Review

Not peer-reviewed version

Neural and Psychological Interplay of Emotion, Attention, and Behavior: A Mini-Review

Alexander Sergeivich * , Serik Akhemtova , Elena Rakhmatova

Posted Date: 30 October 2023

doi: 10.20944/preprints202310.1926.v1

Keywords: Emotion Regulation; Attention; Behavioral Science; Clinical implementation

Review

Neural and Psychological Interplay of Emotion, Attention, and Behavior: A Mini-Review

Serik Akhemtova [1], Elena Rakhmatova [1] and Alexander Sergeivich [1,c]

Affiliation:

[1] Division of Clinical Rehabilitation, KIMEP University, 050010, Almaty, KZ

* Correspondence: author: C Division of Clinical Rehabilitation, KIMEP University, 050010, Almaty, KZ
Email: sergeivich73@mail.ru

Abstract: This review explores the complex interrelationships between emotion, attention, and behavior, drawing upon empirical evidence from psychological, neuroscientific, and clinical studies. It delves into the neural mechanisms that underlie these interactions, with a focus on key brain regions such as the prefrontal cortex and amygdala. Clinical cases involving stroke and attention-deficit/hyperactivity disorder (ADHD) are examined to illustrate the real-world implications of these cognitive interactions. The review also discusses the impact of effective emotion regulation strategies and the role of attention as a cognitive mechanism that influences both emotion and behavior. Neuroimaging studies, particularly functional MRI, are highlighted for their role in providing a deeper understanding of these intricate relationships. The review concludes by emphasizing the importance of this triadic relationship in adaptive functioning and its broader implications for mental health, interpersonal relationships, and quality of life.

Keywords: emotion regulation; attention; behavioral science; clinical implementation

Introduction:

The human brain is an intricate organ, comprising an estimated 86 billion neurons interconnected through trillions of synapses. These neural networks facilitate a wide array of cognitive functions, from basic motor skills to complex decision-making processes. Among the myriad of functions regulated by the brain, emotion stands as a pivotal element that significantly influences human behavior. Emotion regulation, although not elaborated here, plays a crucial role in modulating emotional responses, thereby affecting the overall cognitive architecture. Attention, another key cognitive function, is closely intertwined with emotion and contributes to the regulation of behavior. The interplay between emotion, attention, and behavior forms a complex nexus that is critical for adaptive functioning. This review aims to delve into the intricate relationships among these three elements, drawing upon empirical evidence from psychological and neuroscientific studies.

Emotion and emotion regulation are central constructs in psychology, influencing a wide range of cognitive functions and behaviors **[1–7]**. Emotions are complex psychological states that involve a variety of components, including physiological responses, subjective experiences, and expressive behaviors [2]. Emotion regulation refers to the processes by which individuals influence which emotions they have, when they have them, and how they experience and express these emotions. Studies have shown that effective emotion regulation strategies can lead to better mental health outcomes and improved interpersonal relationships [3], [8], [9]. Attention, another cognitive function, is closely related to emotion. For instance, attentional **[10–13]**biases have been observed in individuals with emotional disorders, such as anxiety and depression [14].Behavior, the overt manifestation of underlying psychological processes, is also influenced by emotion and attention, forming a complex interplay that is crucial for adaptive functioning.

Attention serves as the cognitive mechanism that allocates mental resources to relevant stimuli, thereby influencing how we perceive, think, and act. It is a multifaceted construct that includes various types such as selective attention, sustained attention, and divided attention **[15–19]**. The role

 doi:10.20944/preprints202310.1926.v1

of attention in our lives is profound, affecting academic performance, job efficiency, and social interactions. Studies have shown that attention and emotion are closely linked, with emotional stimuli often capturing attention more effectively than neutral stimuli [4]. Furthermore, attention plays a significant role in modulating emotional responses, which in turn, influence behavior. For example, research has demonstrated that attentional control can mitigate the impact of negative emotions on decision-making processes [20].

Behavior encompasses a wide range of activities, from simple reflex actions to complex cognitive functions like problem-solving and decision-making. It is a manifestation of the intricate interplay between various psychological constructs, including emotion and attention. Emotions often serve as motivational drivers that guide behavior [21], while attention acts as a regulatory mechanism that focuses cognitive resources on relevant tasks. Studies have shown that both emotion and attention can independently influence behavior, but their combined effect can be synergistic, leading to more adaptive or maladaptive outcomes [22].

