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Analysis of the Application of Representativeness Bias in the Scenes of Clinical Practices and Operation Management

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Abstract: In this paper, the representativeness bias is introduced and explained. The purpose is to investigate how representativeness bias can be applied in real world examples, such as healthcare programs and business operation management. Three studies, in two different fields, completed by other researchers, are provided to elaborate the effect of representativeness bias by empirical approach and rational approach. In each field, the experiments would show how the representativeness bias made people choose a different choice, how it guided people to make sub-optimal decisions. Through the studies presented, the benefits, disadvantages, and consequences of the use of representativeness bias are all explained. Through the data collected, representativeness bias is used very frequently, and in some cases, it does lead people to the sub-optimal choice. Also, some steps that people can take to reduce the effect of representativeness bias will also be shown. This allows people to make more accurate judgments not just in specific fields, but also in daily life, and minor matters.

Keywords: Representativeness Bias, clinical application, business operation management.

1. Introduction

When concerned with problems with uncertainty, or probabilistic questions, people tend to use different types of cognitive bias, or mental shortcuts, to assist them in making decisions. Among these cognitive biases, representativeness bias is commonly used in daily life. This bias occurs when we estimate the probability of the event by the similarity to an existing prototype in our minds, rather than by statistical evidence and analysis. As a result, the representativeness bias, acting as a mental shortcut, can reduce the time and effort needed to make a decision or judgement. However, applying representativeness bias in decision-making can also mislead people to make a suboptimal decision or poor judgement because it makes people pay more attention to the similarity [1].

First proposed by Tversky and Kahneman, representativeness biases were used when people decide on an uncertain event "by the degree to which it is (1) similar in essential properties to its parent population; and (2) reflects the salient features of the process by which it is generated" [2]. They presented several examples to explain different consequences of the representativeness bias. For one, subjects in the experiment were presented with a description of a person and were asked to estimate the probability of the person being an engineer or a lawyer. It was told that the population contained 70 engineers and 30 lawyers, and the description was randomly chosen. Although the

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proportion was given, many subjects were affected by the description. In this case, the subjects ignored the prior probability of 70, and many subjects judged the probability to be 50% [3].

2. Analysis of the Applications of Representativeness Bias

2.1. Clinical Practice – 1

This study is completed by Fernández-Aguilar, Carmen, et al. in Primary Care centers in Spain by consulting with new episodes of dyspnea. It aims to identify the use of cognitive bias, specifically, Representativeness, Availability, and Overconfidence in the clinical practice of primary care physicians in cases of dyspnea by an empirical approach [4].

The method of this study is developed by Zwaan Laura. The samples or the patients are chosen based on their symptoms instead of the disease. With a sample with homogenous symptoms and the diagnostic process (Figure 1), the sub-optimal decisions can be defined and identified clearly. The cognitive biases were defined before the study started. Then questionnaires were given to the physicians to identify the possible use of cognitive biases. After the information were gathered and analyzed, researchers classified the sub-optimal cognitive acts [5].

In four Primary Care (PC) centers in Spain, a total of 371 cases of new episodes of dyspnea were selected with 23 participating physicians for this study. The physicians would complete two questionnaires during the study. The first one will be given when seeing the patient. The physician would fill in the First Diagnosis Impression (FDI) before the physician made any diagnostic test, physical examination, etc. the physician would finish the questionnaire by filling in the three probable diagnoses or the Differential Diagnoses (DD) and his/her estimation of his/her confidence in making the correct diagnosis. After the first consultation, the physician can still ask for further diagnostic tests. As the episode of the dyspnoea ended, the physician then filled in the second questionnaire which included the time of the diagnosis, and the confirmatory diagnosis (CD). The case will be reviewed by the assessors and experts, and will determine whether the diagnosis was correct [4].

The representativeness bias is considered when the Confirmatory diagnosis of dyspnea coincides with the FDI made before any clinical interventions were taken, showing that the physicians use their past experience or based on the similarity of the new case with the parent population, the entire set of the case to diagnose [6]. For example, 20 out of 100 patients' symptoms of dyspnea create an FDI of cancer to the physician. If 10 out of the 20 patients who received the FDI of cancer coincide with the confirmatory of The Differential Diagnoses and the estimation of the confidence are factors that determine and identify the uses of Availability bias and Overconfidence.

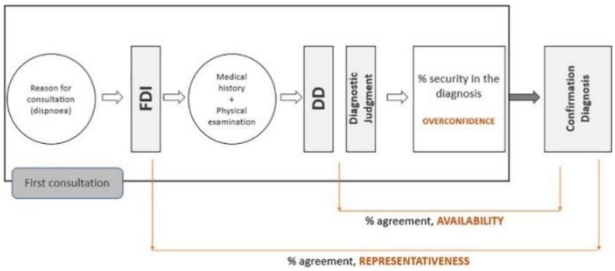

Figure 1: Diagnostic Process Diagram [4].

