BOTTOM-UP MODEL OF STRATEGY SELECTION

Tomasz Smoleń — Jagiellonian University, Krakow, Poland (tsmolen@apple.phils.uj.edu.pl)
Szymon Wichary — Warsaw School of Social Psychology, Warsaw, Poland (swichary@swps.edu.pl)

30TH ANNUAL CONFERENCE OF THE COGNITIVE SCIENCE SOCIETY

Introduction

TTB and WADD. Within the bounded rationality framework, it is common to assume the existence of the repertoire of separate strategies, which are used contingent on the features of the task environment and cognitive characteristics of the decision maker. Two of the proposed strategies deserve a closer look: The Weighted Additive (WADD) model and Take The Best (TTB) strategy. Take The Best is one of noncompensatory strategies, which do not integrate any information. TTB starts the information processing with the best cue, and compares the values of alternatives on that cue. If the cue discriminates between the alternatives, then the alternative with the higher value is chosen. If the cue does not discriminate between the alternatives, then the next cue in the ranking is checked. TTB is noncompensatory as the information of cues with higher validity cannot be compensated by cues with lower validity. In contrast, the Weighted Additive rule is a compensatory strategy, since it integrates all information. WADD chooses the alternative with the highest sum of cue values weighted by cue validities.

Strategy selection. The problem of using the right strategy for a particular decision task has been framed as the strategy selection problem and several models have been proposed to account for this process. The earliest are Beach and Mitchell (1978), Christensen-Szalanski (1978) and Payne, Bettman and Johnson's models (1993) , which all go under the rubric of top-down models of strategy selection. A slight departure from these models is Lee & Cummins' Evidence Accumulation Model (Lee & Cummins, 2004), which assumes that both a rational decision strategy and a fast and frugal strategy are special cases of a sequential sampling decision process. Thus, it is a rather radical departure from the previous models as the assumption of the repertoire of strategies is absent in the model. Its main assumption is that fast and frugal strategy and a rational strategy can be unified within one process.

The model proposed in this paper is based on a few important assumptions related to the nature of working memory. We assume that information stored in working memory takes the form of activation of some parts of long term memory. The parts of this structure are connected with information that is maintained in working memory, in such a way that (a) when given part of structure is activated, the content represented by it is available in mind, and (b) functional connections between parts of the structure reflect associative connections between contents of working memory. Although these assumptions concerning working memory are rather strong, they are discussed in psychology as very plausible (see Cowan's model: Cowan, 1999).

The Bottom-Up Model of Strategy Selection

The proposed model has to choose the best choice alternative among several ones. As input data, the model takes (a) a set of alternatives (each represented as a vector of cue values) and (b) the order of cue weights (cue ranking). Cue values are binary (0 and 1), representing a 'low' and a 'high' quantity of a given cue. Cue values are read into the model's working memory with the order of cue weights, and the higher the weight the cue has, the stronger is its activation in memory. The model assumes that there are two properties of working memory which influence the predecisional information processing: *capacity* and *focus of attention*. Capacity determines how large is the reduction of decrease of activation between successive cue representations (compare Figure 1 and Figure 2), whereas focus determines how large is the reduction of the decrease, when moving from cues with higher validity to those with lower one. The cue first in the ranking always has the activation of 'one' (it is activated on maximum level), the following cues have lower activations, in accordance with formulas shown bellow. After the cues are represented in working memory with an activation computed on the basis of their place in the cue ranking and the given memory properties, all alternatives are compared with regard to their cue values multiplied by their activations. The alternative which has the highest overall value is chosen (if there is a tie, the choice is made at random).

