

# Decision-making under information overload: Visual representation and ‘fast and frugal’ heuristics as strategies for dealing with information overload

Katharine Alison Sephton

Thesis presented in partial fulfilment of the requirements for the degree of MPhil (Decision-making,  
Knowledge Dynamics and Values) in the Faculty of Arts and Social Sciences at Stellenbosch  
University.



Prof HP Müller

March 2013

## **DECLARATION**

By submitting this thesis electronically, I declare that the entirety of the work contained therein is my own, original work, that I am the sole author thereof (save to the extent explicitly otherwise stated), that reproduction and publication thereof by Stellenbosch University will not infringe any third party rights and that I have not previously in its entirety or in part submitted it for obtaining any qualification.

Date: 4 December 2012

## **Abstract**

The volume of information available to the individual today is greater than ever before. From sources that range from verbal to non-verbal, paper to electronic and audio to visual, there is a constant and ubiquitous supply of information. For managers in an organisational context, whose job it is to manage information from various sources and make decisions based on that, this proliferation of information can be overwhelming. As a result, decision-makers can experience information overload, which can have various detrimental effects on them. Both the problems that information overload can cause, as well as some suggested solutions to the effect are explored. A brief investigation follows into the way in which information in different forms is cognitively processed by individuals is explored. Two possible ways in which decision-makers can respond to the problem of information overload are examined. The first focuses on the visualisation of information and visual management in organisations, looking at two examples, the balanced scorecard and the oobeya room. The visualisation of information often integrates information from various sources, reducing its volume to facilitate cognitive processing. The second response to information overload looks at the use of fast and frugal heuristics. These heuristics ignore some of the available information to ease cognitive processing, resulting in faster decisions that use as little information as possible. Both of these two approaches are explored as potential decision support systems for decision-makers in an organisational context, separately and in combination. One approach is structured and planned, while the other is largely unplanned and intuitive. The similarities are investigated in the way that these two approaches structure information. Both methods aim to reduce the amount of cognitive processing for the decision-maker, minimising the chances of information overload occurring and can be used under certain appropriate conditions to minimise the negative effects of information overload on decision-makers in organisations to result in more effective decision-making processes.

## Abstrak

Die volume inligting wat beskikbaar is tot die individu vandag is groter as ooit tevore. Vanaf bronne wat wissel van verbale tot nie-verbale, papier na elektroniese- en klank tot visuele bronne, is daar 'n konstante en alomteenwoordige verskaffing van inligting. Vir bestuurders in 'n organisasiekonteks, wie se werk dit is om inligting uit verskillende bronne te bestuur en besluite op die hierdie verspreiding van inligting te baseer, kan dit oorweldigend wees. As gevolg hiervan kan besluitnemers 'n inligting-oorlading ervaar, wat verskeie nadelige effekte op hulle kan hê. Beide die probleme wat inligting-oorlading kan veroorsaak, asook 'n paar voorgestelde oplossings met betrekking tot die effek, word ondersoek. 'n Kort ondersoek kyk na die manier waarop die inligting in verskillende vorme kognitief deur die individue verwerk word. Twee moontlike maniere waarop besluitnemers kan reageer op die probleem van inligting-oorlading, word ondersoek. Die eerste fokus op die visualisering van inligting en visuele bestuur in organisasies, deur te kyk na twee voorbeelde: die gebalanseerde telkaart en die *oobeya* kamer. Die visualisering van inligting behels dikwels die integrasie van inligting uit verskeie bronne en so word die volume saamgevat om kognitiewe prosessering te fasiliteer. Die tweede reaksie op inligting-oorlading kyk na die gebruik van "snelle en spaarsame" heuristiese metodes. Hierdie heuristiese metodes ignoreer sommige van die beskikbare inligting wat kognitiewe prosessering verlig, wat individue in staat stel om vinniger besluite te neem en so min as moontlik inligting gebruik. Beide van hierdie twee benaderings word ondersoek as moontlike ondersteuningstelsels vir besluitnemings deur besluitnemers in 'n organisasiekonteks, beide afsonderlik en as 'n kombinasie. Die een benadering is gestruktureerd en beplan, terwyl die ander grootliks onbeplan en intuïtief is. Die ooreenkomste in die manier waarop hierdie twee benaderings inligting struktureer, word ondersoek. Beide metodes poog om die kognitiewe verwerkingslading vir die besluitnemer te verminder en so die kanse vir inligting-oorlading te verlaag. So kan dit gebruik word om onder gepaste toestande die negatiewe effekte van inligting-oorlading te verminder, sodat besluitnemers in organisasies meer effektiewe besluitnemingsprosesse kan implimenteer.

## CONTENTS

1. INTRODUCTION	1
1.1 Background of the study	1
1.2 Statement of the problem	2
1.3 Purpose of the study	2
1.4 Significance of the study	3
1.5 Definition of terms	4
1.6 Theoretical framework	5
1.7 Research questions	7
1.8 Limitations	8
1.9 Delimitation	8
1.10 Assumptions	9
1.11 Organisation of the study	10
2. COGNITIVE PROCESSING	12
2.1 Introduction	12
2.1.1 Nature of the topic under discussion	12
2.1.2 Parameters of the topic	13
2.1.3 Basis for the selection of the literature	13
2.1.4 Problem and scope and variables included	13
2.1.5 Organisation of the review	14
2.2 Information overload:	14
2.2.1 The concept of information overload	14
2.2.2 Managerial context	18
2.3.3 History and development	19
2.2.4 Symptoms and effects of information overload	23
2.2.5 Solutions and coping mechanisms	25
2.3 Cognitive processing	28