After collecting all the questionnaires, researchers categorized the sub-optimal decision making into different cognitive biases. First, in 183 out of the 371 cases, the FDI matches the confirmatory diagnosis, and the representativeness bias was considered to be used. Second, in 304 out of 371 cases, the confirmatory diagnosis matches one of the DD, and the availability bias was considered to be

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used. Last, in 214 out of 371 cases, doctors showed above-average confidence in their Diagnostic Judgment (Figure 1), regarding it as overconfidence.

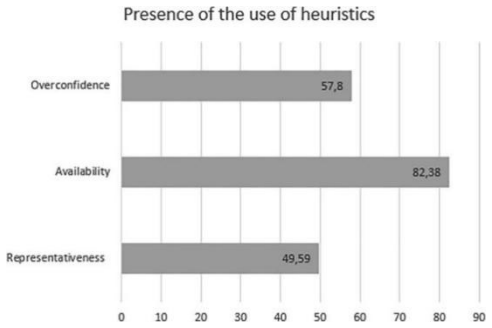

Figure 2: Presence of the Use of Heuristics [4].

While there are 33 diagnostic errors out of 371 cases, 17 of them showed concordance between FDI and confirmatory diagnosis or involved the use of representativeness bias. However, the researchers discovered that there is no statistically significant association between concordance and error according to the Fisher's test.

This study suggested that there is an extensive use of heuristics by primary care physicians, including making decisions based on the similarity of the symptom, and the easiness with which the possible diagnosis comes to the mind (Figure 2). However, there are not enough pieces of evidence that show the uses of cognitive heuristics lead to a significant amount of diagnostic error. This might be caused by the experience of the physicians and the knowledge they have of their patients, since in this study, the doctors are all experts and most had been treating the same lists of patients for a long period [4].

2.2. Clinical Practice – 2

This study is completed by Payne and Crowley, aiming to examine the errors created by representativeness bias during the cognitive process. The researchers pointed out the four situations where representativeness is invoked, as proposed by Tversky and Kahneman. First, it can be invoked by making decisions in terms of a relative frequency distribution of a specific variable in a specific population. Second, it can be invoked by making decisions based on the similarity to a mental prototype. For instance, during a diagnostic process, if the patient's symptom or feature is similar to a mental representation of a disease, then he/she will be more likely to be diagnosed with this specific disease. Third, it can be invoked by making judgement based on the similarity of a subset of the population to the whole. Fourth, it can be invoked by making judgement according to the causal belief. For example, during a diagnostic process, a patient problem might be perceived by the cause-and-effect relationships [7].

The researchers pose two research questions about the representativeness bias. Do clinicians make errors in judging by perceived frequency? This corresponds to the first type of representativeness bias. If base rates and causal information are both available, do clinicians make errors in weighing causal data more heavily? This corresponds to the fourth type of representativeness bias. The subjects include four pathology residents and four internal medicine residents. Subjects are required to complete an assessment consisting of a short clinical description with a set of possible answers. The responses include a correct answer, an incorrect answer and answers that would be consistent with a specific type of representativeness bias (type 1 or type 4). There were two forms used, one with topics in general medicine and was completed by all subjects, and another with topics in general pathology and was completed only by the pathology residents.

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One sample of the task 1 assessment was provided asking for the most likely scenario for a patient admitted from the emergency room with respiratory failure not caused by trauma. Given that most non-trauma patients experiencing respiratory failure in the emergency room had a background of chronic obstructive pulmonary disease (COPD). A significant number of these individuals were in the advanced stages of COPD and were already using continuous home oxygen before their respiratory failure occurred. The typical age of COPD patients is 67. Four options are given: "The patient has COPD and is on home O2", "The patient has COPD", "The patient has COPD and is over 67", "The patient is over 67 and is on home O2" [7].

For Research Question 1: Do clinicians make errors in judging by perceived frequency?

The results show that the subjects chose the correct answer in 59% of the task, and chose an incorrect answer in 41% of the task. Out of the 13 incorrect answers, 76% of them are the representativeness answers.

For Research Question 2: If base rates and causal information are both available, do clinicians make errors in weighing causal data more heavily?

The results show that subjects chose the correct answer in 84% of the task, and chose an incorrect answer in 16% of the task. Out of the 5 incorrect answers, the answer weighted towards casual data was selected 100%.

These results suggested that errors due to type 1 representativeness bias are a result of base rate neglect, and the heuristic bias resulting from base rate neglect accounts for diagnosis error [7].

2.3. Operation Management

This study was carried out by AIKhars, Mohammed, et al. They aimed to investigate the six cognitive biases resulting from the use of the representativeness heuristic, and how cognitive reflection and training affect these. The six cognitive biases resulting from representativeness heuristic are Insensitivity to prior probability of outcomes, Insensitivity to sample size, Misconception of Chance, Insensitivity to Predictability, The illusion of validity, and Misconceptions of regression.

