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# Investigating the Awareness of Decision-Making Heuristics and Biases in the Selection and Definition of Infrastructure Projects

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## Abstract

The decision-making process can be biased by virtue of the role that mental shortcuts play in human decision making. Although many researchers have studied this fact in form of psychological behaviours and behavioural economics, limited research has explored the role of heuristics and biases in the selection and definition of infrastructure projects. Accordingly, this paper provides a baseline for further research, presented in a “codex model”. A survey has been conducted to address the extent of people's awareness of heuristics and biases. The results show that more than 80% of the participants are not familiar with the concept of decision-making heuristics and biases. This research is important because it highlights the fact that increasing the awareness of decision-making heuristics and biases may lead to improved project decisions.

## Keywords

Infrastructure projects, heuristics and biases, selection and definition, codex, awareness

## 1. Introduction

To start with, it is essential to define the term “infrastructure” for clarity and focus of this paper. The word “infrastructure” comes from the combination of the words “infra” and “structure”. “Infra” is a Latin prefix which literally translates to the word “below” and “structure” is an English context which means the arrangement of complex elements. According to (Beeferman and Wain, 2016), analysts are split in two groups by virtue of categorizing the term infrastructure. Some analysts categorize infrastructure into economic infrastructure and social infrastructure. Economic infrastructure involves facilities that can generate reasonable income such as tunnels, toll-roads, bridges, airports, rail network, as well as, shared utilities like gas and water distribution networks, electricity and renewable energy production and distribution. Social infrastructure, includes health care facilities and schools. Unlike economic infrastructure, there may be no identifiable revenue generation from social infrastructure. On the other hand, other analysts categorize infrastructure into three divisions: social infrastructure, transportation, and utilities.

Infrastructure projects have a great impact on economic growth and improving regional Gross Domestic Product (GDP). This fact has been confirmed through different reports and publications, as several regions including Europe, North America, South America, the Middle East and some parts of Africa have gained valuable lessons from developing infrastructure projects (European Commission, 2014; Freund and Lanchovichina, 2012; Kumo, 2012; Ismail and Mahyideen, 2015; Copeland, Levine and Mallett, 2011; The Federation of Canadian Municipalities, 2012; The Canadian Chamber of Commerce, 2016; Development Bank of Latin America, 2011). The development of infrastructure projects has also an essential role in countries' growth and the quality of living for the citizens of those countries. As the requirements of the modern lifestyle quality, such as electricity supply, transports and telecommunications, are exponentially increasing, robust decisions should be taken to mobilize the implementation of infrastructure projects.

There are many potential challenges which could turn infrastructure projects into non-desirable delivery. Infrastructure projects are categorized under the blanket definition of ‘mega-project’ which typically cost US\$1 billion or more (Flyvbjerg, 2014). Major infrastructures are a class of large-scale and critical public infrastructure projects that attracts a lot of shared attention because of its significant impacts on communities, environment, and the economy (Wang et al., 2016). Note that “projects” are usually measured in millions (or tens of millions) of dollars; “major projects” measured in hundreds of millions; and “mega-projects” measured in billions (Flyvbjerg, 2017).

Certain characteristics distinctive to the challenges of decision-making on infrastructure projects include: i) strategic challenge: in which Infrastructure projects could have enormous impact on society, economy and the environment, therefore, care should be take while taking decisions (Wang et al., 2016), ii) Complexity: Infrastructure projects are often highly dynamic, possess uncertain work process, are nonlinear, and are made up of quantitative and qualitative data (Wang et al., 2016; Roger and Brian, 2005). With this in mind, as recommended from previous literatures, it is very important to understand the elements that should be taken into account while taking decisions. Examples of these elements can be:

- **Quantitative methods:** are the methods that are incorporate with decision’s objective measurements and the mathematical, statistical, or numerical analysis. Quantitative methods have an important role to play in the decision-making process, in which complex decisions require complex methods that aim to simulate diverse scenarios and to incorporate a variety of possible outcomes of diverse courses of action. Reliable quantitative methods, therefore, are required to help decision-makers make wiser choices between alternative courses of action (Stefanovic and Stefanovic, 2005).
- **Perform a structured analysis:** people often make bad decisions because they are affected by certain psychological pitfalls, as it will be explained as decision-making heuristics and biases (DH-HB) in section 2. Therefore, performing structured analysis can helps people to improve their judgment and overcome the psychological pitfalls. (Virine, 2013).
- **Increase the awareness of the psychological traps:** recognizing unwelcome heuristics and biases and increasing the awareness of the psychological pitfalls can help to avoid making undesirable decisions (Chatzipanos and Giotis, 2014).

