

Development and Definitions of the RDoC Domains and Constructs

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The RDoC framework consists of a matrix where the rows represent specified functional constructs (concepts representing a specified functional dimension of behavior) characterized in aggregate by the genes, molecules, circuits, etc. used to measure it. Constructs are in turn grouped into higher-level domains of functioning, reflecting contemporary knowledge about major systems of emotion, cognition, motivation, and social behavior. Currently, there are five Domains in the RDoC matrix. The definitions of these domains, constructs and sub-constructs (summarized from the workshop on each domain) are provided here:

Negative Valence Systems: Systems primarily responsible for responses to aversive situations or context, such as fear, anxiety, and loss.

Responses to acute threat (Fear): Activation of the brain's defensive motivational system to promote behaviors that protect the organism from perceived danger. Normal fear involves a pattern of adaptive responses to conditioned or unconditioned threat stimuli (exteroceptive or interoceptive). Fear can involve internal representations and cognitive processing, and can be modulated by a variety of factors.

Responses to potential harm (Anxiety): Activation of a brain system in which harm may potentially occur but is distant, ambiguous, or low/uncertain in probability, characterized by a pattern of responses such as enhanced risk assessment (vigilance). These responses to low imminence threats are qualitatively different than the high imminence threat behaviors that characterize fear.

Responses to sustained threat: An aversive emotional state caused by prolonged (i.e., weeks to months) exposure to internal and/or external condition(s), state(s), or stimuli that are adaptive to escape or avoid. The exposure may be actual or anticipated; the changes in affect, cognition, physiology, and behavior caused by sustained threat persist in the absence of the threat, and can be differentiated from those changes evoked by acute threat.

Frustrative non-reward: Reactions elicited in response to withdrawal/prevention of reward, i.e., by the inability to obtain positive rewards following repeated or sustained efforts.

Loss: A state of deprivation of a motivationally significant con-specific, object, or situation. Loss may be social or non-social and may include permanent or sustained loss of shelter, behavioral control, status, loved ones, or relationships. The response to loss may be episodic (e.g., grief) or sustained.

Positive Valence Systems: Systems primarily responsible for responses to positive motivational situations or contexts, such as reward seeking, consummatory behavior, and reward/habit learning.

Approach motivation: A multi-faceted construct involving mechanisms/processes that regulate the direction and maintenance of approach behavior influenced by pre-existing tendencies, learning, memory, stimulus characteristics, and deprivation states. Approach behavior can be directed toward innate or acquired cues (i.e., unconditioned vs. learned stimuli), implicit or explicit goals; it can consist of goal-directed or Pavlovian conditioned responses. Component processes include reward valuation, effort valuation/willingness to work, expectancy/reward prediction error, and action selection/decision making.

Reward valuation: Processes by which the probability and benefits of a prospective outcome are computed and calibrated by reference to external information, social context (e.g., group input, counterfactual comparisons), and/or prior experience. This calibration is influenced by pre-existing biases, learning, memory, stimulus characteristics, and deprivation states. Reward valuation may

involve the assignment of incentive salience to stimuli.

Effort valuation/Willingness to work: Processes by which the cost(s) of obtaining an outcome is computed; tendency to overcome response costs to obtain a reinforcer.

Expectancy/Reward prediction error: A state triggered by exposure to internal or external stimuli, experiences or contexts that predict the possibility of reward. Reward expectation can alter the experience of an outcome and can influence the use of resources (e.g., cognitive resources).

Action selection/Preference-based decision making: Processes involving an evaluation of costs/benefits and occurring in the context of multiple potential choices being available for decision-making.

Initial responsiveness to reward attainment: Mechanisms/processes associated with hedonic responses—as reflected in subjective experiences, behavioral responses, and/or engagement of the neural systems to a positive reinforcer—and culmination of reward seeking.

Sustained/Longer-term responsiveness to reward attainment: Mechanisms/processes associated with the termination of reward seeking, e.g., satisfaction, satiation, regulation of consummatory behavior.

