schwarz & Clore, 1983). People use their current mood as information about the quality of their environment and their decisions. Good mood is interpreted as an indicator of successful adaptation and leads to more optimistic judgments and risk-taking behavior. Bad mood signals problems and motivates a more cautious, analytical approach.

These findings converge into a picture of cognition in which emotion functions not as a disruptive factor, but as an essential weighting operator. All cognitive content – be it a memory, a belief or a perception – is associated with an emotional valence that influences its processing. Positive valence increases the likelihood that a piece of content will be retrieved, developed, and integrated into future decisions. Negative valence leads to avoidance, suppression or revision of the corresponding content.

Motivated cognition and confirmation bias

The finding that cognition is fundamentally valence-driven sheds new light on phenomena such as motivated cognition and confirmation bias. Ziva Kunda's influential analysis of motivated reasoning shows that people do not process information neutrally, but weight it according to their motives and preferences (Kunda, 1990). This finding is often interpreted as irrationality, but in the valence perspective it appears as a natural consequence of the underlying neuronal architecture.

From this point of view, confirmation bias – the tendency to seek, interpret and remember information that supports one's own beliefs – do not represent cognitive defects, but manifestations of valence-weighted information processing. Raymond Nickerson's comprehensive analysis of confirmation bias shows that this tendency is practically universal and manifests itself in all areas of human thought (Nickerson, 1998). People prefer to look for confirmatory evidence, weight supporting information more heavily than contradictory information, and remember confirming details better.

Leon Festinger's theory of cognitive dissonance explains how people deal with conflicting cognitions (Festinger, 1957). Dissonance arises when simultaneously activated cognitive content has different or opposing valences. This situation is neuronally costly and motivates dissonance reduction through reevaluation, rationalization or selective forgetting. The decisive factor here is that the objectively best solution is not necessarily chosen, but the one that gets by with the least revision of existing valence-laden structures.

Drew Westen and his colleagues investigated the neural basis of motivated cognition using functional imaging during a political assessment task (Westen et al., 2006). The results show that different brain regions are active when evaluating one's own candidate than when evaluating the opposing candidate. In particular, the activation of prefrontal control regions is reduced when information is processed that supports one's own political preference, while limbic regions are more activated. This suggests that valence-congruent information requires less cognitive control and instead activates automatic, affect-driven processing pathways.

Tali Sharot's research on optimism bias illustrates how valence-selective attention and memory lead to systematic biases (Sharot et al., 2011). People systematically overestimate the probability of positive events and underestimate the probability of negative future events. Neuroimaging studies can make the network organization of ideological cognition directly visible. Rich club nodes, which act as highly connected hubs, should have higher activation and greater connectivity among ideologically rigid individuals (van den Heuvel & Sporns, 2011). Modularity, a measure of the segregation of network components, should correlate with ideological coherence: highly modularized networks allow for more consistent but less flexible ways of thinking. The default mode network activity during political judgement tasks should reflect valence-congruent self-referentiality.

Methodological Innovations and Experimental Paradigms

The empirical study of valence-based cognition requires methodological approaches that can capture both the temporal dynamics and the multiscale nature of the processes involved. Traditional experimental paradigms based on static stimuli and one-time measurements do not do justice to the complex feedback processes between valence, attention, and memory.

Adaptive experimental designs that adapt stimuli in real time to the individual responses of the test subjects enable the study of the dynamic stabilization of valence-based preferences. Such paradigms can show how initially weak preferences evolve into stable attractors through repeated valence coupling. The temporal resolution of these measurements is crucial, as the critical processes often take place in millisecond to second ranges.

Ecological momentary assessment through mobile technologies adds real-world validation to laboratory research. Smartphone-based experience samples can record how political attitudes change depending on current moods, social contexts and media consumption. GPS data enable the analysis of spatial influences on ideological cognition, while social network data reveal the interpersonal reinforcement of valence-based beliefs.