## **1.1 Project Scope**

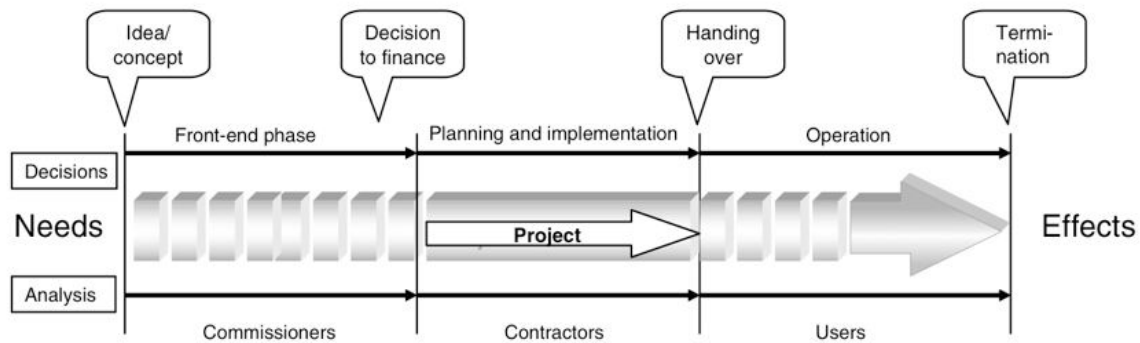
This paper is published as a part of a PhD research, that seeks to provide an analysis of decision-making in the selection and definition of infrastructure projects (SD-IP), with the ultimate aim of improving the decision-making processes in the implementation of infrastructure projects. Through the research it has been found that there have been no sufficient studies carried out as regards DM-HB and their role in the decision-making process, in which the following question is answered (“What are the DM-HB that might affect the decision-making process in the SD-IP?”). This has led to ask the following question (“To what extent are people aware about decision-making heuristics and biases in the selection and definition of infrastructure projects?”), which this paper will attempt to answer.

## **2. Literature review**

### **2.1 A spot on project selection and definition**

Robust analysis and numerous decisions are made for a project selection and definition during the project’s front-end phase. According to Priemus, Flyvbjerg and Wee (2008), project the entire life cycle can be classified as i) Front-end phase, ii) Planning and implementation phase, and iii) Operation phase. During the entire life cycle of a project, a decision-making process runs in parallel with an analytic process which provides input to decision-makers, as shown in Figure 1.

The front-end phase proceeds as a complex process, intended to generate information, confirm stakeholders’ visions and positions, and ends up with the final decision whether to finance the project or not. This typically takes months, even years as in many infrastructure projects. Decisions during the front-end phase will have an effect for planning and implementation of the project and its utility.



**Figure 1 Decision and analysis throughout a project's life cycle (Priemus, Flyvbjerg and Wee, 2008)**

Insufficient/poor decisions made in the project's front-end results in many of the things that make for project failure. Within this context, despite the importance of managing project's front-end, management responsibilities, issues, roles and actions are too often ignored by official project management guidance. This fact has been discussed by Edkins et al. (2013); as the authors proposed that there is a poor understanding and lack of effective/clear guidance on front-end project management practice. The Decision-making approach can be defined as the toughest and riskiest job for project executive (Hammond, Keeney and Raiffa, 2006). Bad decisions can occur in many cases from the way decisions were made whereby alternatives are not distinctly identified, inaccurately costs and benefits weighted. Inappropriate decisions could also be taken from the mind of decision makers, which is known as decision-making traps (heuristics and biases).

