Modelling a Common Cognitive Bias and a Simple Heuristic to Overcome it

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Abstract

We emulated an experiment that shows the Einstellung-effect by building an agent-based model and developed a new heuristic that helps to overcome the effect.

Introduction

The "Einstellung-effect", also called the "Expertise Reversal Effect", is a phenomenon where a high degree of knowledge or expertise can decrease performance (Luchins, 1942; Bilalić et al., 2009; Kalyuga et al., 2012). This seems counterintuitive, as expertise in a domain usually increases performance in that domain (Vicente and Wang, 1998). The Einstellung-effect was first demonstrated in a series of experiments involving puzzles about measuring water using differently sized jugs (Luchins, 1942). Participants learned a specific method to solve problems, but when confronted with a similar problem that could not be solved using the specific method, they were unable to solve it. Naive participants, who did not go through the learning phase, were able to find the solution at a higher rate. Trained participants overlooked the solution because they had a certain mindset (German: "Einstellung") that prevented them from seeing it. Since then, the Einstellung-effect has been replicated in many different contexts (Levitt and Zuckerman, 1959; McKelvie, 1985, 1990), such as anagrams (Ellis and Reingold, 2014) and even magic tricks (Thomas et al., 2018), albeit the most studied context is arguably within the game of chess (Bilalić et al., 2010; Sheridan and Reingold, 2013).

One instance of the Einstellung-effect was shown in an experiment that we replicate for the study at hand (Goldstein and Gigerenzer, 1999). German and American participants where quizzed about which of two American cities had the higher population. It was observed, that German participants outperformed American participants when asked about American cities. The explanation for this surprising finding was that Germans often only knew one of the two American cities that were shown. They then picked the city that was familiar to them. Such reasoning is called "recognition heuristic" (Gigerenzer and Goldstein, 2011), and worked in this case. In contrast, Americans often knew both cities, were not able to use this heuristic, and consequently performed a little worse.

Our study aims at replicating this experiment in an agent-based model. We also present a simple heuristic, the "first contact heuristic" (FCH), that can mitigate this effect. We suggest that, given sufficient meta-cognition, Americans could have guessed the correct city by using this heuristic.

Self-Organization in Evolution

Methods

We designed an agent-based model that emulates the experiment done by Goldstein and Gigerenzer in 1999. Thus, we use terms such as "Germans" and "Americans" or "cities" to refer to "agents" and "objects that can be known". However, the model can be generalized to other domains.

One American and one German agent are generated and function independently from and analogously to each other. There are 25 German and 25 American cities. At each time step, agents have a 90% chance to learn about a city corresponding to their nationality (i.e. German agents learn about German cities, analogously for American agents), as well as a 10% chance to learn about other cities. Agents learn by saving the cities' ID in a list that serves as their memory. The cities have exponentially distributed random populations, and cities with higher populations are more likely to be learned by agents. After 100 repetitions of this process, agents are asked 25 questions about American and German cities each. Questions consist of two randomly drawn cities (from the same country) and for a correct answer agents must pick the city with the higher population. Agents can be in one of two groups: either *not* using the first contact heuristic (groups G1 and A1) or *using* the first contact heuristic (G2 and A2). G1 and A1 guess randomly if they have both or neither of the cities mentioned in a given question in their memory. If they have exactly one of the cities in their memory, they pick this city, using the recognition heuristic. G2 and A2 function exactly as G1 and A1, except that they do not guess randomly in cases in which they have both of the cities mentioned in a given question in their memory. In-

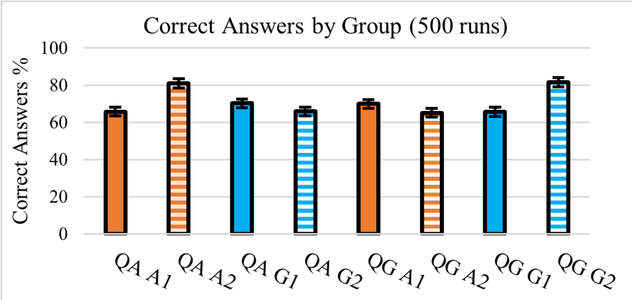

Figure 1: On a quiz about American cities (QA, left half) Germans (G1, orange) have higher scores than Americans (A1, blue). In agents using the FCH (striped), Americans (A2) have higher scores than Germans (G2). The results are reversed in the quiz about German cities (QG, right half).