Parameters and formulas. Memory capacity is an overall amount of activation which can be divided among different cue representations; it is denoted as M. Focus is the kind of mapping between the place of a cue in the ranking based on the weights and the amount of memory allocated to that cue and will be represented as S. Formula (1) shows the relation between the amount of the activation (a) ascribed to nth cue on one hand and focus parameters on the other.

$$a_n = \max\left(\left(\frac{-nl}{M}+1\right)^S, 0\right) + \varepsilon \tag{1}$$

In the formula (1) ε is the activation noise, l stands for the number of choice alternatives and max denotes the function which returns larger of its arguments. The negative values of a, if they occurred, are not taken into consideration — they were treated as zeros. Note that the smaller the n is, the more activation is given to the cue. The model chooses the alternative for which the value v is the highest, where value (v) is computed from the formula (2) based on the Weighted Additive rule.

$$v = \sum_{n=1}^{k} a_n c_n \tag{2}$$

The k stands for the number of cues, a_n is the activation of nth cue, and c_n is the value of the nth cue. Note that all variables except capacity and focus (i.e., values of the cues, number of the cues and number of alternatives) are not brought into the simulation as parameters, but they are features of the environment.

Figure 1 shows the hypothetical levels of cue activation in a situation when relatively large memory capacity is available. In this example all cues are represented in working memory, and all activations are relatively similar (compare figure 2). Figure 2 shows the hypothetical levels of cue activation in a situation of relatively small memory capacity. Only the four first cues are activated in memory and there are big differences between levels of activation.