2.3.1 The concept	28
2.3.2 Information structure and context	34
2.3.3 Background and personal differences	39
2.4 Conclusion	40
3. VISUAL REPRESENTATION	43
3.1 Introduction:	43
3.1.1 Nature of the topic under discussion	43
3.1.2 Parameters of the topic	43
3.1.3 Basis for the selection of the literature	43
3.1.4 Problem and scope and variables included	44
3.1.5 Organisation of the review	44
3.2 History of visual representation	44
3.3 Trends in data visualisation	47
3.4 Dashboard development	56
3.4.1 History and concept	56
3.4.2 Different representations: Graphic and symbolic	59
3.4.3 The balanced scorecard and the oobeya room	63
3.5 Conclusion	68
4. FAST AND FRUGAL HEURISTICS	71
4.1 Introduction	71
4.1.1 Nature of the topic under discussion	71
4.1.2 Parameters of the topic	71
4.1.3 Basis for the selection of the literature	72
4.1.4 Problem and scope and variables included	72
4.1.5 Organisation of the review	72
4.2 Fast and frugal heuristics	72
4.2.1 What are fast and frugal heuristics?	72

4.2.2 The most common fast and frugal heuristics	81
4.3 How heuristics are applied in an organisational context	83
4.4 Core issues	92
4.5 Conclusion	100
5. CONCLUSION	102
5.1 Introduction	102
5.2 Comparison	102
5.2.1 Information overload and visualisation	102
5.2.2 Information overload and heuristics	104
5.2.3 Visual representation and heuristics	108
5.3 Conclusion	112
6. BIBLIOGRAPHY	114

## Chapter 1

### INTRODUCTION

#### 1.1 Background of the study

The amount of information that most people living in developed areas are exposed to on a daily basis is vast and ever increasing. Whether it is in the form of text, visuals, spoken words, images, sounds or other cues, information is both available and being forced on people for most of their waking day. Given this situation, it is not surprising that the problem of information overload has become a more prominent issue in recent years. Organisations face this problem too, both on an institutional and on an individual level. In organisations, it is a manager's job to deal with and integrate information on a daily basis. Whether they are out of the office, meeting with people or in the office working, they are constantly connected, connected to sources of information which produce too much information for them to process efficiently. The result is the effect of information overload, felt both within the organisation and for the individual decision-makers. Because communication technology has become so widely available, decision-makers often share the same time and attention management problems as managers, even if on a different scale. This lack of time to process information not only results in errors, a poorer quality of decisions and feelings of stress, but it also causes the decision-maker to function sub-optimally, hampering creativity and slowing down productivity. This has consequences both for the individual and for the organisation. Rationing of resources such as time and attention can change the way that tasks are processed, and take away from time spent on other tasks as well as adding new pressure to the cognitive demands of the decision-maker (March, 1994 in Speier, Valacich and Vessey, 1999: 339). The result can be information overload, developing from managing too much information with bad practices. The physical and psychological effects of this have repercussions for the organisation and need to be managed in order to avoid them.

There are various mechanisms that have been developed that can be used in organisations by decision-makers in trying to deal with and lessen the effects of information overload. These including multi-tasking (dealing with various demands simultaneously as when they arise to avoid a build-up of task demands) and filtering information to try and reduce the volume of information flow. Though these help to reduce the amount of information the decision-maker is exposed to, they are not in themselves decision support systems. Visualisation of information in various forms has become a widely used method of presenting information, both in and out of an organisational context. Visualisation puts data into a context, so that numbers and trends in a context are immediately visible. This study identifies visualisation of data as a way of representation that is easier than large volumes of text or data for the human mind to process and remember. The study proposes that it may be a strategy used by organisations to help to deal with information overload. Visualisation is often seen only as a method for making data more understandable. This study proposes a different way of framing the success of visualisation.

Running parallel to this visualisation of information being used in a management context, it is proposed that at least two specific fast and frugal heuristics, the take-the-best and recognition heuristics, are cognitive shortcuts that can also be applied to an organisational context with a similar goal of reducing the amount of information required by a decision-maker. The possibility of using these two methods in combination is further proposed as a potential strategy for decision-making under information overload.

## 1.2 Problem statement

The problem of information overload arises from the fact that information is abundant and that decision-makers in organisations are exposed to a mass of information and need to process more of it than they are able to do effectively in order to make good decisions within the available time frame. The negative effects of this information overload leads to a decline in the quality of decisions by these decision-makers, among other negative effects that impact the decision-maker, their productivity and therefore the productivity and growth of the organisation. It is necessary to explore different approaches to dealing with this in such a way that will lessen the information load on individual decision-makers and help them to make good decisions. There are various coping mechanisms for the problem of information overload, but decision-makers need further support in the decision process. Thus, the two approaches explored act as decision support systems (DSSs) that help to reduce information overload.

## 1.3 Purpose of the study

The purpose of this study is to try and explore each of the two approaches or bodies of research in order to understand better the value that they may have as potential ways of reducing information overload, both separately and, potentially, in combination. The aim of this is to gain a general understanding of how and when these techniques could be used individually and in combination to reduce the negative effects of information overload. The similarity between the ways that these two approaches use in structuring information is also investigated. Both visualisation and fast and frugal heuristics can reduce cognitive load when used in certain contexts. The aim is to find out more about how they can achieve this and in contexts with which characteristics. Whether these contexts exist or can be created in an organisational context to reduce information overload, especially at a management level, is what is further explored.