The interplay between attention, behavior, and emotion has been the subject of numerous brain imaging studies and clinical cases. Functional MRI studies have shown that regions such as the prefrontal cortex are involved in emotion regulation and attentional control, thereby influencing behavior [5]. Clinical cases, such as patients with attention-deficit/hyperactivity disorder (ADHD) or emotional disorders, further illustrate the complex relationship between these three constructs [6]. Effective management often requires a multi-faceted approach that addresses emotional regulation, attentional control, and behavioral modification [23].

Neuroimaging studies have been instrumental in elucidating the neural mechanisms that underlie the interplay between emotion, attention, and behavior. For instance, research using fMRI has shown that the amygdala, a region traditionally associated with emotional processing, is also involved in attentional control. The amygdala's activation is often observed in tasks that require emotional attention, suggesting a neural basis for the interaction between emotion and attention [24]. Moreover, the prefrontal cortex (PFC), a region implicated in higher cognitive functions, including attentional control and emotion regulation, has been shown to modulate amygdala activity. Studies indicate that effective emotion regulation strategies, such as cognitive reappraisal, are associated with increased PFC activity and decreased amygdala activity [25].

In the context of behavior, neuroimaging studies have revealed that the striatum and the ventromedial prefrontal cortex (vmPFC) are key regions involved in decision-making processes that are influenced by emotional and attentional factors [26]. For example, individuals with lesions in the vmPFC often exhibit impaired decision-making abilities, particularly in emotionally charged situations, underscoring the role of this region in integrating emotion and cognition to guide behavior [10], [23], [26].

Furthermore, some studies have employed brain imaging techniques to investigate clinical populations, such as individuals with attention-deficit/hyperactivity disorder (ADHD) or emotional disorders like anxiety and depression. These studies often reveal atypical patterns of brain activation, providing a neural basis for the observed disruptions in emotion regulation, attentional control, and behavior and [27].

Stroke can lead to significant behavioral changes, ranging from motor impairments [28], vision **[29–31]**to cognitive and emotional disturbances [32]. The specific behavioral outcomes are largely determined by the location of the stroke in the brain. For instance, strokes affecting the frontal lobes, particularly the prefrontal cortex, often result in changes in executive functions, including attentional control and emotion regulation (Kolb & Whishaw, 1990). Patients may exhibit impulsivity, poor judgment, and emotional lability, which are indicative of compromised prefrontal regulatory mechanisms [33], [34].

Moreover, strokes that impact the limbic system, including the amygdala, can lead to pronounced emotional disturbances, such as heightened anxiety or emotional flatness. These emotional changes can, in turn, affect attentional processes. For example, heightened anxiety may result in an attentional bias towards threat-related stimuli, thereby affecting decision-making and other behaviors [35].

 doi:10.20944/preprints202310.1926.v1

Neuroimaging studies have been instrumental in understanding these behavioral changes. For example, fMRI studies on stroke patients have shown altered patterns of brain activation during tasks that require emotional processing or attentional control, suggesting a reorganization of neural networks post-stroke [36]. These findings have important implications for rehabilitation strategies, as they highlight the plasticity of the brain and the potential for functional recovery through targeted interventions.

Furthermore, clinical case studies have provided valuable insights into the behavioral changes following stroke. For example, patients with damage to the right parietal lobe often exhibit neglect syndrome, a condition characterized by a lack of awareness of one side of space, which has significant implications for attention and consequently, behavior [37].

Stroke can lead to a variety of attentional deficits, depending on the location and extent of the brain lesion. For example, strokes affecting the right parietal lobe often result in neglect syndrome, a condition characterized by a lack of awareness of one side of space. This attentional deficit can have significant repercussions on daily activities, such as driving, reading, and even basic tasks like eating [37]. Similarly, strokes affecting the frontal lobes can lead to deficits in executive attention, manifesting as difficulties in task-switching, planning, and inhibitory control [38].

These attentional changes can also have a cascading effect on emotional regulation and behavior. For instance, impaired attentional control can exacerbate emotional disturbances, as the individual may find it challenging to divert attention away from negative emotional stimuli [35]. This can lead to a vicious cycle where attentional deficits contribute to emotional dysregulation, which in turn affects behavior, such as increased impulsivity or withdrawal from social interactions.

Neuroimaging studies on stroke patients have shown that attentional networks in the brain undergo significant reorganization following the event. For example, fMRI studies have revealed increased activation in the undamaged hemispheres during attentional tasks, suggesting compensatory mechanisms at play [39].

The impact of these attentional changes extends beyond the individual to affect interpersonal relationships and overall quality of life. Rehabilitation strategies often involve cognitive training exercises aimed at improving attentional control, along with pharmacological interventions to manage associated emotional and behavioral symptoms [40].