## **2.2 The role of heuristics and biases in decision-making**

Heuristics and biases play an important role in the decision-making process. According to Lewis (2012), heuristics are mental shortcuts that occurs in the human mind in which some parts of a complex problem is ignored as more focus is given to one aspect of the problem. As a result, some systematic errors might occur when making a decision. It is important to know the role of these biases as people unconsciously fall into them. According to Kahneman (2011), the cognitive nature in human mind split in two systems: System 1 and System 2. System 1, which is an automatic system, is fast and it often work unconsciously. Based on little information system 1 is capable of making quick decisions without deliberation and conscious effort. System 2, which is an effortful system, operates slowly, requires effort and energy to work, and has the ability to filter the instincts of System 1.

Since system 1 operates unconsciously and fast, people often take mental shortcuts when they make decisions. This can result in systematic errors in thinking and decision-making, referred to cognitive bias. Understanding the role of these biases can help to improve the decision-making process. As people will likely be able to avoid falling into these biases.

As stated by Gotham (2018) "decisions are the stepping-stones of progress in a project and the outcomes a project attains is usually directly correlated to the effectiveness of the decisions made". Besides, issues such as cognitive biases lead to ineffective decision making (ibid). In regard to heuristics and biases directly relevant to infrastructure projects, an example of a well-documented bias that affects the decision-making in the project selection, particularly in megaproject, is "Optimism bias". This bias shows itself in planning and forecasting where people tend to be unrealistically optimistic about future event as they normally overestimate the outcome of planned actions (favorable and pleasing outcomes). The optimism bias can be seen where the project's handling cost exceeds the budget submitted in the front-end phase. People tend to judge future events inaccurately in terms of cost and schedule of projects (Flyvbjerg, 2007a). For instance, rail projects had an average cost overrun of 44.7 percent (Flyvbjerg, 2007b).

Kotimäki (2012) identified the role of decision-making heuristics and how could it lead to biased decision making in organizational purchasing context. the study was conducted on a case study of IT infrastructure purchasing. The result of the research indicated that cognitive biases affect the purchasing decision making during the purchasing

process. Other research reviewed the current evidence of behavioural biases and heuristics in project delivery (Behavioural Insights Ltd, 2017). The research provided an overview of evidence and proposed solutions that should consider addressing three biases: i) Planning fallacy, ii) Groupthink, and iii) Sunk cost fallacy.

### **3. Categorizations of decision-making biases**

Virine and Trumper (2008) attempted to do the same work as that done in this paper regarding the categorizations of decision-making biases. Virine and Trumper (2008), however, wrote their work in decision-making in projects and not particularly to SD-IP. It is believed that their work can be improved by delivering a more comprehensive and precise discussion of DM-HB in terms of its contributions particularly in SD-IP. From an overall standpoint, listing the DM-HB can be highly valuable for helping decision-makers mitigate some of these traps and meet up with their targets within their specific scope. For the purpose of this study the following definitions have been made:

- 1. Group and social biases:** are related to that affect people's decision when they make judgments with a group of people or when they get affected by the group.
- 2. Effects and memory biases:** are biases that may convert the content of reported memory or they may impair or enhance the recall of memory.
- 3. Perceptions and behavioral biases:** related to the tendency to judge, notice or believe on a decision based on the individuals' perception. These biases are also related to the decision maker's thinking and feeling in which the biases could affect the way decision makers behave, seek or act.
- 4. Belief and probability estimation biases:** related to the tendency of judging the strength of decisions/choices base on the plausibility of the decision-maker beliefs rather than relying on facts that support the decision. These biases could affect judgments about likelihood or frequency of an event.

Figure 2 below depicts a potential DM-HB that might attempt in SD-IP presented in a "codex model". The codex model depicted on Figure 2 was designed base on a secondary research in which data were obtained from previous literatures. An extensive review was conducted base on previous literatures, where the following steps were followed. First, a broad research was conducted base previous works that have been conducted on decision-making heuristics and biases, in which the question is answered: "What are decision-making heuristics and biases that have been found or stated in previous researches?". In this step, the decision-making heuristics and biases that have been found were not specifically related to selection and definition of infrastructure projects. Second, the set of the decision-making heuristics and biases that has been reviewed from the previous step were selected base on their relationship with selection and definition of infrastructure projects, which answers the question: "What are decision-making heuristics and biases that might affect the process of selection and definition of infrastructure projects?". The results obtained from step 2 contains 105 decision-making heuristics and biases, as presented in Figure 2. This have led to ask the following question: "How can these decision-making heuristics and biases be categorized?". The answer of the previous question was found in the work of Virine and Trumper (2008), where they have grouped all the biases into a few logical categories: 1) behavioral biases and biases related to perception, 2) biases in estimation of probability and belief, 3) social and group biases, 4) memory biases and effects. Virine and Trumper, however, did not give a clear definition of the categories. Hence, we reviewed their list, which consists of about 70 decision-making heuristics and biases and we came up with a definition which we believe it suits their categories (as highlighted earlier). This is because It have been found that 35 of decision-making heuristics and biases where not included in Virine and Trumper's list. Finally, the four categories were plotted on a "codex model".

