The Mind According to LIDA – Executive Summary

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The LIDA cognitive model attempts to answer the question, “How do minds work, be they human, animal, or artificial?” It’s meant to be a cognitive prosthesis; a conceptual device intended to facilitate thinking about thinking. It intends to describe conceptually the mechanisms underlying mental activities. As a systems-level model, LIDA attempts to account for a full range of mental processes from sensing incoming external or internal stimuli, to producing outgoing motor responses, and every sort of mental activity in between.

LIDA’s basic building block is *the cognitive cycle*, its version of the action perception cycle of the psychologists and the neuroscientists (Cutsuridis, Hussain, & Taylor, 2011; Dijkstra, Schöner, & Gielen, 1994; Freeman, 2002; Neisser, 1976). The LIDA model is asynchronous with each cognitive cycle emerging from the actions of its processes. Each such cognitive cycle consists of three phases. Its *understanding phase* interprets the incoming stimuli in light of the current situation and its past memories, and updates its current situational model. The following *attention phase* chooses the most salient portion of the updated current situation, the conscious content, to be broadcast globally (Baars, Franklin, & Ramsøy, 2013; Baars, 1988). This broadcast content enables the final *acting and learning phase* during which memories of several sorts are encoded or reinforced, and a suitable sensory-motor response is selected and executed. Though complex, each cognitive cycle is quite brief, say 300-600ms in humans (Koivisto & Revonsuo, 2010; Madl, Baars, & Franklin, 2011).

The LIDA model asserts that all cognitive processing consists of an overlapping sequence of such cognitive cycles, with different part of overlapping cycles running simultaneously in parallel. Though the model is asynchronous, seriality is maintained by the conscious broadcasts of the cycles so as to allow the illusion of continuity of consciousness. The model further asserts that all *higher level cognitive processing*, for example deliberating, reasoning, planning, etc., is implemented via multiple cognitive cycles acting as cognitive “atoms.”

As is typical of cognitive models, LIDA is composed of various modules each with its own processes. LIDA is not only *asynchronous*, but is almost entirely *local* in its processing, the conscious broadcast being the only almost global process. Most of the model’s modules are memory systems, including sensory, perceptual (recognition), spatial, episodic, attentional, procedural, and sensory motor memories. A preconscious workspace houses LIDA’s current situational model, the global workspace hosts the competition for consciousness, and there are modules for action selection and motor plan execution. Even at the so fleeting cognitive cycle level, the LIDA model is quite complex, with each of these modules claiming its own inner structure and sophisticated processing.

Currently the internal structures of several of the LIDA modules are conceptually and computationally constructed as directed graphs similar to semantic nets, but embodied. Nodes in the graph mentally represent entities such as objects, categories, actions, feelings, events, etc., while their links represent various relations between these entities. Other LIDA modules are composed of more complex structures formed from subgraphs of these. For mostly computational reasons, there is now a movement afoot to move from nodes and links representations to vector representations (Snaider & Franklin, 2012).

The LIDA Computational Framework is a generic and customizable computational implementation of, as yet, much of the LIDA model, programmed in Java (Snaider, McCall, & Franklin, 2011). Its primary goal is to provide a generic implementation of the LIDA model, easily customizable for specific problem domains, so as to allow for the relatively rapid development of LIDA controlled software agents and/or robots. The Framework permits a declarative description of the specific implementation in which the architecture of the software agent is specified using an XML formatted file. In this way, the developer need not define the entire agent in Java, but can simply specify it using this XML file.

The Framework is intended to be *ready customizable* at several levels depending upon the required functionality. At the most basic level, developers can use the XML file to customize their applications. Several small pieces in the Framework can also be customized by implementing particular versions of them. Finally, more advanced users can also customize and change the internal implementation of whole modules. In each case, the Framework provides default implementations that greatly simplify the customization process.

Using the LIDA Framework, we have developed several cognitive software agents that *replicate experiment data* from human subjects (Faghihi, McCall, & Franklin, 2012; Madl, et al., 2011; Madl & Franklin, 2012) in order to show how the computational LIDA architecture can model human cognition in basic psychological tasks. Our main goals with these agents were to substantiate some of the claims of the LIDA model, and to move towards identifying a set of internal parameters. Ideally, these internal parameters will remain constant when disparate datasets from different experiments conducted on human subjects are reproduced with LIDA agents. Finding such a set of parameters would provide empirical evidence of the accuracy and usefulness of the conceptual cognitive model.

As demonstrated by the *real world problem solving* of LIDA's predecessor IDA (Franklin, 2003; McCauley & Franklin, 2002), the LIDA model is quite capable of controlling real world software agents or robots (Franklin, 2001; Franklin & Jones, 2004)

Every comprehensive model of cognition must be grounded in the underlying neuroscience. How is this *grounding of the LIDA Model in neuroscience* to be accomplished? Perceptual symbols (Barsalou, 1999) in the form of nodes and links in LIDA's perceptual memory comprise the common representational currency of the LIDA Model. To ground these perceptual symbols in the underlying neuroscience, we think of them as representing not neurons or cell assemblies, but rather wings of chaotic attractors in an attractor landscape (Franklin, Strain, Snaider, McCall, & Faghihi, 2012; Freeman, 1999; Harter, Graesser, & Franklin, 2001; Skarda & Freeman, 1987). When perturbed by a previously learned exogenous stimulus such as one that may result from an inhalation, the spiking trajectory of a cell assembly, such as an olfactory bulb, falls into a wing of an attractor, and so recognizes an odor. Thus we postulate non-linear dynamics as an intermediate theory serving to ground comprehensive cognitive models such as LIDA in the underlying neuroscience.

A still brief, but much more detailed account of the LIDA model is available.

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