There are six scenarios shown in Table 1, each matching with one of the consequences of representativeness heuristic (Table 1).

Table 1: Scenarios used to investigate the cognitive bias [8].

No.	Cognitive Bias	Scenario
1	Insensitivity to prior probability of outcomes	Restaurant
2	Insensitivity to sample size	Gas Station
3	Misconception of Chance	Truck
4	Insensitivity to Predictability	Sports
5	The illusion of validity	Copy Center
6	Misconceptions of regression	Forecast

A total of 315 students from the University of North Texas participated in this study and 302 valid responses were used in the analysis. In this paper, the consequence misconception of chance and the scenario truck will be shown. The participants are given a cognitive reflection test (CRT) at first, used to operationalize the cognitive reflection construct. There are three questions in total, and for each question, there is a wrong, intuitive answer and a correct, reflective answer. Each question is worth 1 point, so if a participant answers all correctly, he/she will get 3 points in CRT; on the other hand, if he/she answers all wrong, he/she will get 0 for the CRT. Studies have shown that people who score high on cognitive reflection tend to be less likely to be affected by cognitive bias to make a suboptimal decision. The CRT test and questions are shown in Table 2.

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Table 2: Cognitive reflection test [8]

No	Question
1	A bat and a ball cost $1.10 in total. The bat costs $1 more than the ball. How much does the ball cost?
2	If it takes 5 machines 5 minutes to make 5 widgets, how long would it take 100 machines to make 100 widgets?
3	In a lake, there is a patch of lily pads. Every day, the patch doubles in size. If it takes 48 days for the patch to cover the entire lake, how long would it take for the patch to cover half the lake?

In order to investigate the effect of training, participants in each scenario are divided into two groups. One group of participants was given the scenarios with training, and the other group was given the scenarios without training. After the scenario, participants will be given questions to answer. There is only one correct answer; the others are either wrong or intuitively correct.

3. Truck Scenario

"Based on observations from the last year, 99% of deliveries arrived independently of each other within 15 minutes from the target arrival time. Half of them arrived within 15 minutes early (ahead of time) and half of them arrived within 15 minutes late. During the last 6 days, you recorded the status (E = early, L = late) of a certain truck driver as follows (Table 3) [8].

Table 3: Status of the Truck Driver

Mon.	Tues.	Wed.	Thu.	Fri.	Sat.
E	L	E	E	E	E

Q. What do you think will happen on the 7th day (which is a Monday, since Sunday is the driver's day off)?

(1) An early (E) status will most likely be observed on the 7th day

(2) A late (L) status will most likely be observed on the 7th day

(3) Early (E) or late (L) are equally likely to be observed on the 7th day"

Table 4: Relationship between training and biased decisions [8].

Training			Biased
	Freq	%	Truck
0 (No Training)	151	50	56%
1 (Training)	151	50	48%
Total	302	100	52%

Table 5: Relationship between CRT and biased decisions [8].

	CRT		Biased answers
	Freq	%	Truck
0	131	43%	56%
1	68	23%	53%
2	58	19%	47%
3	45	15%	44%
Total	302	100%	52%

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Table 4 show that 52% of participants chose the biased answer in the Truck scenario. Data show that participants who received training have a drop in the number of participants who chose the biased answers. In Table 5, as the score of CRT increases, less participants chose the biased answers.

The result suggests that the representativeness heuristic is pervasive and can play a major role in many real-life decisions and judgments. Also, with the help of training, participants are able to make a more optimal choice, expanding their rational boundary and reducing the effect of representativeness bias. However, the effect of the training is not enough to completely debias it, the decrease in the number of participants who chose biased answers is not significant.

4. Conclusion

Representation is essential for identification and interpretation since it allows us to understand something new without starting from a complete zero. Thus, as we gain more experiences and see more things, people are more likely to be affected by representativeness bias. People would start to make decisions by comparing new subjects or events with events or subjects that they had met before or that existed in their minds. Although it does help people save a lot more time when making decisions, it can still affect people and influence them to make sub-optimal decisions. In the application of healthcare and operation management, all studies show that it is very common for people to use representativeness bias when doing or deciding something. Although in one clinical experiment, there is not enough data to verify that representativeness bias led to sub-optimal choices, it doesn't mean that the use of representativeness bias will always lead to a positive result. Also, many cases in other experiments do show that representativeness bias leads people to make sub-optimal decisions. It is not easy to avoid, but there are many steps that people can take that help to minimize the effect, such as training, revising and checking again, etc. By gaining more knowledge and experience or becoming experts in the field, people would be able to lessen the effect of representativeness bias. With the help of training, people would become more aware of this tendency. When individuals acknowledge that they have unconsciously made decisions relying on these biases, they can work to counteract this tendency. Only training is not enough to completely or effectively reduce this effect. Thus, aids such as technology, discussion groups, real-world examples, etc. can be used to help to revise again and make sure the decision or the choice is the most optimal one, reducing the effect of representativeness bias.

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