The intricate interplay between emotion, attention, and behavior serves as a cornerstone in understanding human cognitive architecture. This multifaceted relationship is mediated by complex neural networks, involving key brain regions like the prefrontal cortex, amygdala, and striatum, each contributing to the modulation and expression of these cognitive functions. Neuroimaging studies, particularly functional MRI, have been pivotal in elucidating these neural underpinnings, revealing how these regions interact to influence our emotional states, focus of attention, and consequent behavior.

Conclusion:

The primary aim of this article is to provide a comprehensive review of the complex interrelationships between emotion, attention, and behavior within the framework of cognitive neuroscience and psychology. By synthesizing empirical evidence from various studies, including neuroimaging research and clinical cases, the text seeks to elucidate the neural and psychological mechanisms that underlie these interactions. Furthermore, it aims to highlight the real-world implications of these cognitive functions, particularly in clinical contexts such as stroke and attention-deficit/hyperactivity disorder (ADHD). Ultimately, the text endeavors to contribute to a deeper understanding of these intricate relationships, thereby informing more effective therapeutic interventions and strategies for adaptive functioning.

Clinical cases, such as those involving stroke or attention-deficit/hyperactivity disorder (ADHD), further underscore the complexity of these interactions. Stroke, depending on the location of the brain lesion, can lead to a cascade of deficits in attentional control, emotional regulation, and behavioral outcomes. These deficits not only affect the individual but also have broader implications for interpersonal relationships and overall quality of life. The plasticity of the brain, as evidenced by

 doi:10.20944/preprints202310.1926.v1

neuroimaging studies, offers a glimmer of hope for functional recovery through targeted interventions, including cognitive training and pharmacological treatments.

Moreover, the role of effective emotion regulation strategies, such as cognitive reappraisal, cannot be overstated. These strategies, often mediated by increased prefrontal cortex activity, have been shown to lead to better mental health outcomes and improved interpersonal relationships. Attention serves as a regulatory mechanism, allocating mental resources to stimuli that are most relevant, thereby influencing both emotional responses and behavior. The synergistic effect of emotion and attention on behavior can lead to either adaptive or maladaptive outcomes, making it crucial to understand this relationship in a nuanced manner.

In summary, the complex nexus between emotion, attention, and behavior is critical for adaptive functioning. Understanding this interplay is not just an academic exercise but has profound implications for mental health treatment, educational strategies, and even the legal system. Future research should aim to further dissect these relationships, possibly employing more advanced neuroimaging techniques and machine learning algorithms to analyze the data, thereby paving the way for more effective therapeutic interventions.

Conflics of Interest: Authors declare no conflict of interests

Funding: This research has been founded by grant 1896/2023 "Президенттік зерттеу қоры" by the Presidential fund for research.

Contribution: Authors confirm equal contribution for this project.

References:

