

The simBorg Approach to Modeling a Dynamic Decision-making Task

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Motivation

Understanding decision-making processes within dynamic task environments via embodied computational cognitive models proves to be a challenge for the modeling community (see Gonzalez, Lerch, & Lebiere, 2003 for an example). Decisions made by an agent may be the result of explicit, strategic moves, or result from implicit, cost-benefit tradeoffs occurring at the level of 1/3 of a second. Understanding and properly modeling decisions occurring at these different levels is a challenge for the modeler. This paper proposes a novel incremental modeling approach (see Byrne, 2001 and Gonzalez et al., 2003 for examples of other incremental approaches) that promises to inform decision theory as well as limitations within the chosen modeling architecture.

The *simulated cyborg* (or, *simBorg*) approach blends computational embodied-cognitive models of interactive behavior with artificial intelligence based components in a simulated task environment (Gray, Schoelles, & Veksler, 2004). *simBorgs* combine human and machine components. This combination of high fidelity cognitive modeling (human) and AI (machine) facilitates the development of families of models that allow the modeler to hold components (memory, vision, etc) at different levels of expertise without concern for cognitive plausibility. For example, rather than modeling human problem solving, the modeler can rely on various *black-box* techniques (i.e., cognitively implausible AI), thereby focusing on predicting how subtle differences in costs and benefits in interactive methods affect performance and errors.

The current modeling endeavor adopts the *simBorg* approach in order to build a family of interactive decision-making agents. The following section will present the task of interest followed by a fraction of the family of *simBorgs* under development. Finally, we conclude with future directions we plan to lead the family of *simBorgs*.

Task Description

The dynamic decision-making task is Decision-Making Argus Prime (D-MAP). D-MAP is a scenario-driven simulated radar environment. The display contains a radar display on the left half and a decision-making task (DMT) on the right half. The users' goal was to choose the alternative with the highest threat value (TV) from the DMT. See Figure 1 for an example of D-MAP.

Each DMT contained a minimum of 2 and a maximum of 6 alternatives. The alternatives were presented in a tabular format where each table entry corresponded to a radar target. There was only one correct answer for each DMT.

Each DMT was limited in time (60 s), and had a 1 s interval between the offset of one DMT and the onset of another.

A correct decision resulted in the elimination of the chosen target from the radar. Threat values were accessed by moving the cursor to a radar target and clicking it. It is important to note it was not necessary, nor were participants instructed, to access the TVs for all targets in a given DMT. A scenario continued for 720 s or until all remaining targets had a threat value of 1.

The amount of time for the TV to appear after clicking on a radar target varied as a between-subjects independent variable. One group (n = 12) had no time between clicking the target and the appearance of the TV (0-Lock). The second group (n = 12) had a 2 second delay between clicking a target and TV appearance (2-Lock).

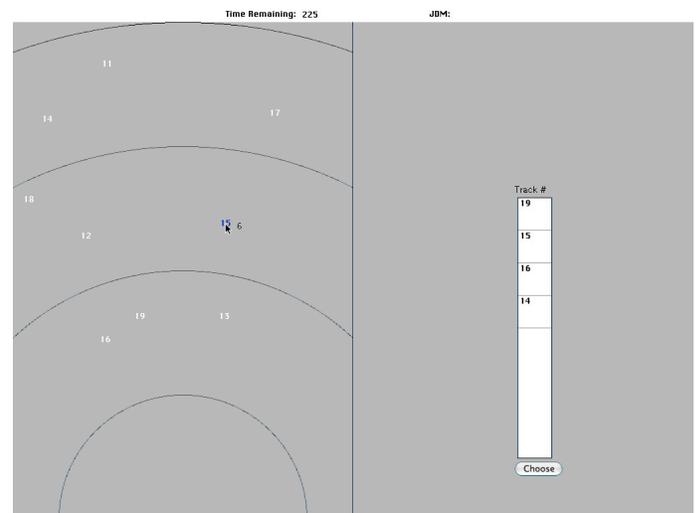


Figure 1. The D-MAP task environment with 4 alternatives occurring in the DMT.