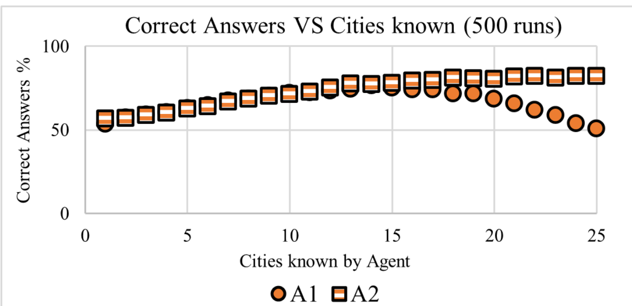

Figure 2: Group A1 (circles, no FCH) shows an optimum of correct answers at around 14 known cities, while group A2 (squares, using FCH) has increasing correct answers with increasing known cities before plateauing at 18 known cities.

stead, they pick the city which they learned about first, using the first contact heuristic.

Results

We report mean correct answers of German (G) and American (A) agents, without (1) and with the first contact heuristic (2) after 500 runs. In the first group (G1 and A1), Germans score higher than Americans in the quiz about American cities (QA), and vice versa. Agents using the first contact heuristic (G2 and A2) have higher scores, see figure 1. Mentioned differences were found to be statistically significant ($p < .00001$) using a Mann-Whitney U Test. Further, we report correct answers and known cities of American agents without (A1) and with (A2) the first contact heuristic, see figure 2. A1 shows a maximum of correct answers at 14 known cities, and a decreasing percentage of correct answers with further increasing known cities. A2 has increasing correct answers with increasing known cities. Groups G1 and G2 are not shown here but behave very similarly.

Discussion

In our study, a surplus of information prevents agents to use the recognition heuristic. Consequently, agents with less knowledge perform better, as they can overcompensate their relative lack of knowledge by using this heuristic. This is shown in figure 1, in which German agents have better scores on a quiz about American cities and vice versa. Beyond a certain point, more knowledge does not lead to more correct answers, see figure 2. Agents often recognize both cities in questions about their own country, but only one of the cities in questions about the foreign country. In the former case, they cannot use the recognition heuristic, since they recognize both. In the latter case, they choose the city that they recognize. The heuristic works well because the likelihood of hearing about a city is, in the real world as well as in the model, linked to its size: Larger cities usually are more well known. Our results replicate the “Less-is-More”-effect, shown by Goldstein and Gigerenzer 1999.

Given that, one can analyze situations where the likelihood of knowing a given entity (e.g. a city) is related to a property (e.g. the population size) as trade-off situations. A high amount of knowledge is beneficial, but comes with a cost: a lesser ability to use the recognition heuristic. In cases as the study presented here, the cost of knowledge beyond a certain point is higher than the benefit. To counteract this effect, we propose a new heuristic that needs no further external information but instead uses meta-cognition: agents using our “first contact heuristic” (A2 and G2) pick the city they heard about first. The recognition heuristic implicitly assumes that one is more likely to hear about larger cities. Analogously, our “first contact heuristic” assumes that one likely hears about larger cities *first*, and only later about smaller cities. In contrast to the recognition heuristic however, it can be used even if both cities are known. This is shown by the higher scores of A2 compared to A1 in the QA condition, as well as the higher scores of G2 compared to G1 in the QG condition, shown in figure 1.

The recognition heuristic can be useful, but fails when the probability of recognition is inversely related, or not connected at all, to the property in question: if one would be asked about which of two cities has the *smaller* population, and only recognizes one out of two options, then one should *not* pick the recognized option. Our results suggest that the recognition heuristic can be an effective method to draw inferences when used in the right situation. However, when it cannot be applied, the “first contact heuristic” can fulfill a similar role and is a valuable piece of the cognitive toolkit of simulated as well as real persons alike.

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