1. E. Kalanthroff, "Stop feeling: inhibition of emotional interference following stop-signal trials," *Front. Hum. Neurosci.*, 2013, doi: 10.3389/fnhum.2013.00078.
2. L. Nummenmaa and H. Saarimäki, "Emotions as discrete patterns of systemic activity," *Neurosci. Lett.*, vol. 693, pp. 3–8, 2017, doi: 10.1016/j.neulet.2017.07.012.
3. B. R. Bocanegra and R. Zeelenberg, "Emotion improves and impairs early vision," *Psychol. Sci.*, vol. 20, no. 6, pp. 707–713, Jun. 2009, doi: 10.1111/j.1467-9280.2009.02354.x.
4. A. Öhman, A. Flykt, and F. Esteves, "Emotion drives attention: Detecting the snake in the grass," *J. Exp. Psychol. Gen.*, vol. 130, no. 3, pp. 466–478, 2001, doi: 10.1037/0096-3445.130.3.466.
5. K. N. Ochsner, S. A. Bunge, J. J. Gross, and J. D. E. Gabrieli, "Rethinking Feelings: An fMRI Study of the Cognitive Regulation of Emotion," *J. Cogn. Neurosci.*, vol. 14, no. 8, pp. 1215–1229, Nov. 2002, doi: 10.1162/089892902760807212.
6. H. Christiansen, O. Hirsch, B. Albrecht, and M.-L. Chavanon, "Attention-Deficit/Hyperactivity Disorder (ADHD) and Emotion Regulation Over the Life Span," *Curr. Psychiatry Rep.*, vol. 21, no. 3, p. 17, Mar. 2019, doi: 10.1007/s11920-019-1003-6.
7. M. Ahsan Khodami, M. Hassan Seif, R. Sadat Koochakzadeh, R. Fathi, and H. Kaur, "Perceived stress, emotion regulation and quality of life during the Covid-19 outbreak: A multi-cultural online survey," *Ann. Méd.-Psychol. Rev. Psychiatr.*, vol. 180, no. 6, pp. 514–518, Jun. 2022, doi: 10.1016/j.amp.2021.02.005.
8. M. A. Khodami and L. Sheibani, "An investigation on Negative Activity, Alexithymia, Emotion Regulation, and Internet addiction in a sample of high school students: A randomized controlled trial," *Ann. Méd.-Psychol. Rev. Psychiatr.*, vol. 178, no. 6, pp. 624–631, Jun. 2020, doi: 10.1016/j.amp.2019.10.007.
9. W. C. Lewis, "The development of the language of emotions.," *Am. J. Psychiatry*, 1971.
10. B. G. Ciesielski, T. Armstrong, D. Zald, and B. Olatunji, "Emotion Modulation of Visual Attention: Categorical and Temporal Characteristics," *PLoS ONE*, vol. 5, 2010, doi: 10.1371/journal.pone.0013860.
11. M. A. Khodami, S. M. Hosseini, S. Bagheri, and S. Kireeva, "associations between recurrent COVID-19, attention and mental health: a longitudinal study." PsyArXiv, Aug. 02, 2023. doi: 10.31234/osf.io/msx69.
12. N. Srinivasan and R. Gupta, "Emotion-attention interactions in recognition memory for distractor faces.," *Emotion*, vol. 10 2, pp. 207–15, 2010, doi: 10.1037/a0018487.
13. R. Vimal, "Attention and Emotion," vol. 10, 2008, doi: 10.5016/1806-8774.2008.V10P84.
14. Y. Bar-Haim, D. Lamy, L. Pergamin, M. J. Bakermans-Kranenburg, and M. H. van IJzendoorn, "Threat-related attentional bias in anxious and nonanxious individuals: A meta-analytic study," *Psychol. Bull.*, vol. 133, no. 1, pp. 1–24, 2007, doi: 10.1037/0033-2909.133.1.1.