Both visual representations and fast and frugal heuristics can be used as techniques to reduce information overload, but they need to be used strategically if the aim is to reduce information overload. To be used appropriately, they need to be planned in such a way that takes into consideration the limitations, biases and other negative effects that accompany them, as well as the positive effects. This will enable decision-makers to know better when (in what environments or under what conditions) and how best they can be exploited to achieve optimal results in decision-making and in minimising information overload. These two approaches are explored to determine what the values and limitations of each are and if or when they should be used appropriately.

The link between information and cognitive processing is explored, followed by an exploration of relating visual representation and of fast and frugal heuristics and the relating each to information overload through cognitive processing. The value and relation of each is then explored when used in combination and related to information overload, again through cognitive processing. The purpose of this is to try and discover the structure of similarities between visual representation and fast and frugal heuristics. Both of the approaches are cognitive information management processes that assist decision-makers by reducing information to be understood more easily, while also both evidencing cognitive biases in the decision-making process. The structure of these similarities between the two methods is further explored.

#### 1.4 Significance of the study

The significance of a study shows what it contributes to existing research and what the results can be used for. This study will add to an understanding of the values and limitations in using visual representations and heuristics as distinct but similar decision support systems in the reduction of information overload in organisations. It will create a better understanding of the conditions or environment in which these approaches can be used successfully to prevent from the negative effects of information overload. An understanding of how these techniques reduce cognitive load for decision-makers should be gained too. The possibility of the two approaches being used in combination is a new area of research for further study.

This study frames and combines existing issues differently, advancing an understanding of a different problem than the one usually at stake when visualisation and heuristics are addressed. Visualisation is being framed in a different way to show that it not only aids a better understanding of data, but also that it can be used as a decision support system and as a tool to simplify and speed up decision-making processes. The literature on heuristics is being framed differently too, not just as an awareness of an unconscious way of thinking, but as a cognitive information management system that can be exploited in an organisational structure as a solution to information overload to improve the efficiency of decision-making processes. The similarities between the two approaches in the way that information is handled and the consequences thereof are explored, including the possibility of combining these two methods. The way in which these techniques are framed shows the problem situation as something that can be actively addressed and not accepted as a product of current times. A deeper understanding of visualisation and of fast and frugal heuristics is developed by framing them in a way that highlights aspects of them not usually focussed on. The use of these approaches as cognitive information management systems is applied to information overload, compared to one another and combined, using existing research in such a way as to better understand these issues differently. Similarities between visualisation and fast and frugal heuristics in the structure of the way information is handled are sought, exploring the issue of information overload in a different way.

The results of this study can be used by management in creating an awareness of how both the environment and information structure together affect decision-makers and consequently how this can be planned or structured to get desirable results. It opens up new ways of

thinking about minimising the effects of information overload in organisations and draws attention to the importance of the problem and of planning for the issue in an explicit strategic way to enable increased productivity amongst decision-makers at all levels. The study provides generalisations to create awareness and generate thinking among managers and organisational decision-makers rather than giving specific solutions to specific problems. These general approaches can be adapted and applied appropriately to different organisations.

### 1.5 Definition of terms

There are a number of terms that are used fairly frequently in this study. The chapters include discussions of some of their definitions, while other terms are not discussed. The following is a list of the most used terms and what is meant by them in common sense terms. Some of them require deeper discussion in the body of the research.

‘Information’ and ‘data’ are two different terms, but they are sometimes used interchangeably in this study. Many would argue that according to the definition of these terms, information is data that has been received and processed, with a degree of interpretation involved. The reason they are used interchangeably at times, specifically in the chapter on visual representation, is because much of what is represented has already been processed by the decision-makers who decide what and how to display it. Because of this selection, there is a degree of interpretation and what is represented is not data in its raw form, but has been converted to information through the process of choice involved in displaying it visually. Data refers to the raw ‘facts and figures’ that are then interpreted by decision-makers.

‘Visualisation’ or ‘visual representation’ are terms used interchangeably and refer to data that has been represented in a format that does not include tables or raw numbers, but that has been represented in another format. Examples include decision trees, graphs, balanced scorecards, oobeya rooms, dashboards, interactive charts, diagrams, models, mind maps and other forms of visual representation of data or information that are used in organisations.

‘Fast and frugal heuristics’ and ‘heuristics’ may be used interchangeably. Heuristics refer to general cognitive heuristics, whereas fast and frugal heuristics refer specifically to take-the-best and recognition heuristics. Wherever heuristics is used refer to cognitive heuristics though, and not computational heuristics.

‘Management’ refers to any managers in an organisational context. In some cases it refers specifically to more senior managers who play a stronger role in the strategic planning of an organisation. However, any decision-maker in a management position has more power to create change and influence the decision environment and is also more likely to suffer from information overload, as s/he is exposed to a greater volume of information. As a flatter management structure becomes more popular, the management gradient becomes steeper, affording more strategic power, as well as greater information flow, to those who are in management.

‘Organisations’ refer specifically to larger businesses that may or may not have multiple branches.

‘Information overload’ refers to the problem of the cognitive load being too great for the decision-maker to process effectively in the available time. The resulting negative emotional, psychological and physical effects have an impact on the decision-maker, the decisions made and on the organisation.

‘Cognitive load’ refers to the amount of resources being used to process information in the brain. It is the amount of input stimuli that require some kind of output, interpretation or processing.