The *Borgs: A Family of simBorgs

This modeling endeavor is based on the *simBorg* approach of holding particular cognitive processes of decision-making at an expert level and varying others. The models will range from a cognitively *implausible* optimal agent (*allBorg*) to a cognitively more plausible simulated human user. We title this process the **Borg family of simBorgs*, where the * represents a wildcard for the type of *simBorg* under development. For example, if visual search is of interest and memory is held optimal, the *seeBorg* is born. Such models allow optimization of one aspect of human performance while allowing other aspects to be realistically simulated (Gray, Schoelles, & Myers, 2002) informing both theory and application. An early goal of the *Borg family of

models is to predict when and explain why participants *satisfice* (Simon, 1956) in the D-MAP task environment. It is extremely likely that participants *satisfice* as a result of the costs embedded in the task environment, therefore it is important to pinpoint which costs (visual search, memory, TV delay, etc) are the greatest contributor.

It is likely that the *simBorg* approach will uncover adaptively optimal behavior that might be construed as *satisficing*. For example, suppose *all* threat values are *correctly* recalled for each alternative in a DMT and a decision is made without checking one radar target. This is actually optimal behavior, however it could easily be misinterpreted as *satisficing*.

All *simBorgs* are modeled using the ACT-R architecture, however it is important to point out that this method may be employed using any cognitive architecture. Only two of the **Borg* models will be discussed at a general level in this abstract due to space limitation.

Normative (*allBorg*)

The *allBorg* will be cognitively implausible in nearly all aspects of the decision-making process (memory, visual search, etc) to provide the highest level of performance possible in D-MAP. Only movement times for eyes and hands will be the agent's constraints. Figure 2 provides a process flow of the *allBorg* agent. The *allBorg* agent will provide a ceiling of performance that we propose all human participants strive to achieve given the environmental constraints.

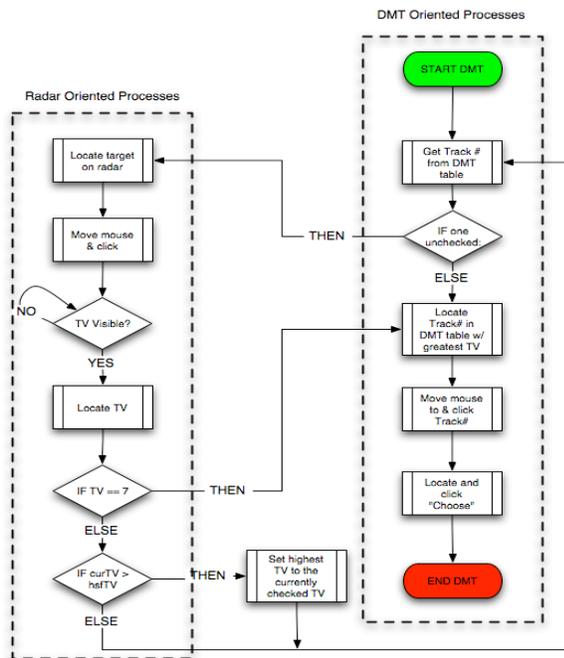


Figure 2. Process flow of *allBorg*. *curTV* stands for Current TV being checked and *hsfTV* stands for Highest So Far TV.

Refining Visual Search (*seeBorg*)

The *seeBorg* agent's memory will use ACT-R's declarative memory repository without decay. Thus, *seeBorg*'s memory

will always be precise, holding the cost associated with memory to a minimum. In contrast, *seeBorg*'s visual search processes and strategies will be the modeling focus and will provide insight to the benefits of different search strategies and the effect of costs involved.

The primary goal of the *seeBorg* will be to explore the effectiveness of different search processes. For example, storing radar target positions in memory to be used in later DMTs (Byrne, 2001; Ehret, 2002). However, because the *seeBorg*'s memory is absolute, we will gradually impose the same limitations on *seeBorg*'s memory which humans face, namely decay which leads to errors of omission and commission.

Future Directions & Conclusions

Although all of the models have not been completely constructed (nor discussed in this abstract), we believe that the **Borg* family of *simBorgs* will inform both decision-making theory as well as model development. We believe that what appears to be *satisficing* on the surface and that may actually be adaptively optimal behavior will naturally fall out of the incremental *simBorg* approach to modeling. Finally, after fitting the cognitively most plausible agent to the human data, we plan on porting the agent to a version of D-MAP that includes Argus Prime's target classification task (Schoelles & Gray, 2001), allowing us to determine if the same visual search and memory strategies transfer to the new task environment.

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