論文の内容の要旨

論文題目:

The adaptive use of heuristics: Investigations of human inferential strategies in a new task structure

（ヒューリスティックの適応的な利用: 新たな課題構造における人の推論方略の検証）

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Abstract:

People make inferences about the real world under many cognitive constraints such as their limited knowledge and computational power. Since it is difficult to find the best strategy based on detailed analyses, people often rely on simple and intuitive inferential strategies like a rule of thumb, called *heuristics*, and try to find the way to solve the problem approximately. Initially, heuristics were regarded as strategies that would produce systematically biased inferences (e.g., Tversky & Kahneman, 1973, 1974, 1981, 1983). Later, however, the adaptive nature of heuristics has been reported (e.g., Gigerenzer & Goldstein, 1996; Todd & Gigerenzer, 2000). That is, people have multiple strategies in their minds and intuitively use a certain appropriate strategy among them for solving tasks under their cognitive constraints. This framework is known as *adaptive toolbox* (e.g., Gigerenzer et al., 1999), and is regarded as one of the most important aspects about human intelligence.

In this thesis, I investigate people's adaptive use of heuristics within the adaptive toolbox framework. Although it is believed that people adaptively change their heuristics, previous studies have examined this so far only for one task wherein two objects ("A" and "B") were presented as alternatives and a simple comparison between these two objects were required (e.g., population inference task; Fig. 1, upper left). So, it is not clear whether people really use different strategies for a different *task structure* (i.e., a different location in a problem statement where objects are presented, and a different computation that a person is required for solving the task). It can be predicted that, if a task structure differs from the structure addressed in previous tasks, then an *environmental structure* (i.e., the frequency of appearance of certain information that people see or hear through media in the real world) that people may exploit will differ, and adaptive heuristics for the tasks will also differ. Then, I investigate this issue by proposing a new task structure: A *relationships-comparison task*. In this new task, one object is presented in a problem statement along with two objects in alternatives, and a comparison of two dyad relationships ("Q and A" and "Q and B") are required (Fig. 1, upper right). In this thesis, from Study 1 to Study 4, I use inferential tasks about general knowledge in a specific environmental structure according to Gigerenzer and his colleagues' works. In Study 5, on the other hand, I use the same task structure as in Studies 1~4 but focus on a preferential task wherein people are asked which item they want to buy and are not asked about general knowledge.

It may be highly obvious that a heuristic for solving the task will change if a task structure differs. In examining the adaptive use of heuristics, however, the following two concepts are important. One concept is, of course, the *accuracy*: How much can people make inferences by using a heuristic? Even if a certain heuristic is a simple strategy, it can produce accurate inferences if the heuristic fits well with an environmental structure, which is called ecological rationality. In a population inference task, the frequency of appearance of objects in the real world is positively correlated with people's familiarity, and the criterion (population size) is positively correlated with the frequency of appearance. Thus, using a heuristic that chooses the recognized or more familiar alternative can lead to correct inferences (e.g., Gigerenzer & Goldstein, 2011; Honda et al., 2017). However, another concept, the *applicability*, is also important: How often can people use a certain heuristic in tasks? Even if a certain heuristic is ecologically rational and highly accurate in tasks, it is not useful for solving them if there are little chances to use it due to cognitive constraints. For example, a heuristic that chooses the more familiar alternative cannot be used when people cannot judge which alternative is more familiar (e.g., Schooler & Hertwig, 2005; Schurz & Hertwig, 2019).

Based on these considerations, I investigated the adaptive use of heuristics in a relationships-comparison task in terms of the strategy that people used (Study 1, Study 3, and

Study 5), its accuracy (Study 2) and its applicability (Study 4), according to the adaptive toolbox framework. The outline of this thesis is as follows. I first describe the definitions of important terms and the standpoint of this thesis. Then, I also describe the detailed purposes of five studies (Chapter 1). Specifically, as to an interaction between a heuristic and an environmental structure that people may exploit in a relationships-comparison task, I predict as follows. The frequency of appearance of objects is positively correlated with familiarity. And the frequency of appearance of objects in a question (e.g., city) will also be positively correlated with that of objects in alternatives (e.g., country in which the presented city is located). So, a new heuristic that chooses the alternative whose familiarity is more similar to that of an object in a question will be an ecologically rational strategy. I propose such a new heuristic based on similarity in familiarity as *familiarity-matching*. To explain human inferences in a relationships-comparison task, I introduce three inferential models for familiarity-matching (FM), for familiarity heuristic (FH), and for knowledge-based inference (KI) (Chapter 2). In Study 1 (Chapter 3), through a behavioral experiment and model-based analyses, I investigated what strategy participants used in a relationships-comparison task, based on which model could best explain individuals' inferential patterns. I found that FM was often used with stronger evidence, especially in difficult questions (Fig. 1, lower left). In Study 2 (Chapter 4), through a behavioral experiment, analyses of the real-world data, and computer simulations, I examined the accuracy of FM in a relationships-comparison task in terms of ecological rationality. The results showed that FM could reflect an environmental structure well, and FM could lead to many correct inferences (Fig. 1, lower middle). In Study 3 (Chapter 5), through a behavioral experiment, I replicated the main findings of Study 1 by using Study 2's experimental materials. In Study 4 (Chapter 6), I examined the applicability of FM in a relationships-comparison task. First, as Study 4a, I investigated which strategies would be more adaptive in terms of the accuracy (correct rate) and applicability through analyses of behavioral data. Second, as Study 4b, I investigated the accuracy and applicability of heuristics (FM and FH), manipulating individuals' decision threshold (i.e., the sensitivity to discriminate between similarities in familiarity) through computer simulations. These results revealed that, although the accuracy did not so differ between the three inferential strategies, FM was more applicable than the other strategies in a relationships-comparison task, regardless of people's decision threshold. In Study 5 (Chapter 7), through a behavioral experiment, I investigated whether people would use FM for a different task with the same task structure, even if the type of task changed (i.e., not inferential choices but preferential choices). As a result, I could obtain the first evidence that people used FM even in preferential-choice situations.