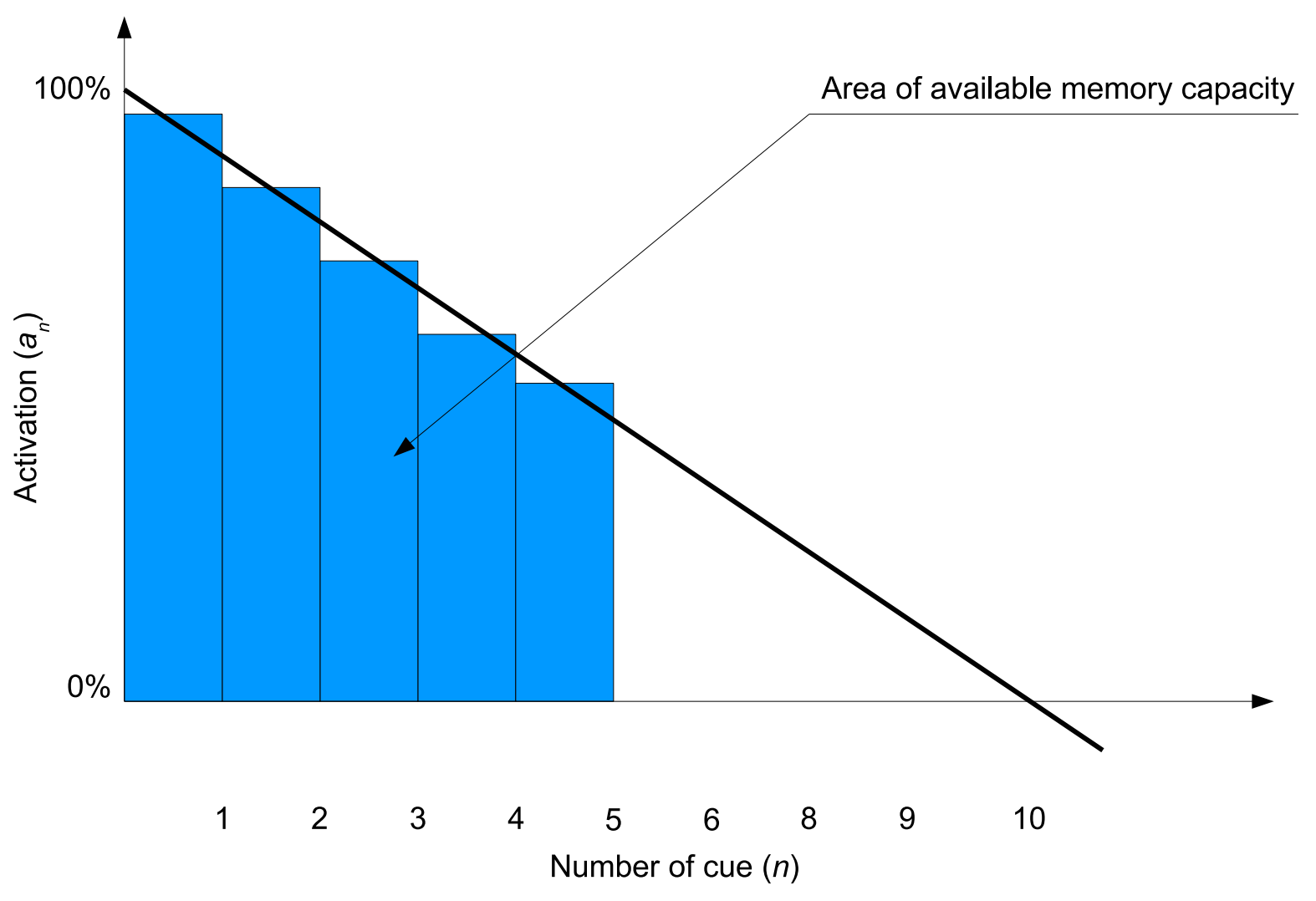

FIGURE 1: Cue activations given by the model with large memory capacity.