Computational modeling offers the possibility to formally specify complex hypotheses via valence-based cognition and to generate quantitative predictions. Agent-based models can simulate how ideological attractors spread and stabilize in social networks. Neural network models with implemented three-factor plasticity can deduce the emergence of cognitive biases from basic learning mechanisms. Bayesian models with valence-dependent priors can explain why rational actors come to different conclusions despite identical evidence.

Valence and predictive processing: a critical distinction

An explicit distinction from the currently influential Predictive Processing (PP) theory is necessary, as both approaches have superficial similarities, but pursue fundamentally different explanatory approaches. Andy Clark, Jakob Hohwy, Anil Seth, and others argue that the brain functions fundamentally as a prediction machine that continuously attempts to anticipate sensory inputs through generative models (Clark, 2016; Hohwy, 2013; Seth, 2014).

Karl Friston's Free Energy Principle represents the most mathematically sophisticated version of this theory, claiming that all biological systems are designed to minimize surprising sensory inputs (Friston, 2010). However, this perspective is problematic for several reasons. First, it postulates a teleological orientation of biological systems towards prediction accuracy, without explaining how this teleology might have arisen. Second, it reduces the rich phenomenology of emotional and motivational processes to mathematical optimization problems.

Valence theory explicitly rejects these teleological assumptions. Valence does not arise from the system's "desire" to minimize prediction errors, but from the inherent physico-chemical properties of neurochemical systems. Dopamine neurons fire on unexpected rewards not because the system is "surprised," but because their neurochemical makeup makes them respond to certain stimuli. These reactions evolved because they had adaptive consequences, not because they represent mathematically elegant solutions to inference problems.

Empirically, the limitations of the PP approach are shown in its inability to explain the specific effects of different neuromodulators. Why would a system that is primarily designed for predictive accuracy develop separate systems for dopamine, norepinephrine, serotonin, and acetylcholine? Valence theory explains this diversity by the different adaptive functions of different evaluation dimensions: reward, threat, social bonding, attention, etc.

Integration with evolutionary approaches

Valence theory gains additional plausibility through its compatibility with evolutionary explanatory approaches. Emotions and the evaluation mechanisms that underlie them did not evolve by chance, but reflect the adaptive importance of different environmental situations for the survival and reproduction of our ancestors.

Paul Ekman's research on basic emotions shows that certain emotional expressions and the associated evaluation tendencies are universal across cultures (Ekman, 1992). Fear, anger, disgust, joy, grief and surprise reflect fundamental adaptive challenges: predator avoidance, resource competition, contamination avoidance, social cooperation, loss management and attention orientation. The neurochemical systems that implement these emotions can therefore be understood as evolutionarily calibrated assessment modules.

Leda Cosmides and John Tooby's evolutionary psychology extends this perspective to more complex cognitive processes (Cosmides & Tooby, 1992). Cognitive biases such as confirmation bias or fundamental attribution error do not appear in an evolutionary perspective as irrationality, but as special equipment for the social and ecological challenges of Pleistocene environments. In small groups, where reputation and social alliances were essential for survival, it could be adaptive to favor one's own group and view outgroups skeptically.

Robert Trivers' theory of self-deception offers an evolutionary explanation for the persistence of ideological beliefs (Trivers, 2011). Self-deception can have adaptive advantages if it increases persuasiveness over others. People who are sincerely convinced of their beliefs appear more authentic and are therefore more influential than conscious manipulators. The neurochemical mechanisms of valence may therefore have evolved not only to enable accurate environmental assessments, but also to support persuasive self-presentation.

Social reinforcement and cultural evolution

The collective dimension of valence-based cognition requires an extension of the evolutionary perspective to include cultural evolutionary mechanisms. Rich Boyd and Peter Richerson's theory of double inheritance shows how cultural information is subject to its own evolutionary dynamics, which are different from genetic evolution (Boyd & Richerson, 1985). Ideas, beliefs, and practices can spread, recombine, and mutate horizontally between individuals, creating cultural landscapes comparable to biological ecosystems.