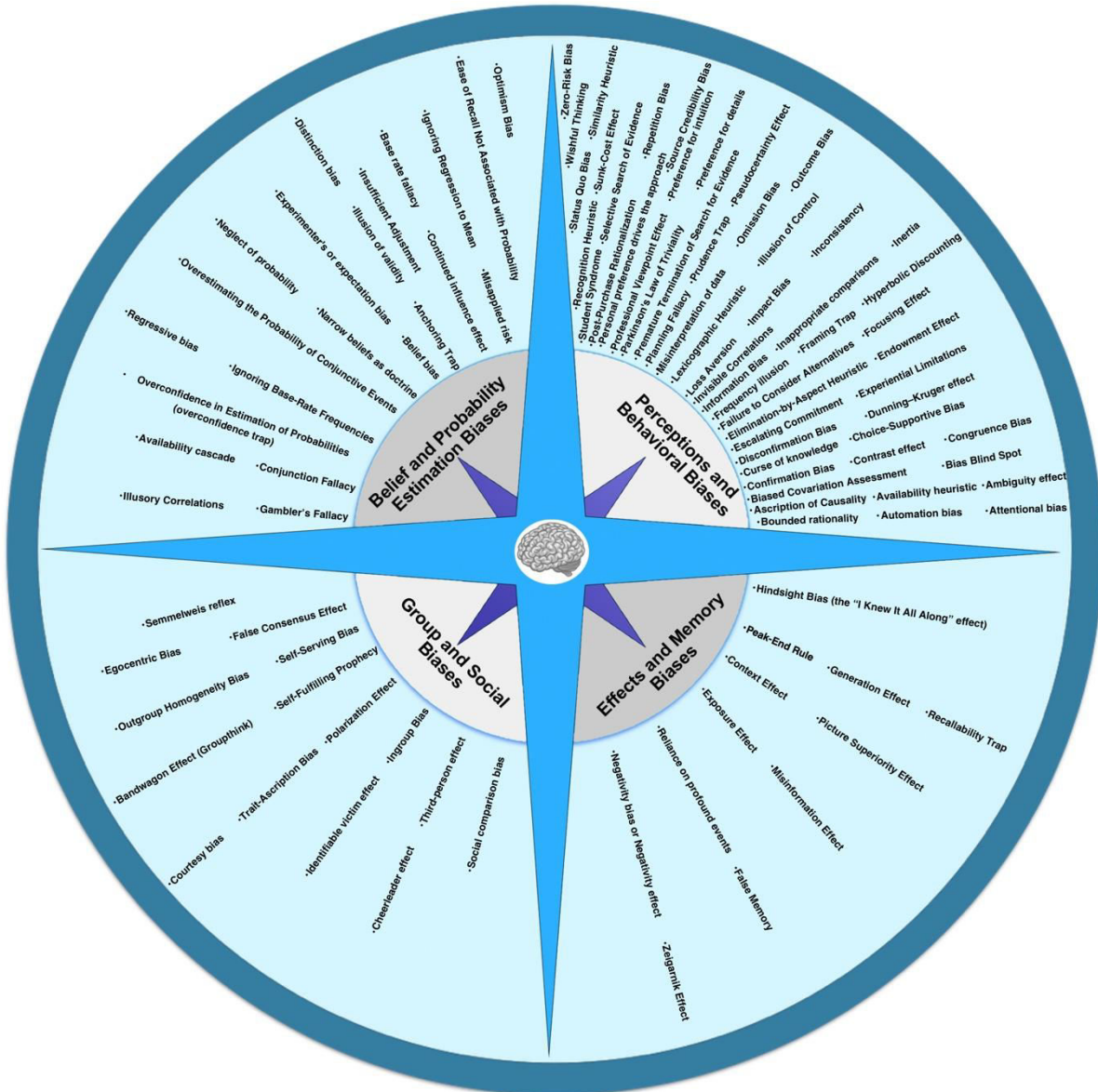


Figure 2 Codex model of potential DM-HB that might attempt in SD-IP - Extracted from Virine and Trumper (2008) and other resources