‘Cognitive processing’ is the performance of mental activity; the process of mentally sorting through cognitive inputs.

‘Decision-makers’ refers to any individual in an organisation who makes a decision based on any kind of cue and includes managers.

‘Decision strategy’ refers to a sequence of mental operations that are used to transform an initial state of knowledge into an achieved goal state in which the decision problem is solved

## 1.6 Theoretical framework

This thesis is based on existing theoretical research that is reviewed and integrated in such a way that tries to frame an answer to the research question. This study combines different bodies of research with a focus on four main areas. The theoretical framework for each area of research is applied to an organisational context and integrated to formulate an answer.

This choice of study method was chosen primarily due to the subject matter being discussed. In order to look at the different areas of research in a new light and link them together, a review of the current literature in each was conducted. This enabled the establishment of a basic background understanding of each from which new relations could be discovered and conclusions drawn. If new insights are to be drawn or propositions made, they should be based on something known already, which is why literature was selected as the primary method of research. In order to gain a better understanding of the compatibility of these different areas of research, time was spent over a period of months at an organisation that used data to make visualisations for clients. The management and decision-making in this organisation was observed, as well as psychological workshops attended on how visualisations affect the decision-making of the public. It was decided that no raw data would be gathered from this internship and that it would serve as background knowledge to add insight to what the literature provided. There is room for further research in the direction of this study, but to begin with, literature was used as a base from which to work.

The literature was chosen according to its significance and relevance to the overall purpose of the study. It was located through general research that was then further narrowed down by establishing who key researchers were in different areas, and the most important concepts in those areas. The availability of information also helped to direct the research. Further investigation was then conducted into the works of these researchers and into the concepts that were discovered. This research was then critically analysed to assess whether or not it should be included. This analysis was done with regard to the relevance of the literature to

the other bodies of research and the overall study, as well as to the level of coherence and depth of insight in comparison with other related literature. Based on this assessment, the literature was either selected for inclusion or discarded.

Information overload is a large body of research that encompasses a range of areas from consumer choice case studies to the biases that result in decision-making from overload. Of these many areas, the focus of this study will be on the psychological process of being overloaded and the effects of information overload on a descriptive level. The key researchers in this section are the works of Bettman and Kakkar, Eppler and Hutchinson, Alba and Eisenstein. This framework was chosen as the explanation of the concept can be understood with regard to cognitive processing and how the two areas relate.

Cognitive processing is a separate body of research. This includes research on the neurological and more medical and strictly psychological aspect and theories of how much information can be processed, amongst other issues. The focus in this section is a very brief and basic understanding of how information is processed by the brain at a descriptive level. It looks at factors that ease cognitive processing and how the presentation or structure of information affects processing so as to gain a better understanding of how these factors and characteristics may be applied to an organisational context. There was also a focus on the difference between graphics and tables and the types of processing involved in each. Vessey and Sweller are some of the key contributors to this area of research. This research is used as a point of departure for the study, as the explanation in this framework can be applied to understand how visualisation and fast and frugal heuristics can be used to reduce information overload.

Visualisation is a very large and diverse area of research, incorporating many different and related smaller bodies of research. This includes information that ranges from being quite outdated to very new forms of visualisation that are still being developed. It includes the effects of visuals on people and what is better responded to under certain conditions, how best to compile such visuals, the technology used, the type of organisation they are used in, case studies of their use and many other aspects. The research is extensive and varies from being quite general to very specific. This study focusses on a few smaller sections located under the umbrella of visualisation. The use of graphics and tables, the use of visuals in the knowledge economy and dashboard development are focussed on. Benbasat, Lurie, Tegarden and Tufte are among some of the authors whose research contributed to the value of this study. These areas were selected as the framework because they are relevant, can be applied to an organisational context and view visualisation as an accessible mode of display that is already in use.

Fast and frugal heuristics is a large and growing body of knowledge, with more attention being given to it in popular literature too. Much of the existing research had to be applied to an organisational context for the purposes of this study. In the research involving heuristics, only the take-the-best and recognition heuristics were focussed on. Much of the research on biases was not included, with only the factors out of which they arise and the fact of their presence being noted. Different types of biases and when they arise are not discussed, and

neither are other heuristics. Research that was specifically applicable to an organisational environment was selected where possible. The plausibility of heuristics was not discussed, as they are assumed to be psychologically plausible for the purposes of this study. The use of heuristics in forecasting and judgement was useful in the application of heuristics to an environmental context that involves uncertainty and strategic planning for the future. Kahneman, Tversky and Gigerenzer are major contributors to this area of research. The framework shaped by their work was chosen as it has been widely discussed and built on in the general research on heuristics. This enables an understanding that allows it to be related to other the areas of research.

Much of the literature on fast and frugal heuristics is based on the work of Gigerenzer. Gigerenzer has contributed a great deal to the field of heuristics and it is his work, as opposed to that of Tversky and Kahneman, that is focussed on the mind as being adaptive (to the decision environment) and making adjustments, as opposed to being inherently rational and logical with deviations being labelled as biases that are irrational. Gigerenzer conceives of the mind as being adaptive to decisions, responding to the nature of the stimuli it receives and making decisions based upon those, without the assumption of decisions necessarily being rationalised. Particularly in an organisational environment, which is dynamic, such an approach is more realistic in its assessment of how decisions are made.