In this perspective, ideological systems function as cultural organisms that compete for the scarce resource of human attention. Successful ideologies are not necessarily those that are objectively true or useful, but those that most effectively exploit the valence-based evaluation mechanisms of human cognition. Conspiracy theories, for example, are often empirically untenable, but psychologically attractive because they trigger strong emotional responses, offer simple explanations for complex phenomena, and reinforce ingroup-outgroup distinctions.

Dan Sperber and Deirdre Wilson's relevance theory explains how cultural information spreads depending on its cognitive relevance (Sperber & Wilson, 1995). Relevance arises from the interaction between the informative content of a message and the cognitive effort required to process it. Valence-laden information has a processing advantage because it activates automatic attention mechanisms and leaves emotionally marked memory traces. Therefore, emotionalizing narratives often spread faster and further than sober facts.

Social media platforms implement technical reinforcement mechanisms that systematically exploit these psychological tendencies. Algorithms maximize engagement by favoring controversial, emotionalizing content. Echo chambers are created by preference-based filtering, which primarily provides users with confirming information. Viral marketing uses the social amplification mechanisms of human psychology to spread commercial and political messages. These technical systems function as artificial selection environments that favor certain types of cultural information and disadvantage others.

Political and social implications

Valence theory has far-reaching implications for the understanding of political processes and democratic institutions. If political beliefs are based primarily on valence-based evaluations and only secondarily on rational evidence consideration, then democratic systems must take these psychological realities into account in order to remain functional.

Deliberative theories of democracy, which are based on the assumption of rational opinion-forming through public discussion, are challenged by the findings on valence-based cognition. Jürgen Habermas' ideal of domination-free discourse presupposes that people are willing and able to revise their convictions in the face of better arguments (Habermas, 1981). However, valence theory shows that this willingness is highly dependent on emotional and motivational factors influenced by the structure of the discourse itself.

Media literacy programs must go beyond the traditional focus on source criticism and fact-checking and also address the emotional and unconscious dimensions of information processing. Citizens need to understand how their own valence-based preferences influence their media reception and develop strategies to fairly evaluate even contradictory information.

Institutional design should take into account the psychological tendencies towards polarization and groupthink. Mechanisms such as random sampling for political offices, various advisory bodies, or structured advocacy processes can help to minimize the negative effects of valence-based biases. Constitutional checks and balances gain additional importance as protection against the destabilizing effects of extreme ideological mobilization.

From Individual to Collective Valence: Ideology as Social Cognition

The transition from individual to collective cognition marks a further increase in complexity, in which valence-based weighting mechanisms manifest themselves at the social level. In this perspective, ideologies can be understood as collective attractors in the space of possible worldviews – stable configurations of beliefs, values and narratives that arise through repeated valence coupling and stabilize themselves.

John Jost and his colleagues developed a comprehensive theory of political ideology that takes into account both motivational and cognitive factors (Jost, Federico, & Napier, 2009). Her research shows that political orientations are not only rational responses to objective conflicts of interest, but also reflect different psychological needs. Conservatives, for example, show a higher sensitivity to threats, a stronger preference for order and security, and a lower tolerance for ambiguity. These differences manifest themselves at the level of perception and attention before conscious political considerations set in.

Henri Tajfel and John Turner's Social Identity Theory explains how group affiliation leads to systematic biases in the perception and evaluation of social information (Tajfel & Turner, 1979). The mere categorization into ingroups and outgroups activates valence-based evaluation mechanisms: ingroup members are perceived more positively, their successes are attributed internally and their failures externally. Outgroup members are treated in reverse. These distortions are not intentional, but arise automatically through the valential marking of group affiliations.

George Lakoff's work on cognitive linguistics shows how linguistic frames structure political perception (Lakoff, 2004). Metaphors are not just stylistic devices, but cognitive tools that determine which aspects of a situation are salient and how they are evaluated. The metaphor "nation as family", for example, activates different moral intuitions, depending on whether an authoritarian or a caring family model is used. These frames act as valential filters that determine which information is perceived as relevant and compelling.