Reward Learning: A process by which organisms acquire information about stimuli, actions, and contexts that predict positive outcomes, and by which behavior is modified when a novel reward occurs or outcomes are better than expected. Reward learning is a type of reinforcement learning, and similar processes may be involved in learning related to negative reinforcement.

Habit: Sequential, repetitive, motor, or cognitive behaviors elicited by external or internal triggers that, once initiated, can go to completion without constant conscious oversight. Habits can be adaptive by virtue of freeing up cognitive resources. Habit formation is a frequent consequence of reward learning, but its expression can become resistant to changes in outcome value. Related behaviors could be pathological expression of a process that under normal circumstances subserves adaptive goals.

Cognitive Systems: Systems responsible for various cognitive processes.

Attention: Attention refers to a range of processes that regulate access to capacity-limited systems, such as awareness, higher perceptual processes, and motor action. The concepts of capacity limitation and competition are inherent to the concepts of selective and divided attention.

Perception: Perception refers to the process(es) that perform computations on sensory data to construct and transform representations of the external environment, acquire information from, and make predictions about, the external world, and guide action.

Declarative Memory: Declarative memory is the acquisition or encoding, storage and consolidation, and retrieval of representations of facts and events. Declarative memory provides the critical substrate for relational representations—i.e., for spatial, temporal, and other contextual relations among items, contributing to representations of events (episodic memory) and the integration and organization of factual knowledge (semantic memory). These representations facilitate the inferential and flexible extraction of new information from these relationships.

Language: Language is a system of shared symbolic representations of the world, the self and abstract concepts that supports thought and communication.

Cognitive Control: A system that modulates the operation of other cognitive and emotional systems, in the service of goal-directed behavior, when prepotent modes of responding are not adequate to meet the demands of the current context. Additionally, control processes are engaged in the case of novel contexts, where appropriate responses need to be selected from among competing alternatives.

Working Memory: Working Memory is the active maintenance and flexible updating of goal/task relevant information (items, goals, strategies, etc.) in a form that has limited capacity and resists interference.

These representations: may involve flexible binding of representations; may be characterized by the absence of external support for the internally maintained representations; and are frequently temporary, though this may be due to ongoing interference. It involves active maintenance, flexible updating, limited capacity, and interference control. For further details, see Working Memory: Workshop Proceedings (July 11-13, 2010) at: <http://www.nimh.nih.gov/research-funding/rdoc/working-memory-workshop-proceedings.shtml>

Systems for Social Processes: Systems that mediate responses to interpersonal settings of various types, including perception and interpretation of others' actions.

Affiliation and Attachment: Affiliation is engagement in positive social interactions with other individuals.

Attachment is selective affiliation as a consequence of the development of a social bond. Affiliation and Attachment are moderated by social information processing (processing of social cues) and social motivation. Affiliation is a behavioral consequence of social motivation and can manifest itself in social approach behaviors. Affiliation and Attachment require detection of and attention to social cues, as well as social learning and memory associated with the formation of relationships. Affiliation and Attachment include both the positive physiological consequences of social interactions and the behavioral and physiological consequences of disruptions to social relationships. Clinical manifestations of disruptions in Affiliation and Attachment include social withdrawal, social indifference and anhedonia, and over-attachment.

Social Communication: A dynamic process that includes both receptive and productive aspects used for exchange of socially relevant information. Social communication is essential for the integration and maintenance of the individual in the social environment. This construct is reciprocal and interactive, and social communication abilities may appear very early in life. Social communication is distinguishable from other cognitive systems (e.g., perception, cognitive control, memory, attention) in that it particularly involves interactions with conspecifics. The underlying neural substrates of social communication evolved to support both automatic/reflexive and volitional control, including the motivation and ability to engage in social communication. Receptive aspects may be implicit or explicit; examples include affect recognition, facial recognition and characterization. Productive aspects include eye contact, expressive reciprocation, and gaze following. Although facial communication was set aside as a separate sub-construct for the purposes of identifying matrix elements, social communication typically utilizes information from several modalities, including facial, vocal, gestural, postural, and olfactory processing.

Social Communication was organized into the following sub-constructs:

Reception of Facial Communication: The capacity to perceive someone's emotional state non-verbally based on facial expressions.

