

Model: Interactive Activation Network Model of Contention Scheduling

Authors		
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<u>Brief Description *</u>	<p>The model attempts to account for the selection of actions within a routinised, habitual, or over-learned, sequence (as in everyday activities such as dressing, grooming, meal preparation and commuting). The model generates goal-directed sequences of "basic-level" actions (fixate-X, grasp, open, pour, etc.) and has been most extensively validated in the domain of action disorganisation following neurological damage (e.g., closed head injury, left-temporo-parietal CVA).</p>	
<u>Narrative *</u>	<p>It is assumed that routine sequential action of the kind that dominates everyday behaviour is controlled through hierarchically organised action schemas, where each schema comprises (a) a goal that the schema might be used to achieve, and (b) a partially ordered sequences of basic actions or sub-goals. Hierarchical structure follows from the goal/sub-goal relations between schemas, while the basic actions in schemas are assumed to make contact with the highest level of the motor control system. Thus, basic actions are at the level of "fixate on X", "grasp", "open", etc. Schemas can be thought of as forming a tree-like structure (though one schema may be on multiple branches). At any time one branch of the tree may be selected, and this branch controls behaviour. Selection is controlled through a mechanism called "contention scheduling", in which nodes corresponding to schemas compete for activation within an interactive activation network. Nodes within the contention scheduling network have activation values that (for implementation purposes) range from zero to one, with a "resting level" of 0.1 (i.e., if a node receives no input then, over time, its activation will settle to 0.1). The activation of each node is affected by five independent sources: (a) top-down activation (including excitation from a super-ordinate schema or deliberate excitation/inhibition from the supervisory system, as described below); (b) bottom-up activation from the current model of the world (reflecting affordances, such as when an object affords grasping or a switch afford pushing); (c) lateral inhibition (i.e., inhibition from nodes corresponding to competing schemas, and proportional to the activation of the competing schema, thus ensuring that multiple competing schemas cannot be simultaneously highly active); (d) self excitation (an excitatory influence that partially counteracts lateral inhibition and ensures that all nodes don't settle to their resting levels); (e) random noise (reflecting assumed variability in the activation propagation process, and essential to prevent activation "ties", which could lead the system to deadlock). When the activation of a node corresponding to a sub-goal exceeds a threshold (of 0.6 to 0.7 in published simulations) the node is selected and top-down excitation is passed to its sub-schemas. When the activation of a node corresponding to a basic action exceeds the selection threshold the basic level action is executed by the motor</p>	

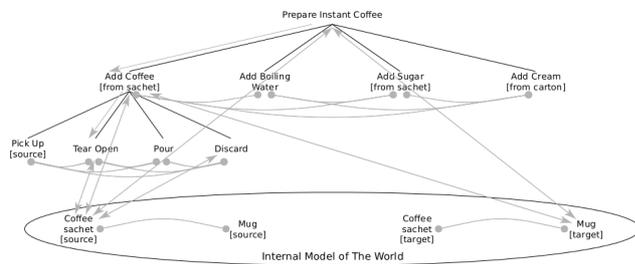
system. Partial ordering of items within a schema is implemented in terms of preconditions and postconditions on items. Thus, if a schema is selected (and hence current behaviour is under the control of that schema) then top-down excitation is only passed to those items sub-schemas have (a) preconditions that are true given the current mode of the world and (b) postconditions that are false given the current model of the world. If the postconditions of a selected schema become true, then the schema is deselected and inhibited, allowing another schema to become selected and take control of behaviour. It is assumed that routine behaviour is under the control of contention scheduling operating autonomously, but that in situations which require deliberate or controlled behaviour activation within the contention scheduling system may be modulated by a high-level system - the supervisory system - which is able to selectively excite or inhibit nodes. Thus, deliberate behaviour occurs not through the deliberate selection of specific actions, but through the deliberate modulation of contention scheduling. This modulation may be impaired in patients with frontal brain injury, leading in those patients to behaviour that is primarily controlled by contention scheduling. This is seen in action disorganisation syndrome (aka Frontal Apraxia), where supervisory processes are impaired, or utilisation behaviour and environmental dependency syndrome where supervisory processes are completely dysfunctional.

Tags

apraxia, interactive activation network, neuropsychology, parietal lobe, prefrontal cortex, routine action selection, schema theory

Architecture

Diagrams



The partial hierarchical structure of schemas involved in preparing instant coffee, together with a partial representation of the internal model of the world and arrows showing influences (grey lines) on the activation of schemas and object representations at a point during preparation of instant coffee (when tearing open the coffee sachet). Within the schema network, each intermediate level schema consists of a (partially ordered) set of lower level schemas. Influences include: top-down influences of schemas on other schemas; bottom-up influences from the representations of objects in the internal model of the world (which are bidirectional); and lateral inhibitory influences between competing schemas. The coffee sachet (as a source) and the mug (as a target) are excited by the Prepare Instant Coffee and the Add Coffee schemas because these schemas require objects with those features in those roles. The coffee sachet (as a source) is additionally excited by the Tear Open schema because (at this point in task execution) it is held. It is excited by the Discard schema for the same reason. For

clarity neither perceptual schemas nor bottom-up influences are shown.

Inputs		
Name	Data Type	Description
Intention	real	Excitation (or inhibition) from the hypothesized supervisory system to one or more schema nodes within the Schema Network
Outputs		
Name	Data Type	Description
Action Sequence	categorical sequence	A sequence of time-stamped actions selected by the model as it performs a routine task
Submodules		
Name	Description	
Effector Network	A set of nodes corresponding to effector subsystems (e.g., hands, feet, eyes, but also possibly cognitive subsystems such as a language understanding subsystem). Each node has an associated activation value (a real number in the range [0.0, 1.0]).	
Object Representation Network	A set of object representation nodes that make up the system's internal model of the world. Each node has a vector of activation levels (real numbers in the range [0.0, 1.0] corresponding to the current salience of the object representation with respect to each of a set of argument roles (e.g., source, target, theme, implement).	
Schema Network	A set of schema nodes, with hierarchical relations between nodes. Each node has a goal, a triggering condition (i.e., a state of the world that activates the schema node), a partially ordered set of subgoals (i.e., the schema's subgoals with ordering constraints), and an activation value (a real number in the range [0.0, 1.0]).	

Submodule: Effector Network

<u>Brief Description *</u>	A set of nodes corresponding to effector subsystems (e.g., hands, feet, eyes, but also possibly cognitive subsystems such as a language understanding subsystem). Each node has an associated activation value (a real number in the range [0.0, 1.0]).
<u>Tags</u>	

Submodule: Object Representation Network

<u>Brief Description *</u>	A set of object representation nodes that make up the system's internal model of the world. Each node has a vector of activation levels (real numbers in the range [0.0, 1.0] corresponding to the current salience of the object representation with respect to each of a set of argument roles (e.g., source, target, theme, implement).
<u>Tags</u>	

Submodule: Schema Network

<u>Brief Description *</u>	A set of schema nodes, with hierarchical relations between nodes. Each node has a goal, a triggering condition (i.e., a state of the world that activates the schema node), a partially ordered set of subgoals (i.e., the schema's subgoals with ordering constraints),
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	and an activation value (a real number in the range [0.0, 1.0]).
Tags	