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Commentary

Response to: "The triadic model perspective for the study of adolescent motivated behavior"

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The triadic model by Ernst and colleagues is a foundational theory of brain development that proposes key linkages between adolescent brain function and emotional changes that accompany this phase of the lifespan. Not only has the triadic framework become a 'modern classic' in the field of developmental neuroscience, it has been highly influential in motivating empirical inquiry concerning the relationships between neurodevelopment, brain function, and adolescent behavior. Its importance to the field is undisputable.

The triadic model proposes that adolescent emotion-guided behavior arises, in part, from key developmental shifts in the functional properties of three interacting neural systems: an approach system centered in the striatum, an avoidance system centered in the amygdala, and a control system centered in the prefrontal cortex. Indeed, the functional properties of these brain structures play a key role in shifts in adolescent motivated and emotional behavior, as supported by a broad empirical corpus. However, might recent advances in cognitive neuroscience warrant reconsideration of the proposed structure–function trichotomy?

Since the original triadic model was put forth (Ernst, Pine, & Hardin, 2006), a wave of cognitive neuroscientific research has motivated a more complex, process-oriented view of the function of subcortical structures including the amygdala and striatum. Whereas the amygdala was classically conceptualized as a fear module that mediates avoidance behavior, contemporary work has demonstrated that amygdala responding is better predicted by emotional salience than by a given valence category (Costafreda, Brammer, David, & Fu, 2007). Similarly, early accounts of the striatum as a reward module have been expanded upon to highlight the key role of the striatum in coding not just reward properties of information, but of expectancy (Pagnoni, Zink, Montague, & Berns, 2002) in both appetitive and aversive contexts (Delgado, Li, Schiller, & Phelps, 2008). These and other findings have motivated theoretical shifts away from a modular view of valenced emotion centers of the brain (Lindquist, Wager, Kober, Bliss-Moreau, & Barrett, 2012) and toward a view that emphasizes the sensitivity of these systems to stimulus dimensions of salience and predictability.

Recent advances in computational approaches have emphasized a functionalist perspective whereby emotion inputs – approach and avoidance cues – invoke learning mechanisms that associate environmental cues with positive and negative outcomes, which in turn support emotion-guided behavior. Interestingly, the proposed roles for the amygdala and striatum in learning are complimentary but distinct (Murray, 2007). While both the amygdala and striatum play interactive roles in facilitating emotion-guided learning, the amygdala response is best explained by associative learning computations whereas the striatum signal is tuned to prediction errors – discrepancies between predicted and actual outcomes (Li, Schiller, Schoenbaum, Phelps, & Daw, 2011). Thus, amygdala and striatal function stretches beyond detecting appetitive and aversive cues to guide emotional learning in complex ways.

Importantly, the perspective sketched above remains compatible with empirical evidence suggesting that adolescent emotion-guided behaviors (such as risk-taking and emotional lability) may result, in part, from sensitization of the amygdala and striatum. Cohen et al. (2010) reported exaggerated positive prediction error signaling in the adolescent striatum, which could serve to amplify the strength of positive outcomes on learning, facilitating risk-taking behavior. Though speculative, sensitized amygdala-based associative learning mechanisms could enhance appetitive and aversive associations, thereby strengthening emotional triggers during the adolescent years. In contrast with the valence-specific theories that remained prevalent until recently, the findings described above offer a contemporary viewpoint that holds the potential to refine extant accounts relating neurodevelopment with adolescent emotional behaviors. Our hope is that engaging in critical analysis of these and other perspectives will help to propel theoretical and empirical advances in the nascent and vibrant discipline of adolescent neuroscience.

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