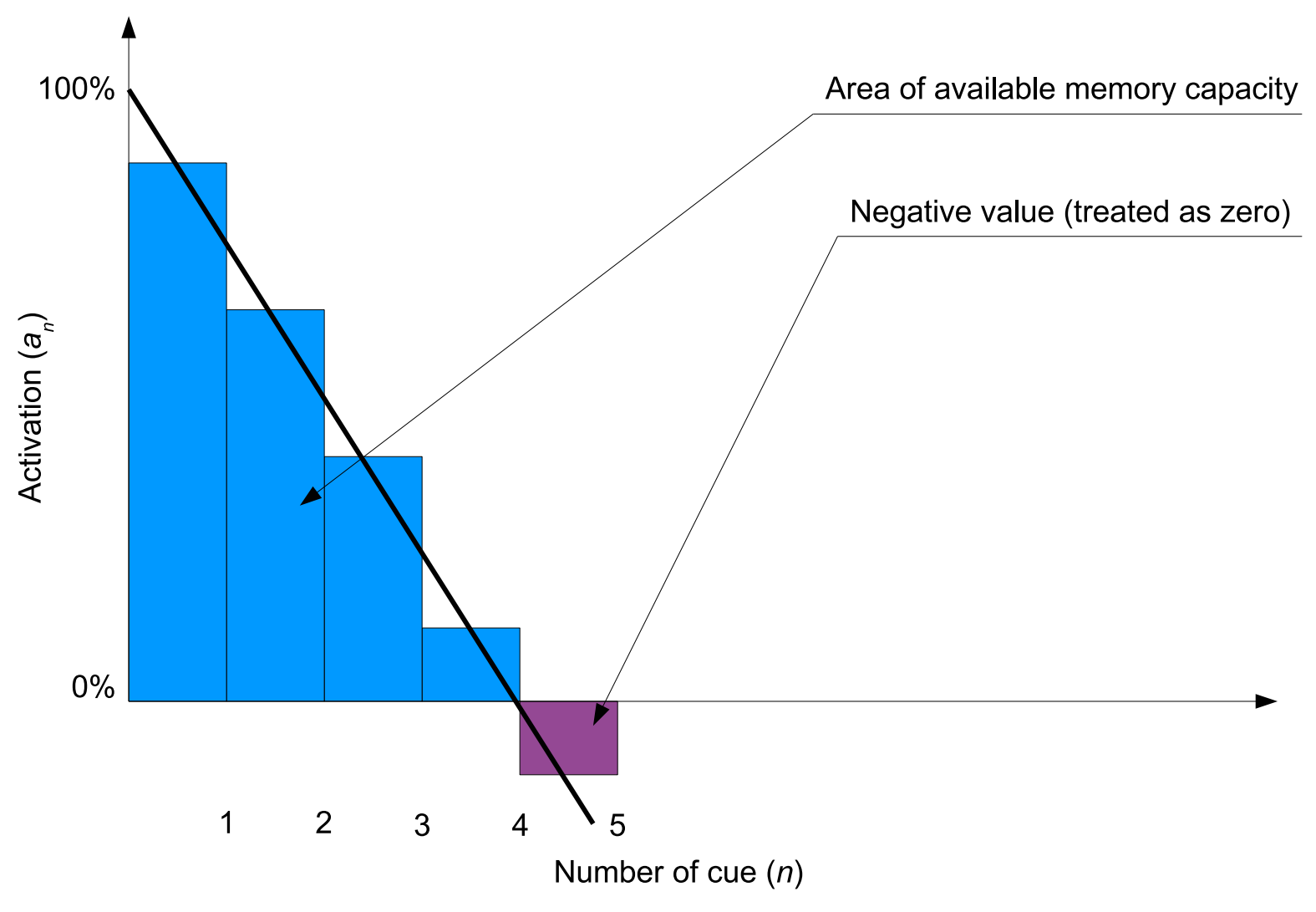

FIGURE 2: Cue activations given by the model with small memory capacity.

Results of simulations

Predictions. There are two interesting predictions of the model. The first concerns differences between the fit of different strategies (TTB and WADD) in environments with specific characteristics. We expect that agents with memory features that determine the use of a simple noncompensatory strategy (i.e., low capacity, high focus) will be more accurate in the noncompensatory environment, and analogously, opposite memory features will result in higher agents' accuracy in a compensatory environment. Another prediction relates to the correspondence between decisions given by our model and the WADD or Take The Best strategies. We expect that responses given by the agent with memory characteristic favouring the use of a compensatory strategy will be consistent with WADD responses, whereas the agent with memory features favouring the use of a noncompensatory strategy will give responses consistent with Take The Best.

Results. In this paper, we present the results concerning only one parameter — the memory capacity. We set the model's parameter M to two values: low (2) and high (6) and tested the performance of these two versions in the two different environments. The model's processing capacity indeed interacted with the environment structure. In the compensatory environment, there was no difference in the accuracy of choices made by the high and low capacity versions of the model. However, in the noncompensatory environment, the low capacity version of the model, surprisingly made better choices than the high capacity version of the model (see Figure 3).