#### 4. Research methodology

To investigate the awareness level of decision-making heuristics and biases in the selection and definition of infrastructure projects, an online survey questionnaire is selected to be as a methodology for this study. This methodology takes into account people from different positions, locations and experiences to enrich the sample space.

The survey aims to develop an understanding of the decision-making processes used in the selection and definition for major infrastructure projects. Hence participants were asked, when answering the questions, to relate their answers to decisions made in the selection and definition phase. This to ensure the validity of the survey results, as well as, making the research results more substantial, reliable and objective. To ensure the validation of the survey's questions, a pilot questionnaire test was given to 5 potential participants to critique, complete and validate the questionnaire.

The survey was conducted over a three months period, starting on the 15<sup>th</sup> of December 2017 and ending on the 23<sup>rd</sup> of March 2018. Participants were selected from LinkedIn social network (a well-known platform that hosts professional communities). The sample size obtained for this study is 50.

To avoid any biases in the results, participants were carefully selected base on their background, experience and job position mostly related to infrastructure projects. Following of this section will explain the general finding from the survey.

## 5. General findings from the survey

The section includes main information of participants backgrounds, such as academic qualification, current job position, infrastructure projects involved in, working experience, number of projects participated, and average rough order of magnitude proposed cost of the projects.

Participants are currently employed various job positions with the majority of project managers (24%), projects engineers (14%), executive directors (8%) and systems engineers (6%). Figure 3 shows Participant’s current job positions.

As shown in Table 1 the majority of participants that have been involved in decision-making where 56% have been significantly involved in project implementation, 16% have been involved in decision-making but have not been significantly involved in project implementation.

Participants in this study are considered as experts in different infrastructure projects, as described in Table 3. Participants responded to the survey also have a wide variety of characteristics, such as education, project Experience, number of projects participated, and rough order of magnitude proposed cost of the project. The majority of the respondent’s highest academic qualification are bachelor’s degree (54.0%) and master’s degree (32.0%).

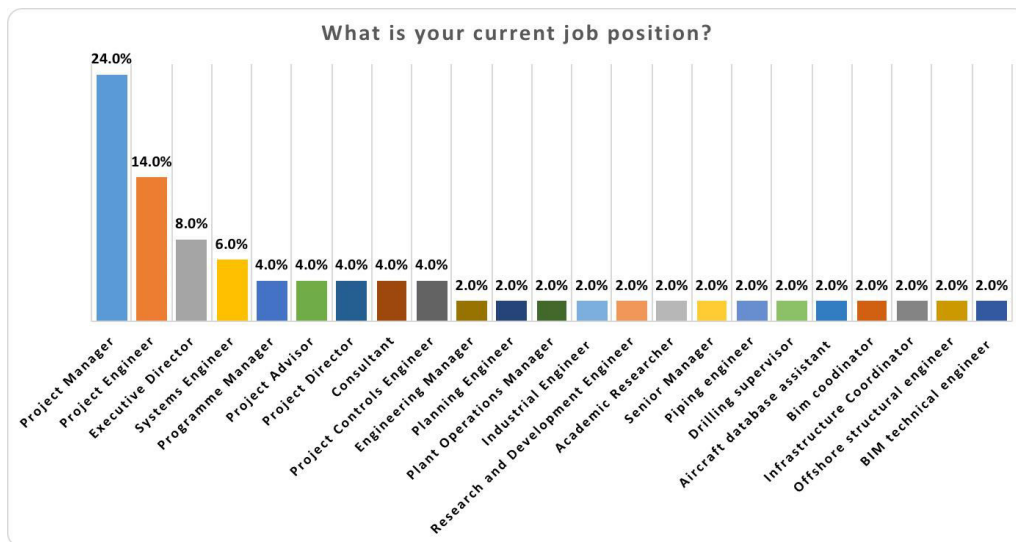
In regard to years experiences, the majority of the participants have 1 - 5 years of experience (32.0%), more than 15 years (30.0%), and 10 - 15 years (20.0%). With an average rough order of magnitude proposed cost (in US Dollar) of the projects commonly worked on 10 to 100 Million (32.0%), 100 Million to 1 Billion (22.0%), 1 Billion or more (22.0%). Further characteristics of the despondences is described in Table 2.