Following the literature on heuristics, the study then tries to combine these four areas, proposing visual representation and fast and frugal heuristics as ways to ease cognitive processing, and thereby reducing information overload. The final section of this study is based mainly on the conclusions drawn and the findings in the preceding chapters and has no theoretical framework as such. It is a combination of the frameworks that are previously discussed, relating them to one another. In general, articles or authors cited in other related articles numerous times were screened to see whether the main topic was of concern or applicable to this research. Where the area of research was quite broad, the focus was on that which was relevant or related to the other sections either explicitly or in a way that could be applied to the other areas of research. Case studies, experiments, literature reviews and academic articles have all served as sources of information for the research used in this study.

## 1.7 Research questions

This study addresses the primary question in three parts that all relate back the overall problem situation:

How can information overload in organisations be reduced in order to make managerial decisions more efficiently?

- What is the value of using visual representations?
- What is the value of using fast and frugal heuristics?
- Can these means of reducing information overload be connected and overlap successfully?

By the value in visual representations or the value in heuristics, reference is made specifically to the value of these approaches in the reduction of information overload for decision-makers in an organisational context, to enable more efficient decisions.

### 1.8 Limitations

Limitations include any factors that may have an effect on the interpretation of the findings or on the capacity to draw generalised conclusions from results. These are factors not under the control of the researcher. The limitations of this study include primarily the current available research, as the study was based on existing research. Some of the studies are outdated and there are no newer studies available on the same topic. Particularly in the area of visualisation, in the technological advances that have been made in recent years, there is a lack of research about the effects that this has on decision-makers in terms of ease of use and interpretation in decision-making. The specific focus on certain areas of bodies of knowledge and the application of these to certain contexts or the linking of particular concepts yields a limited finding, if at all, among published research. Further, the research presented in this study is of a general nature. Circumstances may vary in different cultures, types and sizes of organisations. There are no specific solutions provided for specific environments, but rather generalisations that can be adapted by management and applied appropriately to different organisations. In applying the concepts dealt with in this study to a management context, some assumptions have had to be made about the applicability of studies to such a context due to lack of existing research on such topics.

### 1.9 Delimitation

In this section the self-imposed boundaries on the purpose and scope of the study are discussed. Decision-making is complex and affected by many issues, not all of which can be explored in relation to the context of this study. There is awareness of what this study does not discuss, what is outside of the scope of this research. Looking at the study as a whole, a distinction needs to be made between organisational and individual information overload. In general, this study deals with information overload on an individual level for decision-makers in an organisational context. Though the approaches suggested can be implemented on an organisational level, they aim to target the individual decision-makers affected by the problem. On an organisational level, the 'solution' would be more in line with better knowledge management (KM) and structures that would favour good KM practices. However, the focus of information overload is in an organisational context, as opposed to the specific neurological processes or detail on the individual psychological effects that it has on decision-makers.

Another major choice is that the focus of this study is not on visual representations and fast and frugal heuristics in general, but specifically as decision support systems in an organisational context. Decision support systems are ways that information can be managed in order to support the decision-making process. Methods such as filtering aim to reduce information overload, but they do not assist in the process of choice. The two approaches suggested here aim to reduce the cognitive load as well as to act as aids in the decision-

making process. Not only do they reduce the amount of information considered by a decision-maker, but they assist in the process of choice. These two approaches are specifically being considered as decision support systems that also reduce information overload.

In exploring fast and frugal heuristics, this study does not go into a lot of detail about what biases result under which circumstances, but simply that they do arise at certain times. When referring to individual differences in decision-makers, there is no detail on individual characteristics, such as cognitive style, but simply recognition that individual differences play a role. The same applies to organisational culture. It is referred to very generally and does not go into detail about how the age, management structure, type and size of the organisation play a role, or how the culture is shaped and the role it plays, but rather simply that these factors do all affect the decision context in different ways. The country, industry and wider socio-economic context also play a role in the internal environment in an organisation and how much information is coming from which sources. While these are all important issues, the focus is on coping strategies, which can be adapted to be appropriate for the above listed factors shaping the context.

There is no detail either on the specifics surrounding decision quality. Some of the research refers to it, but this study does not specify what makes a decision good or bad, what a decrease in decision quality means or how it is measured. The problem of decision failures is an issue not dealt with specifically either. It is assumed that based on the techniques that are provided as DSSs, that a decision will be made. A failure to make a decision, the failure to make the 'right' decision or one that produces 'good' results is not discussed. What the conditions may be that lead to decision failure, when information overload may lead to decision failure or the consequences of it are not areas that are explored in this study. While this is an important issue, it falls beyond the scope of this study.

In the research on the use of fast and frugal heuristics, when suggesting that the decision environment can be structured or planned to encourage the use of certain heuristics, the nature of recognition and take-the-best heuristics suggests that this would imply that one way of doing so would involve presenting the decision-maker with only a few choices. How these choices are decided upon or what methods should be used (eg. Filtering) to reach these options are not discussed in the scope of this study. The type of organisation that may be more suited to each of these two approaches that are discussed, and the management structure conducive to their successful use are speculated on, but not discussed in detail.

This study notes the positivist approach taken by most of the theorists discussed, to the problem situation, as opposed to a normative approach. In lieu of that context, the study aims to be more descriptive than idealistic, with a focus on reality. The philosophical and idealist views of the situation are not investigated.

#### 1.10 Assumptions

There are a few assumptions that are made, ideas that are believed to hold and are accepted as operational for the purposes of the research. It is assumed that management has some kind of

influence in shaping the environment in their organisations, in which decision-makers operate. The degree to which they are able to and do varies, but it is assumed that they have the power, leadership and resources to create change.