Production of Facial Communication: The capacity to convey one's emotional state non-verbally via facial expression.

Reception of Non-Facial Communication: The capacity to perceive social and emotional information based on modalities other than facial expression, including non-verbal gestures, affective prosody, distress calling, cooing, etc.

Production of Non-Facial Communication: The capacity to express social and emotional information based on modalities other than facial expression, including non-verbal gestures, affective prosody, distress calling, cooing, etc.

Perception and Understanding of Self: The processes and/or representations involved in being aware of, accessing knowledge about, and/or making judgments about the self. These processes/representations can include current cognitive or emotional internal states, traits, and/or abilities, either in isolation or in relationship to others, as well as the mechanisms that support self-awareness, self-monitoring, and self-knowledge. Perception and Understanding of Self was organized into the following sub-constructs:

Agency: The ability to recognize one's self as the agent of one's actions and thoughts, including the recognition of one's own body/body parts.

Self-Knowledge: The ability to make judgments about one's current cognitive or emotional internal states, traits, and/or abilities.

Perception and Understanding of Others: The processes and/or representations involved in being aware of, accessing knowledge about, reasoning about, and/or making judgments about other animate entities, including information about cognitive or emotional states, traits or abilities. Perception and Understanding of Others was organized into the following sub-constructs:

Animacy Perception: The ability to appropriately perceive that another entity is an agent (i.e., has a face, interacts contingently, and exhibits biological motion).

Action Perception: The ability to perceive the purpose of an action being performed by an animate entity.

Understanding Mental States: The ability to make judgments and/or attributions about the mental state of other animate entities that allows one to predict or interpret their behaviors. Mental state refers to intentions, beliefs, desires, and emotions.

Arousal/Regulatory Systems: Systems responsible for generating activation of neural systems as appropriate for various contexts, and providing appropriate homeostatic regulation of such systems as energy balance and

sleep.

Arousal: Arousal is a continuum of sensitivity of the organism to stimuli, both external and internal.

Arousal:

- facilitates interaction with the environment in a context-specific manner (e.g., under conditions of threat, some stimuli must be ignored while sensitivity to and responses to others is enhanced, as exemplified in the startle reflex),

- can be evoked by either external/environmental stimuli or internal stimuli (e.g., emotions and cognition),

- can be modulated by the physical characteristics and motivational significance of stimuli,

- varies along a continuum that can be quantified in any behavioral state, including wakefulness and low-arousal states including sleep, anesthesia, and coma,

- is distinct from motivation and valence but can covary with intensity of motivation and valence,

- may be associated with increased or decreased locomotor activity, and

- can be regulated by homeostatic drives (e.g., hunger, sleep, thirst, sex).

Circadian Rhythms: Circadian Rhythms are endogenous self-sustaining oscillations that organize the timing of biological systems to optimize physiology and behavior, and health.

Circadian Rhythms:

- are synchronized by recurring environmental cues;

- anticipate the external environment;

- allow effective response to challenges and opportunities in the physical and social environment;

- modulate homeostasis within the brain and other (central/peripheral) systems, tissues and organs;

- are evident across levels of organization including molecules, cells, circuits, systems, organisms, and social systems.

Sleep and wakefulness: Sleep and wakefulness are endogenous, recurring, behavioral states that reflect coordinated changes in the dynamic functional organization of the brain and that optimize physiology, behavior, and health. Homeostatic and circadian processes regulate the propensity for wakefulness and sleep.

Sleep:

- is reversible, typically characterized by postural recumbence, behavioral quiescence, and reduced responsiveness;

- has a complex architecture with predictable cycling of NREM/REM states or their developmental equivalents. NREM and REM sleep have distinct neural substrates (circuitry, transmitters, modulators) and EEG oscillatory properties

- intensity and duration is affected by homeostatic regulation;

- is affected by experiences during wakefulness;

- is evident at cellular, circuit, and system levels;

- has restorative and transformative effects that optimize neurobehavioral functions during wakefulness

Learn more about the development of the RDoC matrix.