**Table 1 Participant’s projects decisions and implementation involvement**

Characteristics of Respondents			
Background Question	Characteristics	Response Percent	Response Total
Projects decisions and implementation involvement	have been involved in decision-making and significantly involved in project implementation	56.0%	28
	have not been involved in decision-making, but have been significantly involved in project implementation	16.0%	8
	have been involved in decision-making, but have not been significantly involved in project implementation	16.0%	8
	have not been involved in decision-making or implementation, but have expert knowledge (e.g. research in a relevant subject area)	8.0%	4
	None of the above	4.0%	2

**Table 2 Participant’s background information**

Characteristics of Respondents			
Background Question	Characteristics	Responses	
		Response Percent	Response Total
<b>Education</b>	A-level or equivalent	2.0%	1
	Bachelor's degree	54.0%	27
	Master’s degree	32.0%	16
	Ph.D. Degree (doctorate)	6.0%	3
	Other	6.0%	3
<b>Project Experience</b>	Not applicable	2.0%	1
	1 - 5 years	32.0%	16
	5 - 10 years	16.0%	8
	10 - 15 years	20.0%	10
	more than 15 years	30.0%	15
<b>No of projects participated</b>	Not applicable	12.0%	6
	1 to 5 projects	38.0%	19
	5 to 10 projects	10.0%	5
	10 to 15 projects	8.0%	4
	more than 15 projects	32.0%	16
<b>Rough order of magnitude proposed cost of the project (in US Dollar)</b>	Less than 1 Million	8.0%	4
	1 to 10 Million	16.0%	8
	10 to 100 Million	32.0%	16
	100 Million to 1 Billion	22.0%	11
	1 Billion or more	22.0%	11



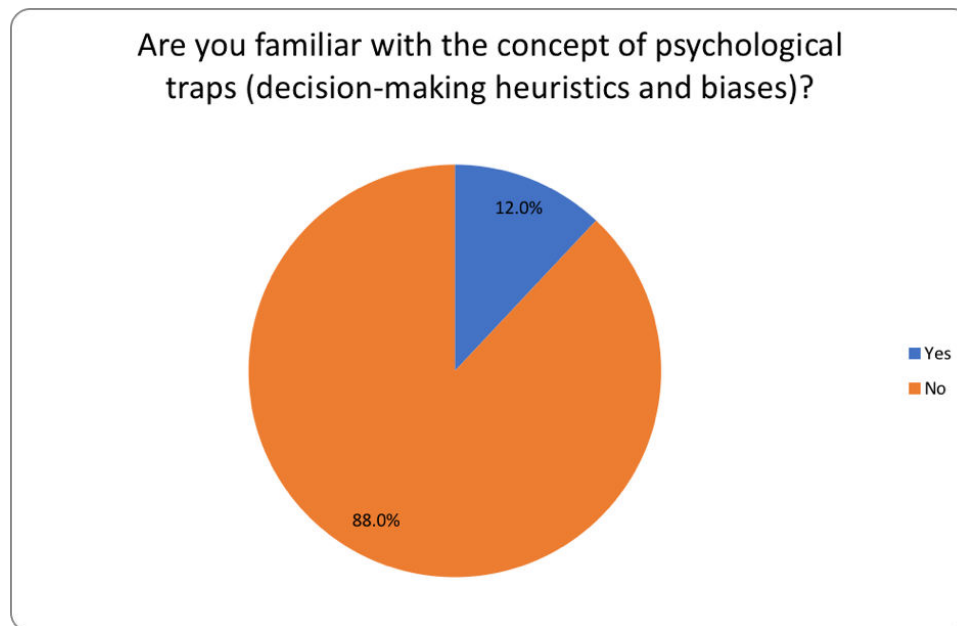
**Figure 3 Characteristics of respondents - job position**