It is assumed that a reduction in information overload is desirable for optimum decision-making. It is assumed that data that is presented visually is accepted as valid by decision-makers. Further, it is assumed that biases are inherent when humans are involved in decision-making, where choice exists. Objectivity is limited by inherent biases and only the extent of their influence can be affected. The assumption exists that (fast and frugal) heuristics are psychologically plausible and the existence of their operation in cognitive processing is not questioned.

In some cases where research was lacking that directly linked to the context in which this study was framed (management or decision-making in organisations), assumptions were made regarding the application of existing research to the management context. Depending on the nature of the research, certain findings were assumed to be applicable to decision-makers in a management context too.

A key assumption is that how decision-makers decide how to decide reflects considerations both of cognitive effort and of the accuracy of various information processing strategies (Payne and Bettman, 2004: 116). The assumption is made that decisions are taken based on given information and not on pre-existing knowledge of other options that are not presented. In reality, this may not be the case, and unique personal backgrounds are evidenced in the different biases and framing that is evident in decisions. Particularly in the use of heuristics, decision-makers can be primed, but it is assumed that the options presented to the decision-maker are the only options that are considered. It depends on the level of involvement of the decision-makers in the process of collecting or interpreting the data. The 'noise' and amount of attention available also influence the focus on the actual problem, but are not discussed in detail. The assumption is made though, that when the decision-maker takes a decision, it is based on the information presented in the visual representation or in what is selected for choice in the heuristics paradigm, and not based on other known information to do with the decision problem. This would add a complexity to the decision-making process that is unknown and beyond the scope of this study.

The assumption is made that most decision-makers working in an organisation experience the problem of information overload to some degree, depending on how well information is managed personally and by the organisation. It is therefore assumed that the problem is fairly widespread and applicable to decision-makers in various types of organisations in different countries throughout the world.

### 1.11 Organisation of the study

Chapter 2 lays out the problem of information overload. It is divided into two sections. The first section discusses the concept of information overload, the way it is defined, how it is relevant for management in organisations, a brief history of the problem and then some of its effects on decision-makers and potential solutions. The second section focusses on cognitive

processing, on the actual processing of data by the brain and how a reduction in cognitive load eases processing, thereby reducing the effects of information overload. The way that information is presented can affect cognitive processing, with the information environment and the problem representation, as well as individual differences playing a role in information acquisition and processing.

Chapter 3 deals with the broad topic of visual representation. A history of visualisation and its development and context within management is followed by a discussion of the trends and important issues in data visualisation, including critiques of visualisation as a method of representation. Dashboard development as a feature of visual representation is then explored, concluding with two examples of dashboards; the balanced scorecard and the oobeya room. This chapter explores visual representation in an organisational management context from a psychological perspective.

Chapter 4 proposes that fast and frugal heuristics can be used as a decision support system to reduce information overload. How fast and frugal heuristics work and how they can be applied in a management structure, as well as a critique on these ideas is provided. There is a focus on the take-the-best and recognition heuristics as they are most popular and have been given most attention in the literature. The chapter concludes with a summary of both the values and limitations of fast and frugal heuristics.

Chapter 5 links both visual representation and fast and frugal heuristics to information overload through the concept of cognitive processing. The similarities of the two approaches are compared and the possibility of using visual representation and fast and frugal heuristics in combination as a decision support mechanism to reduce information overload is explored. The proposition is made that the outcome or motivation for using the two approaches is similar and that if used in a planned manner in the appropriate context, these two techniques could be complementary. Conclusions are drawn regarding the value of both visualisation and fast and frugal heuristics, as well as their limitations and the dependence of good decision-making on a realistic assessment of both advantages and disadvantages of any cognitive process.

This study aims to explain the problem of information overload through an understanding of cognitive processing. Cognitive processing is then used to explore how the use of visual representation and fast and frugal heuristics, both individually and in combination, can be used as potential approaches to reducing information overload in an organisational context. The similarities in information structuring between the two approaches are investigated for a better understanding of how each can be used as cognitive management systems.

## Chapter 2

### COGNITIVE PROCESSING

#### 2.1 Introduction

In a variety of contexts, including management sciences, psychology, marketing, accounting and information sciences, the concept of information overload has been recognised (Eppler and Mengis, 2003: 4). Research has been conducted in order to try and better understand its causes and effects, as well as possibilities for the avoidance of its negative effects.

In an organisational context, information overload can result from an abundance of telephone calls, meetings, reports and emails, amongst other information sources, all needing the attention of a manager, to be integrated and for decisions to be based on. It was reported that Intel's annual cost of time wasted due to the handling of unnecessary emails and recovering from interruptions was \$1 billion (Hemp, 2009: 86). This shows that not only can information overload affect an individual, but the organisation too. The negative effect of information overload causes symptoms in an individual that can result in a detrimental effect on personal productivity and on the organisation and its profits. It is therefore in the best interests of both individual decision-makers and organisations to try and avoid or reduce the problem of information overload.

At a fundamental level, distinctions can be made between different types of information. A common distinction is between two different types of information, one that is belief based and the other that is data based (Hutchinson, Alba and Eisenstein, 2010: 627). Belief-based information is that which decision-makers believe about the environment in which they operate. Data-based, on the other hand, is information based on the facts and figures that are found in every organisation. This chapter focuses on data based information, that which is explicit and can easily be shared between decision-makers in an organisation.