15. E. Battistoni, T. Stein, and M. Peelen, "Preparatory attention in visual cortex," *Ann. N. Y. Acad. Sci.*, vol. 1396, 2017, doi: 10.1111/nyas.13320.
16. G. Boynton, "A framework for describing the effects of attention on visual responses," *Vision Res.*, vol. 49, pp. 1129–1143, 2009, doi: 10.1016/j.visres.2008.11.001.
17. B. Hommel, C. S. Chapman, P. Cisek, H. F. Neyedli, J.-H. Song, and T. Welsh, "No one knows what attention is," *Atten. Percept. Psychophys.*, vol. 81, pp. 2288–2303, 2019, doi: 10.3758/s13414-019-01846-w.
18. G. Logan and N. J. Zbrodoff, "Selection for Cognition: Cognitive Constraints on Visual Spatial Attention," *Vis. Cogn.*, vol. 6, pp. 55–81, 1999, doi: 10.1080/713756797.
19. M. Mancas, "What Is Attention," pp. 9–20, 2016, doi: 10.1007/978-1-4939-3435-5_2.
20. L. Pessoa, "How do emotion and motivation direct executive control?," *Trends Cogn. Sci.*, vol. 13, no. 4, pp. 160–166, Apr. 2009, doi: 10.1016/j.tics.2009.01.006.
21. B. Scott-Parker, "Emotions, behaviour, and the adolescent driver: A literature review," *Transp. Res. Part F Traffic Psychol. Behav.*, vol. 50, pp. 1–37, Oct. 2017, doi: 10.1016/j.trf.2017.06.019.
22. R. J. Davidson *et al.*, "Neural and behavioral substrates of mood and mood regulation," *Biol. Psychiatry*, vol. 52, no. 6, pp. 478–502, Sep. 2002, doi: 10.1016/S0006-3223(02)01458-0.
23. L. D. C. Leventhal Howard, "Self-regulation, health, and illness: An overview," in *The Self-Regulation of Health and Illness Behaviour*, Routledge, 2002.
24. P. Vuilleumier, "How brains beware: neural mechanisms of emotional attention," *Trends Cogn. Sci.*, vol. 9, no. 12, pp. 585–594, Dec. 2005, doi: 10.1016/j.tics.2005.10.011.
25. I. L. Lamont, P. A. Beare, U. Ochsner, A. I. Vasil, and M. L. Vasil, "Siderophore-mediated signaling regulates virulence factor production in Pseudomonas aeruginosa," *Proc. Natl. Acad. Sci.*, vol. 99, no. 10, pp. 7072–7077, May 2002, doi: 10.1073/pnas.092016999.
26. A. Bechara, H. Damasio, D. Tranel, and A. R. Damasio, "Deciding Advantageously Before Knowing the Advantageous Strategy," *Science*, vol. 275, no. 5304, pp. 1293–1295, Feb. 1997, doi: 10.1126/science.275.5304.1293.
27. L. Seidman, E. Valera, and N. Makris, "Structural Brain Imaging of Attention-Deficit/Hyperactivity Disorder," *Biol. Psychiatry*, vol. 57, pp. 1263–1272, 2005, doi: 10.1016/j.biopsych.2004.11.019.
28. A. Rehme and C. Grefkes, "Cerebral network disorders after stroke: evidence from imaging-based connectivity analyses of active and resting brain states in humans," *J. Physiol.*, vol. 591, 2013, doi: 10.1113/jphysiol.2012.243469.
29. T. Iizuka, F. Sakai, S. Kan, and N. Suzuki, "Slowly progressive spread of the stroke-like lesions in MELAS.," *Neurology*, vol. 61, no. 9, pp. 1238–1244, Nov. 2003, doi: 10.1212/01.wnl.0000091888.26232.fe.
30. M. A. Khodami, E. Altieri, and L. Battaglini, "Hemianopia Rehabilitation: From Lab to Life, The Missing Piece." Preprints, Jun. 22, 2023. doi: 10.20944/preprints202306.1596.v1.
31. K. M. Sand, A. Midelfart, L. Thomassen, A. Melms, H. Wilhelm, and J. M. Hoff, "Visual impairment in stroke patients--a review," *Acta Neurol. Scand. Suppl.*, no. 196, pp. 52–56, 2013, doi: 10.1111/ane.12050.
32. D. Aschwanden, M. Kliegel, and M. Allemand, "Cognitive Complaints Mediate the Effect of Cognition on Emotional Stability Across 12 Years in Old Age," *Psychol. Aging*, vol. 33, pp. 425–438, 2018, doi: 10.1037/pag0000246.
33. H. I. O. BRAIN, "Neuroanatomy/neuropsychology," *Handb. Neurosci. Behav. Sci. Vol. 1*, vol. 1, p. 136, 2009.
34. G. A. Metz, B. Kolb, and I. Q. Whishaw, "Neuropsychological tests," in *The behavior of the laboratory rat: a handbook with tests*, Oxford University Press New York, 2005. Accessed: Oct. 27, 2023. [Online]. Available: https://books.google.com/books?hl=en&lr=&id=S_B0awYlnbQC&oi=fnd&pg=PA475&dq=kolb+whishaw+human+neuropsychology&ots=IgjfDE2s41&sig=8ve5E7JMNqU2uuX95KeebnTnsoU
35. M. Mather and M. Knight, "Goal-directed memory: The role of cognitive control in older adults' emotional memory," *Psychol. Aging*, vol. 20, no. 4, pp. 554–570, 2005, doi: 10.1037/0882-7974.20.4.554.
36. D. Saur *et al.*, "Dynamics of language reorganization after stroke," *Brain*, vol. 129, no. 6, pp. 1371–1384, Jun. 2006, doi: 10.1093/brain/awl090.
37. M. K. M. Heilman and E. V. MD, *Clinical Neuropsychology*. Oxford University Press, 2010.
38. D. T. Stuss and M. P. Alexander, "Is there a dysexecutive syndrome?," *Philos. Trans. R. Soc. B Biol. Sci.*, vol. 362, no. 1481, pp. 901–915, Apr. 2007, doi: 10.1098/rstb.2007.2096.
39. M. Corbetta, M. J. Kincade, C. Lewis, A. Z. Snyder, and A. Sapir, "Neural basis and recovery of spatial attention deficits in spatial neglect," *Nat. Neurosci.*, vol. 8, no. 11, Art. no. 11, Nov. 2005, doi: 10.1038/nn1574.
40. K. D. Cicerone *et al.*, "Evidence-Based Cognitive Rehabilitation: Updated Review of the Literature From 1998 Through 2002," *Arch. Phys. Med. Rehabil.*, vol. 86, no. 8, pp. 1681–1692, Aug. 2005, doi: 10.1016/j.apmr.2005.03.024.