Taken together, in a new task structure, people use an adaptive heuristic that shows

not only high accuracy but also high applicability. Specifically, in a relationships-comparison task, people often use FM which can be an ecologically rational and more applicable strategy. This thesis is the first study to examine the adaptive use of heuristics focusing on a task structure within the adaptive toolbox framework. It is noteworthy that people intuitively "selected" a more accurate and applicable strategy among several strategies, even in a completely new task structure. I believe that I could provide further understandings of people's adaptive use of heuristics in that the adaptive toolbox framework held true in a new task structure. The findings of this thesis suggest that it is important to pay more attention to a task structure in order to deeply understand the adaptive use of heuristics.
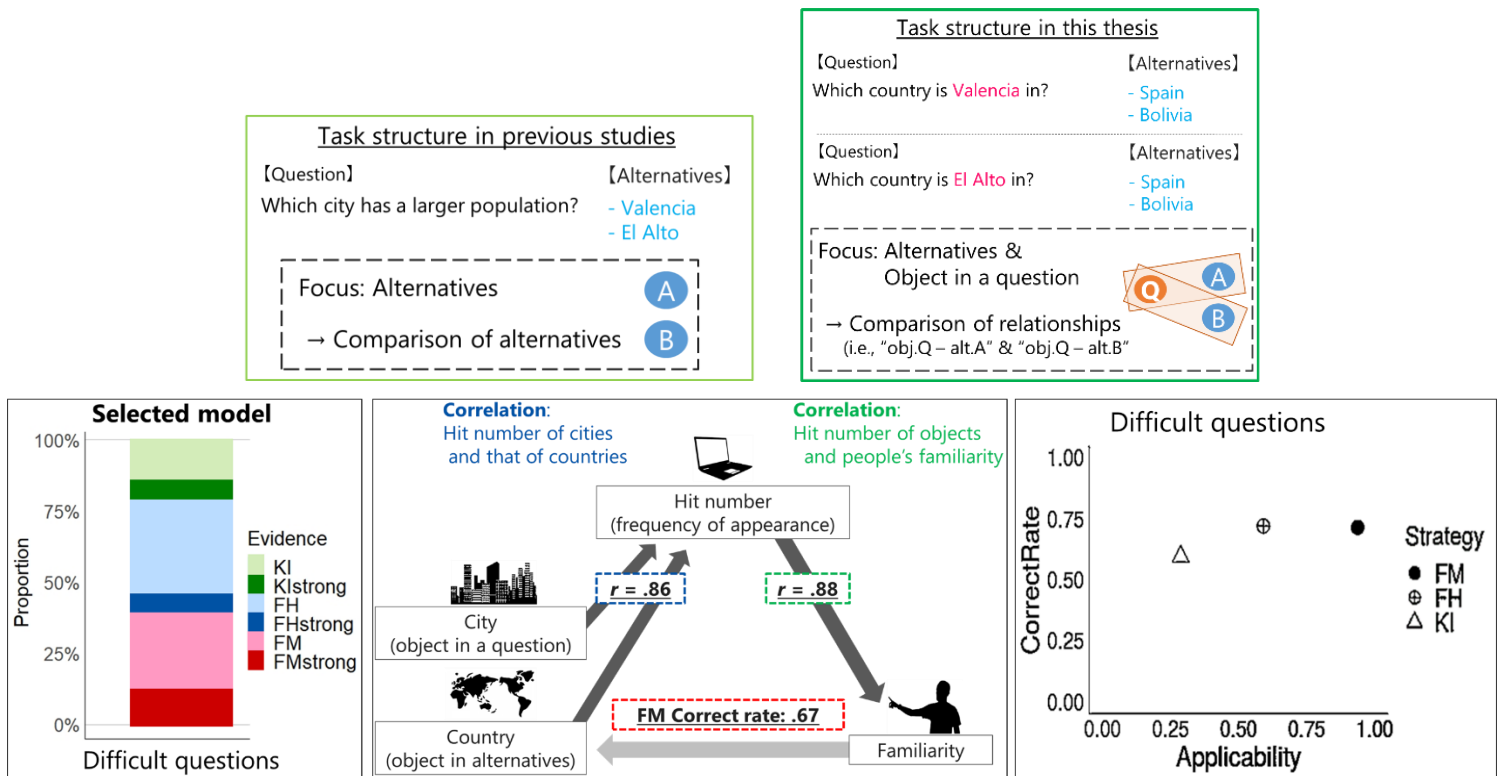

Fig. 1   (Upper left) Task structure of a population inference task. (Upper right) Task structure of a relationships-comparison task. (Lower left) Main result about the strategy that people used. (Lower middle) Main result about the accuracy in terms of ecological rationality. (Lower right) Main result about the applicability.