##### 2.1.1 Nature of the topic under discussion

Information overload can be defined in different ways by different groups of people. From the perspective of organisations, studies on information overload explore the cognitive processing ability of an individual as well as considering other constraints, such as environmental and time constraints that may be placed on the decision-maker to cause overload. This is the view that is adopted here to explore information overload and can be contrasted to studies that focus more on the psychological or individual impact of information overload, such as the feelings of anxiety, stress, confusion, pressure and low motivation that arise from individuals experiencing information overload (Eppler and Mengis, 2004: 328). Because the focus is on decision-making in an organisational context, external factors do play a role in information overload, and not simply the psychology of the problem.

The nature of both of the discussed topics is very broad. These are relatively established areas of research with many studies having been done. As a result of this, there are numerous theories that exist within the different topics, with varying degrees of consensus as to their relevance.

### 2.1.2 Parameters of the topic

Given the broad nature of the two topics covered in this chapter, there are some necessary choices to be made as to the scope of the contents. The first section deals very basically with the concept of information overload and is limited to that in an organisational context, with a focus on management. There is no detail on decision quality and how that is determined either. The focus is on a descriptive level as opposed to a normative level, not focussing on how the organisation should present information or how it should avoid information overload, but rather describing what does or can happen. The existence of the problem is not questioned, nor the reality or effects of it, but rather, information overload as a reality in organisations and life in general is explored.

The focus on information overload in this study is on an individual level, as opposed to an organisational level. The proposed approaches to dealing with the issue can be implemented in an organisational context, but are aimed at reducing the information overload of decision-makers, and are coping methods for individuals as opposed to organisations. Though the proposed approaches are knowledge management techniques, they are also decision support systems, aimed at individuals.

The parameters for the second section, an investigation of cognitive processing, are also defined. The section includes a general overview of cognitive processing and different formats of information, but does not go into neurological or detailed psychological explanations of the concept. In addition to this, the chapter does not include research on cognitive styles or the different psychological profiles of decision-makers. The problem of how attention is allocated to decision problems or how decision strategies are chosen is beyond the scope of this study.

### 2.1.3 Basis for the selection of the literature

Due to the wide range of research available on these topics, and the variety in their content, literature was selected according to how closely it related to the parts of the topic that had been selected for coverage, relating to the chapters that follow. Only perspectives pertaining to selected aspects of each subject was included, with a focus on that relating to graphical processing or heuristics.

### 2.1.4 Problem and scope and variables included

Information overload and the negative effects it has on both individuals and organisations has become more of a problem in recent years, as both the amount and the ease of availability of information has increased exponentially. In order to better understand what and how strategies may help to protect against or reduce information overload, knowledge of the psychology of information acquisition, and how it is affected by the information environment and personal differences, is needed.

The research on information overload is limited to the fundamental concept of information overload and the general situations in which it arises. Reasons and effects of information overload in an organisational environment are explored too. The research on cognitive

processing is limited to a basic understanding of how individuals acquire information. It does not go into detail on the neuropsychology of the process. In terms of the factors that influence problem representation and information processing, two are focussed on. These are the information environment and the way in which information is structured; and individual differences. This does not include the cognitive style of decision-makers and differences between them, but is a more general discussion of the fact that differences between decision-makers exist. The variables taken into account thus include the organisational or decision context, the personal background of the decision-maker and the type of information involved.

### 2.1.5 Organisation of the review

The review is divided into two main sections. The first section focuses on the problem of information overload, looking at the definition and the concept itself, followed by its importance for managers in an organisational context. A history of the problem and its causes is then discussed, followed by some of the symptoms that it causes and concluding with a selective overview of some suggestions for avoiding or reducing the problem. The second section concentrates on the cognitive processing of data. The psychological process of information acquisition is explored, along with how the way that information is presented can affect this. The information environment and the problem representation are looked at as one aspect that affects information acquisition and processing for the decision-maker. The other factor affecting this is individual differences among people from different backgrounds. The chapter then concludes with an understanding of information overload, cognitive processing of information and how the two relate in order to understand what strategies might be effective in reducing information overload.

## 2.2 Information overload:

### 2.2.1 The concept of information overload

In trying to define the term, two main perspectives are evident in the literature; viewing the problem from an information science perspective and from a psychological perspective. This section explores information overload from an information science perspective, while section 2.3 investigates the psychological process of receiving and processing information.

The most general definition of information overload is when the information processing requirements of a task exceed the information processing capacity of the individual(s) involved (Eppler and Mengis, 2003: 11). This is influenced by various factors, including the amount of information, the time available in which to process the information and various attributes of the information, including its ambiguity, uncertainty or complexity. Schick (1990) emphasises the role that time pressure plays in decision-making and information overload. Increasing information can lead to a decline in decision quality under time pressure (Lurie, 2004: 473). Given a certain volume of information, if an individual cannot perform a task within the allocated time due to an inability to process the information required, then information overload does occur. However, if that individual is given more time (with the same information), and is able to complete the task, then information overload does not occur. Thus, Schick argues that information overload is dependent on the time factor and the

information processing capacity of an individual to meet the task requirements within the available time (1990: 203). Savolainen (2007: 612) makes a similar argument, conceptualising information overload as “a subjective experience of the insufficiency of time needed to make effective use of information resources available in specific situations”.