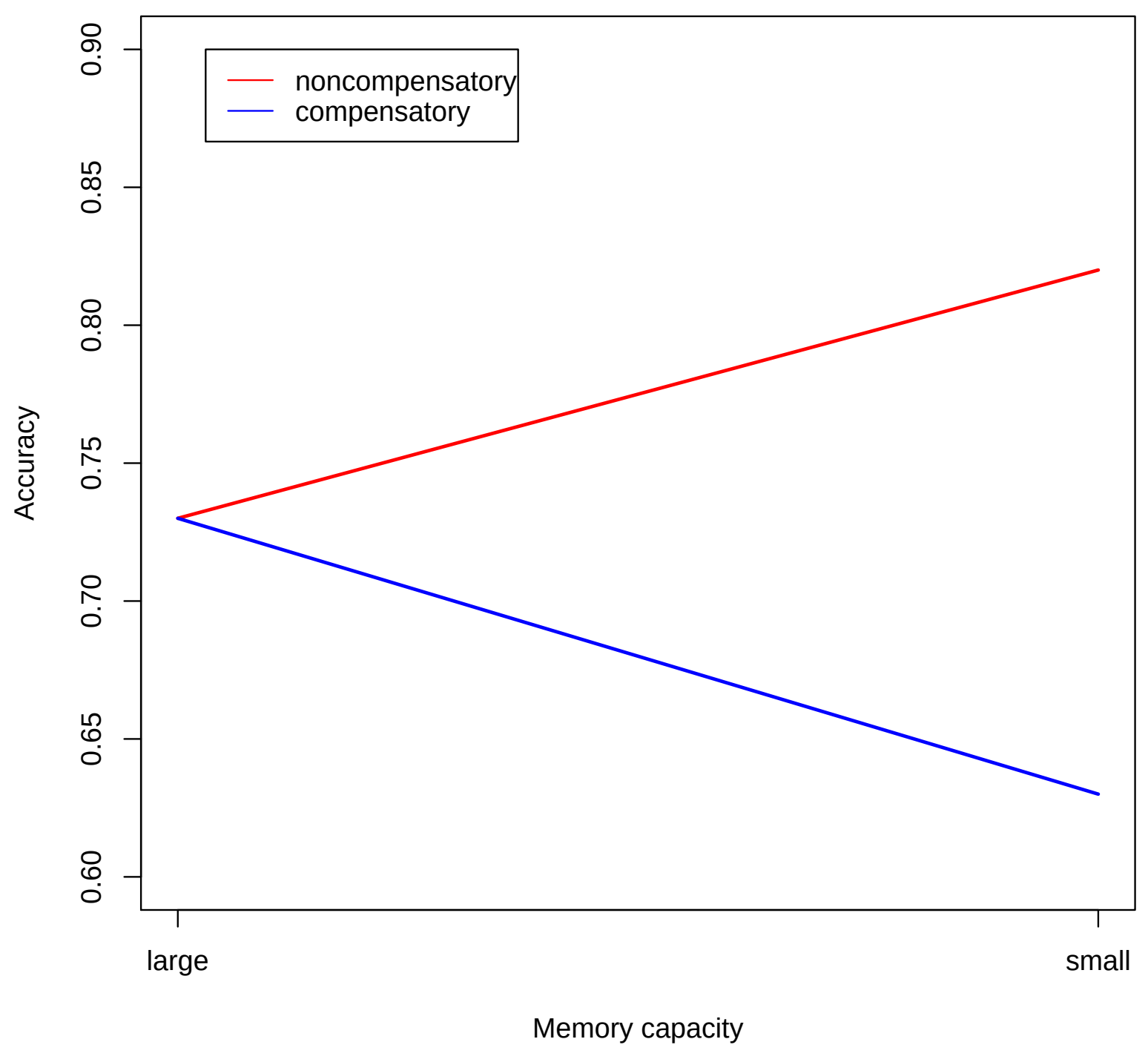

FIGURE 3: Simulation results: interaction between working memory capacity and the type of environment.