Louis Althusser's concept of ideological state apparatuses captures how social institutions contribute to the reproduction of dominant worldviews (Althusser, 1970). From a valence theory perspective, these institutions function as collective reinforcement systems that repeatedly positively mark certain ways of thinking and values, while alternative perspectives are marginalized or negatively evaluated. In this way, schools, media, religious organizations and other cultural institutions implement system-wide valence fields that shape individual cognition.

Therapeutic and pedagogical implications

The valence theory of ideology has far-reaching implications for therapeutic and educational interventions. If ideological rigidity is based on neurochemical reinforcement mechanisms, then interventions that modulate these mechanisms should be able to increase the flexibility of thought.

Mindfulness-based interventions such as meditation can improve attention regulation and reduce automatic reactivity to emotional stimuli. Sara Lazar and her colleagues showed that regular meditation practice leads to structural changes in prefrontal control regions (Lazar et al., 2005). These changes could improve the top-down regulation of emotional responses and thus increase the ability to fairly evaluate valenzine-congruent information.

Cognitive behavioral therapy is aimed directly at correcting dysfunctional evaluation patterns. Aaron Beck's concept of the cognitive triad – negative views of self, world, and future – can be understood as an example of pathological valence bias (Beck, 1967). Therapeutic techniques such as thought protocols, reality tests, and cognitive restructuring can help make automatic assessments aware and correct.

Exposure therapy uses the principles of associative conditioning to weaken pathological fear associations. Through repeated confrontation with feared stimuli under safe conditions, negative valence associations can be gradually replaced by neutral or positive ones. This principle could possibly be transferred to ideological contexts: Controlled exposure to outgroup members or contradictory evidence could moderate extreme evaluations.

Educational interventions may aim to increase metacognitive awareness of valence-based biases. Critical thinking curricula that explicitly explain confirmation bias, motivated cognition, and emotional influence could have immunizing effects. Perspective-taking exercises, which encourage people to look at situations from different angles, can reduce the rigidity of ideological frames.

Intergroup contact interventions use the power of direct social experiences to break down stereotypes and prejudices. Gordon Allport's contact hypothesis states that prejudice between groups can be reduced by personal contact under favorable conditions (Allport, 1954). From a valence theory point of view, this works by recalibrating automatic evaluation reactions: positive experiences with outgroup members create new, positive valence associations that conflict with existing negative stereotypes.

Immunization mechanisms and attractor stability

A particularly important aspect of ideological systems is their ability to self-stabilize through immunization mechanisms. These mechanisms protect central beliefs from contradictory evidence and ensure that ideological attractors remain stable even under challenging conditions. From the perspective of valence theory, several such mechanisms can be identified.

Affective priming accelerates the processing of valence-congruent information. Russell Fazio and his colleagues showed that settings are automatically activated when corresponding setting objects are perceived (Fazio et al., 1986). This automatic activation influences the subsequent information processing: valence-congruent information is recognized more quickly, better understood and evaluated more positively. This creates a self-serving bias that systematically favors existing beliefs.

Social reinforcement multiplies individual valence preferences through interaction effects. Prestige bias leads to the opinions of high-ranking people being weighted more heavily. Pressure to conform reinforces majority positions at the expense of minority views. Ingroup favoring systematically enhances the arguments of group members. These social reinforcement mechanisms create collective valence fields that go far beyond the sum of individual preferences.

Of particular interest is the role of the noradrenergic system in modulating ideological rigidity. Sara locus coeruleus-noradrenaline system modulates the balance between exploration and exploitation depending on uncertainty and stress (Sara, 2009). Under threat, existing behavioral programs are reinforced and alternative strategies are suppressed. On a cognitive level, this manifests itself as increased rigidity: Under stress, familiar thought patterns are preferred and new information is judged more skeptically. This explains why ideological polarization often increases in times of crisis.

Empirical predictions and testability

The valence theory of ideology generates a set of testable predictions that can be tested using established neuroscientific and psychological methods. These predictions differ systematically from alternative theories and thus allow empirical validation or falsification of the proposed mechanisms.