**Table 3 Characteristics of respondents - expertise**

<b>Characteristics of Respondents</b>			
<b>Background Question</b>	<b>Characteristics</b>	<b>Responses</b>	
		<b>Response Percent</b>	<b>Response Total</b>
<b>Project expertise</b>	Railway lines – including new lines and station extensions	20.0%	10
	Major roads – including Bridges and tunnels	16.0%	8
	Utilities	16.0%	8
	Renewable energy power plants	14.0%	7
	Oil and gas facilities – including extraction facilities, pipelines, terminals, storage facilities and refineries	8.0%	4
	Airports – including new runways, runway extensions and airport terminals	4.0%	2
	Nuclear power plants	4.0%	2
	Constructions	4.0%	2
	Digital communications – including delivering broadband deployment, fibre network, delivering 4G coverage or a 5G strategy	4.0%	2
	Dams and reservoirs	2.0%	1
	Thermal power plants	2.0%	1
	Public Transportation	2.0%	1
	Finance and banking	2.0%	1
	Plant Installation	2.0%	1



The results obtained from the survey show that the concept of decision-making heuristics and biases is not highly known in the context of selection and definition of infrastructure projects. In the survey, participants were asked if they are familiar with the concept of psychological traps (decision-making heuristics and biases). The results show that 88% of the participants are not aware of the concept.



**Figure 4 A pie chart shows to what extent participants were familiar with the concept of DM-HB**

## **6. Discussion and conclusion**

The decision-making process can be biased by virtue of the role that mental shortcuts play in human decision making. Although many researchers have studied this fact in form of psychological behaviours and behavioural economics, limited research has explored the role of heuristics and biases in the selection and definition of infrastructure projects. Accordingly, this study shows that there is poor awareness about the concept of decision-making heuristics and biases in the context of selection and definition of infrastructure projects.

Base on the conducted survey, 88 percent of the participants were not familiar with the concept of decision-making heuristics and biases, and this may result in distorting and perceptions while making a decision. As evident in the survey the poor level of awareness is also true for people who are involved in the decision-making process, where 71% of the participants have been involved in decision-making. The fact is also true for people whom get involved in projects with an average rough order of magnitude proposed cost of 10 million and more.

The low level of awareness on decision-making heuristics and biases may discourage the decision-making process. McCray, Purvis and McCray (2002) have stated that through the explicit recognition and purposeful mitigation of unwelcome heuristics and biases the project management process can be enhanced noticeably. This establishes the importance of increasing the awareness of the psychological traps can help to avoid some of the mental pitfalls (Chatzipanos and Giotis, 2014). With the given figures, further research is required to answer the question of how the role of heuristics and biases affects the decision making in infrastructure projects? To what extent does do people fall into do people fall into the decision traps when selecting an infrastructure project? And how the effectiveness of decisions in infrastructure projects can be affected by the presence of heuristics and biases?

### **6.1 Future work**

- 1) **Develop a model and show the potentials of DM-HB:** the selection and definition stage of infrastructure projects requires lot of works, data to be analyzed, modelling across individuals and teamwork. A useful thing to do, as it has been suggested in previous literature, is to increase the awareness of the DM-HB. This can be

obtained by developing a model that describes the decision-making process and show the potential DM-HB that might occur in each step.

- 2) **Personality testing:** Other work can be done by relating people's personalities to the potential of DM-HB. Such as using Carl Jung's theory by showing which personality has a bigger chance of falling into specific traps. This can help to understand the potential of each trap in an individual level.
- 3) **The contribution of heuristics and biases in the decision-making process:** The decision-making process in SD-IP typically involves multidisciplinary team where the majority of the individuals might not be experts in DM-HB. Hence, prioritizing the DM-HB can be useful in individuals and organizational levels to know which of the biases should be given more attention, and which of the heuristics and biases have more impact on causing failures in infrastructure projects.

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## **Biographies**

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**Raúl Leal** is a Senior Teaching Fellow, and the Business Development Manager for the Technology Management Group at the Department of Space and Climate Physics in UCL. He is interested in systems thinking, systems modelling, systems design, project management and the professional development in these areas in industry. His involvement in education and training extends to over 20 years and several countries. Before joining UCL Dr. Leal was systems design authority in the development of a nuclear imaging (PET) instrument.