Neurochemical Responses During Stress, Salience, and Spontaneously Elicited Discrete Emotions

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DISCLAIMER – I relied heavily on searches using artificial intelligence to develop this report. I did retrieve all the articles cited below and did a cursory review of them to ensure they were accurately described. Still, I am not an expert in this area and would refer to others who are for confirmation.

Introduction

This document summarizes the literature concerning the neurochemical literature on emotions, with particular emphasis on studies that examine neurochemical responses during naturally occurring or spontaneously elicited emotional experiences. The literature can be divided into two broad domains: (1) stress/salience neurochemistry and (2) discrete emotion neurochemistry.

Stress and Salience Neurochemistry

Core Question:

How do neurochemical systems respond to psychologically important, stressful, threatening, or motivationally significant events? Representative studies include:

- Pruessner et al. (2004)
- Soliman et al. (2008)
- Dedovic et al. (2005)

Major Findings:

1. Psychological stress reliably produces dopamine release in the ventral striatum
2. Dopamine responses are closely coupled with cortisol responses
3. Neurochemical responses track motivational salience and psychological significance rather than pleasure alone
4. Individual differences in stress responsivity are associated with variability in dopamine responses

Overall Conclusion:

This literature suggests that dopamine functions as a general-purpose salience system that responds to important events regardless of whether they are pleasant or unpleasant. These findings support motivational, salience, and reinforcement-learning models.

One limitation of these studies was that they studied the undifferentiated state of "stress," which can refer to any negative emotion. Thus, I refocused the literature search for studies on discrete emotions.

Discrete Emotion Neurochemistry

Core Question:

How do neurochemical systems respond during recognizable emotional states such as pleasure, love, grief, disgust, and surprise?

Emotion Categories Examined:

- Pleasure/Joy
- Romantic Love and Attachment
- Grief
- Disgust and Aversion
- Novelty and Surprise

General Finding:

Different emotional states recruit overlapping neurochemical systems, particularly dopaminergic circuits. These emotions appear to differ in the configuration, timing, and contextual organization of those systems rather than in unique neurotransmitters.

Pleasure and Joy

Koepp et al. (1998). Evidence for Striatal Dopamine Release During a Video Game. Demonstrated dopamine release during enjoyable video game play.

Blood & Zatorre (2001). Showed that intensely pleasurable musical experiences engage reward-related brain systems.

Salimpoor et al. (2011). Demonstrated dopamine release during both anticipation and peak emotional experiences ('chills') induced by music.

Summary: Pleasure appears to involve coordinated activation of mesolimbic dopamine systems with distinct anticipatory and consummatory phases.

Romantic Love and Attachment

Bartels & Zeki (2000). The Neural Basis of Romantic Love.

Bartels & Zeki (2004). The Neural Correlates of Maternal and Romantic Love.

Fisher, Aron, & Brown (2006). Romantic Love: A Mammalian Brain System for Mate Choice.

Summary: Romantic love and attachment consistently recruit dopamine-rich reward and motivational systems. These findings suggest that love is not simply positive affect but a biologically organized motivational and attachment state.

Grief

O'Connor et al. (2008). Bereaved individuals exposed to reminders of deceased loved ones showed activation in reward-related circuitry.

Summary: Grief appears to involve continued engagement of attachment and reward systems. These findings suggest that grief cannot be understood solely as sadness and may reflect persistent attachment-related motivational processes.

Disgust and Aversion

Zald & Pardo (1997). Examined emotional responses to aversive olfactory stimuli and demonstrated amygdala involvement.

Zald et al. (2004). Showed dopamine-related responses during aversive stimulation.

Summary: Disgust and aversion engage salience systems, sensory evaluation systems, and dopamine-related mechanisms. Dopamine appears to participate in aversive as well as rewarding experiences.

Novelty and Surprise

Bunzeck & Düzel (2006). Demonstrated activation of substantia nigra and ventral tegmental regions during exposure to novel stimuli.

Summary: Novelty and surprise recruit dopamine-related systems associated with learning, prediction error, and environmental updating.

Although the above set of studies were on discrete emotions, I further limited the review to studies that examined spontaneously elicited discrete emotions.

Spontaneously Elicited Discrete Emotion Studies

The strongest evidence comes from studies that used naturally meaningful stimuli rather than instructions to imagine or report emotions.

Included Studies:

Pleasure/Joy:

- Koepp et al. (1998)
- Blood & Zatorre (2001)
- Salimpoor et al. (2011)

Romantic Love:

- Bartels & Zeki (2000)
- Bartels & Zeki (2004)
- Fisher et al. (2005)

Grief:

- O'Connor et al. (2008)

Disgust/Aversion:

- Zald & Pardo (1997)
- Zald et al. (2004)

Novelty/Surprise:

- Bunzeck & Düzel (2006)

Shared Characteristics:

- Personally meaningful stimuli
- Music-induced emotion
- Romantic partner cues

- Bereavement reminders
- Aversive odors
- Genuine novelty

These paradigms produce emotional states that arise naturally from engagement with meaningful stimuli rather than from explicit instruction.

Theoretical Implications and Conclusion

The evidence argues against simple one-emotion/one-neurochemical models but remains compatible with biologically organized discrete emotions if those emotions are defined by multivariate physiological patterns rather than unique chemical signatures. The strongest evidence for spontaneously elicited emotional neurochemistry comes from studies of pleasure, romantic love, grief, disgust/aversion, and novelty. Across these studies, dopamine-related systems repeatedly emerge as important components of emotional processing. However, the recurrence of dopamine across emotions does not necessarily imply that emotions are indistinguishable. Rather, the evidence suggests that shared neurochemical systems may be configured differently across emotional states, leaving open both salience-based and discrete-emotion interpretations of the data.