Pharmacological interventions provide direct access to the neurochemical basis of valence-based cognition. Beta-blockers such as propranolol block the noradrenergic enhancement of emotional memory formation and should therefore reduce the rigidity of ideological judgments (Cahill & McGaugh, 1998). Dopamine agonists and antagonists modulate reward processing and should accordingly influence the evaluation of political information. Serotonin reuptake inhibitors change the balance between patience and impulsivity and should have an impact on the willingness to pursue long-term versus short-term policy goals.

Sleep interventions enable the investigation of consolidation-dependent processes. REM sleep deprivation should impair the solidification of valence-laden political memories and thus increase the flexibility of ideological judgments (Diekelmann & Born, 2010). Conversely, consolidation during sleep should stabilize ideological positions and immunize against subsequent revision.

Psychophysiological measures provide continuous indicators of valential arousal and attention. Pupillometry reflects the activity of the locus coeruleus and should predict when people switch between different ideological frames. Skin conductance and heart rate changes indicate emotional activation and should differentially accompany the processing of valence-congruent versus incongruent political information.

Future perspectives and open research questions

The valence theory of ideology opens up numerous research directions that can deepen the understanding of human cognition and social organization. Technological developments in neuroscience, artificial intelligence, and data analytics are creating new opportunities to study the complex interactions between valence, cognition, and social behavior.

In the future, brain-computer interfaces could provide more direct insights into the real-time dynamics of valence-based cognition. If it becomes possible to continuously monitor neuromodulatory signals, we could observe how ideological beliefs change moment-to-moment depending on social contexts and emotional states. However, such technologies also raise significant ethical questions regarding privacy and mental autonomy.

Artificial Intelligence Systems equipped with valence-based learning mechanisms could serve as model systems for the study of ideological processes. If AI systems develop similar distortions and rigidities as humans, this would support the universality of the proposed mechanisms. At the same time, such systems could also have practical applications, for example as more empathetic and persuasive dialogue partners.

Longitudinal studies across lifespans could shed light on how ideological beliefs develop and stabilize over time. Critical periods in development, during which the system is particularly plastic and can be influenced, could be identified. Such findings would be of great importance for both pedagogical and therapeutic interventions.

Cross-cultural studies can test the extent to which the proposed mechanisms are universal or culturally modulated. Different cultural contexts create different selection environments for ideological content and could therefore generate systematic differences in the characteristics of valence-based cognition.

Conclusion and Synthesis

The valence theory of ideology developed here offers a unified perspective on seemingly disparate phenomena – from chemical bonds to political beliefs. The common thread that connects these different levels is the principle of preferential stabilization: structures reinforced by positive valence coupling persist and expand, while negatively rated configurations are destabilized and eliminated.

This view has several important implications. First, it relativizes the sharp distinction between rationality and irrationality. What often appears as a cognitive distortion or ideological blindness turns out to be a natural consequence of the evolutionarily shaped architecture of human cognition. Second, it focuses on the neurochemical and social mechanisms that implement and modulate these architectures. Third, it opens up new possibilities for intervention that address the underlying evaluation processes rather than just their superficial manifestations.

Valence theory is not a determinism that reduces human thinking to neurochemical processes. Rather, it shows how biological foundations and cultural developments interact in complex feedback loops. Understanding these mechanisms can help to more realistically assess both the possibilities and limitations of human rationality and to develop interventions that are compatible with the nature of our cognitive architecture rather than working against it.

In a time of increasing political polarization and ideological hardening, valence theory offers both diagnostic insights and therapeutic hope. She explains why people are so stubborn in holding beliefs that seem obviously wrong to others, while also showing ways in which this stubbornness could be overcome. The solution lies not in more facts or better arguments, but in changing the valence-based evaluations that determine which facts and arguments are perceived as relevant and convincing.

Ultimately, valence is the hidden weight that determines what survives and thrives in our minds and our societies. His research is not only of scientific interest, but of existential importance for the future of rational discourses and democratic institutions in an increasingly complex and interconnected world. In other words, the brain learns less from bad news than from good news.

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