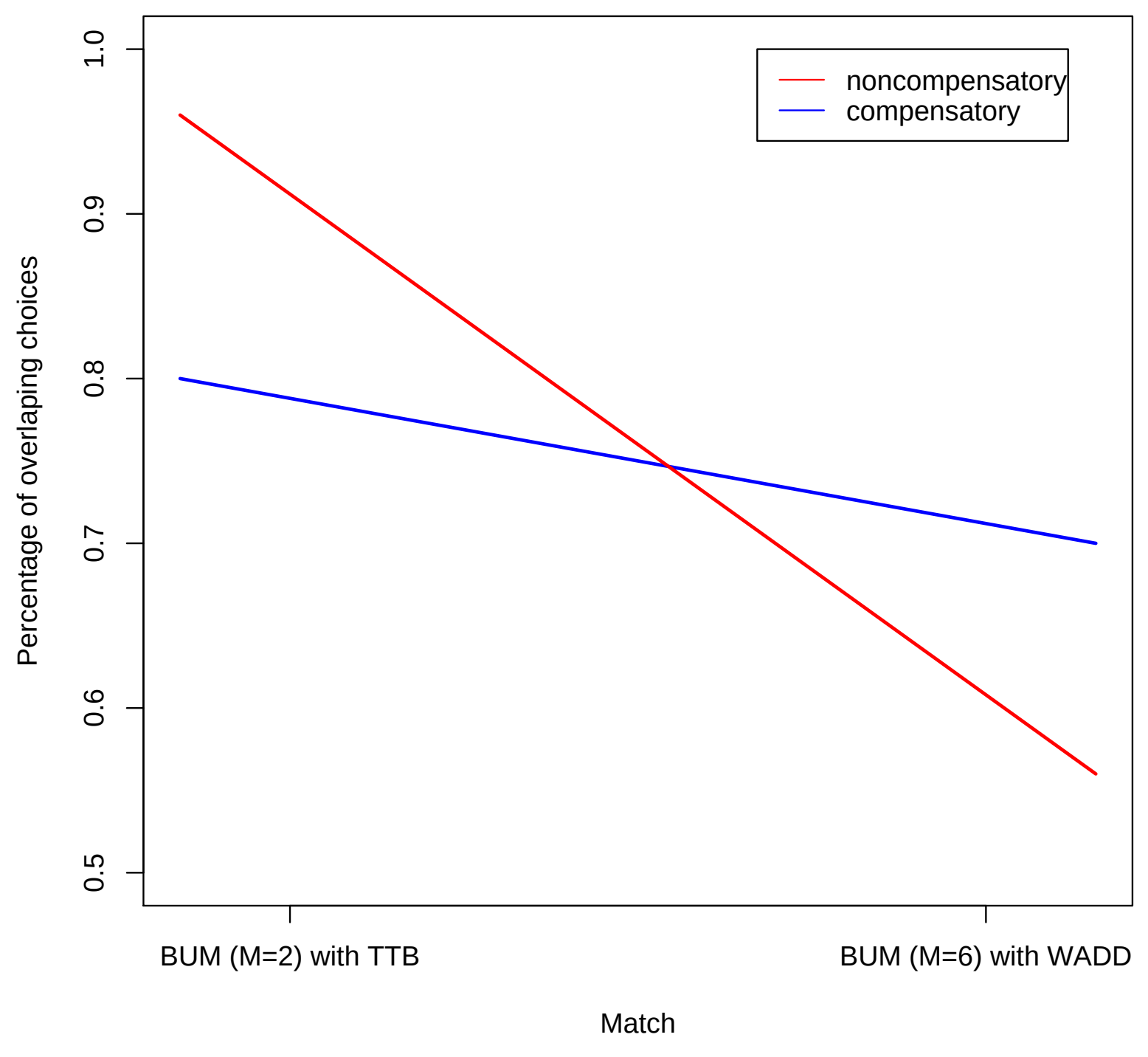

FIGURE 4: Simulation results: match in choices between the versions of the Bottom-Up Model and WADD and TTB strategies in different type of environments.

Second, we present the results concerning the match in choices between our model and the strategies we used for comparison, namely TTB and WADD. The question we ask here is whether our model is a good approximation of these two strategies. First, we manipulated the parameter M of the model, which describes the processing capacity to be divided among all cues. Again, we set this parameter to two values: high and low . We assumed that with the high processing capacity our model will accurately recreate the choices made by WADD strategy. The actual percent of overlapping choices between our model and WADD is **70%** for the compensatory environment and **56%** for the noncompensatory environment. Similarly, we assumed that with the low processing capacity the model will accurately recreate the choices of the TTB strategy. In fact, the match between our model and TTB was quite high — **80%** for the compensatory environment and **96%** of choices in the noncompensatory environment (Figure 4).

Discussion

The model proposed above is based on two novel ideas which can help explain the process of strategy selection during decision making. The first idea is that there are no separate strategies chosen and used on the basis of either deliberation or earlier learning, but all strategies are various expressions of one process which depends on some cognitive characteristics, which can vary intra- and interindividually.

In this perspective, our model shares some features with Lee & Cummins (2004) unifying model of strategy selection. The most important one is the assumption that the selection of strategy is not a real choice, but is only seen as such from the observer's third-person perspective. Both models establish that some decision maker's internal property can be changed and thus result in apparent use of different strategies.

The second idea that distinguishes the Bottom-Up Model of Strategy Selection from the majority of the models proposed so far, lies in the emphasis of the importance of working memory in decision making. It is claimed here that such memory operating characteristics like capacity and attention focus are essential for the process of decision strategy selection. It is also an important feature distinguishing the present model from Lee and Cummins' model. As our model employs an idea that is central to cognitive psychology (namely, working memory), it thus seems to be better prepared to corroborate other models of performance on complex cognitive tasks.

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