This is not to say, however, that, given enough time, any issue could be solved without information overload being experienced. Particularly in complex environments, such as organisations, information overload is almost inevitable and is a given for the organisation or decision-maker. These include established environments where there is a lot of information known about an issue, as well as those environments that involve multiple issues; those that overlap, relate in new and different ways and involve information from areas too large or different to define and process specifically. In such complex situations, it is a given that there is too much information available for it all to be processed, no matter how much time is available. Problems facing organisations today are often complex in nature, involving forecasts, decision-making under uncertainty or in complex situations that have not been faced before and for which there is no ‘prescribed’ way of dealing with it. In such circumstances, satisficing becomes a necessity. Optimal solutions involve searching through all available information, taking into consideration as much as possible about a situation to reach the best solution. When unable to consider all information, it is more feasible to consider only that which is necessary to reach a decision that yields a satisfactory outcome. Satisficing in organisational decision-making is thus a more realistic option to finding solutions to problems.

An increase in information does not necessarily result in a negative effect on decision-making. The effectiveness of decision-making has a positive correlation to an increase in information supplied, but only up until a certain point (O’Reilly, 1980: 692). After this point has been reached, information is no longer integrated into the decision-making process, and the decision-maker may start to experience the negative effects of information overload. This correlation resembles an inverse U shape, where more information is only helpful up until a certain point, after which it becomes detrimental to the decision-maker (Eppler and Mengis, 2004: 326). In research conducted amongst consumers, a similar result was found by Schick (1990: 200), where, after a certain point, more information can lead to poorer decision-making. On the opposite end of the scale, decision-makers who are not exposed to enough information can display lower levels of learning and poorer performance (Lucas and Nielsen, 1980: 685). Decision-makers need to try and find the optimum amount of information, at the ‘top’ of the inverted U curve, where they have as much information as possible to make a decision with before becoming overloaded.

The point at which information overload begins is where an individual’s ability to effectively process information reaches its maximum (Schick, 1990: 200). The capacity of an individual to process information is their ability to perform such processing activities (Schick, 1990: 203). One determinant of this is the structure of the organisation (Schick, 1990: 204). The issue in dealing with information overload is thus how to manage the organisational structure and the interactions between organisation members and those with outsiders, including both their frequency and duration (Schick, 1990: 204). This is derived from Mackenzie's span of

control concept, which has to do with having enough time to process information (Mackenzie, 1974 in Schick et al, 1990: 204). The argument is that exposure to a certain amount of information over a shorter period of time leads to overload, whereas exposure to the same information, but with enough time to process it does not lead to overload. The key factor is time. This means that individuals who use simplifying strategies to complete their work in time should not be overloaded. However, such individuals often are overloaded. This could be due to an overload at an organisational level, with the number of issues requiring decision-makers being too high for the corresponding availability and processing capacities of organisational resources. In this case, better knowledge management and other practices to reduce information overload would need to be implemented on an organisational level.

Though both problems exist in society today, the distinction between individual and organisational information overload is definite, with the latter being more significant in this context. Organisational information overload impacts both decision-makers and information systems on various levels. It has more far-reaching effects with more serious consequences on the latter, affecting not only the organisation's financial situation, but other factors such as its reputation and stakeholders. Information overload is more complex on an organisational level. In organisational information overload, there is necessarily a time constraint, as they exist for a purpose, to achieve a goal. When there is something that is being worked towards and decisions to be made along the way, there are expectations from internal and external stakeholders and time pressure on decisions for the organisation to achieve its purpose. Organisational information overload can be influenced by many factors. These include the people who belong to it, the information systems in place, the quality of information received, (time) pressure and many other external factors. In comparison with individual overload, the overload experienced at an organisational level can affect more people, with more extensive consequences that are more serious and less easily rectified.

One view of information overload is that it can be measured by four factors. These are said to include the number and difficulty of decisions required from information, the available time in which to make the decision/s, the quality of information processing required and the predictability of information inputs (Sparrow, 1999: 144). Information overload is increased with information that has a low quality, requiring additional mental effort, a low value, requiring assessment of the validity in comparison with other information and that which is highly contradictory, requiring decision over what is certain and what is ambiguous (Sparrow, 1999: 144). Such information requires an increased amount of mental effort, increasing the processing time and assessment necessary. When processing time is limited, the decision-maker in this context would experience information overload in relation to better quality information from other sources (Sparrow, 1999: 144).

According to Simons' bounded rationality, the behaviour of decision-makers is shaped both by the cognitive limitations of the decision-maker and by the structure of the task environment (Simon, 1990: 7). Glazer, Steckel and Winer (1992: 214) believes that it is the information processing capacity of the individual that is the scarce resource. The attention that is allocated to information is dependent on how accessible that information is, how necessary it is perceived to be and the way in which it is framed (Glazer, Steckel and Winer,

1992: 214). In situations where information is not readily accessible, not very necessary or framed in such a way that the decision-maker cannot easily relate to it, information overload may occur, and better decisions may be made in the absence of information rather than in the presence of such information (Glazer, Steckel and Winer, 1992: 223). The quality and content of information is important and decision-makers deprived of valuable information will display lower levels of learning and poorer performance (Lucas and Nielsen, 1980: 985). Ultimately, it is a combination of factors both internal and external to the decision-maker that affect information overload, both inherent cognitive constraints as well as factors such as time and information structure.

Another factor that influences how decision-makers respond to and process information is personal and background differences. People come from different upbringings and have learnt to think and to solve problems in different ways, some of which are more conducive to the effective processing of more information than others. Personality, education and experience will thus play a role in determining an individual's susceptibility to the effects of information overload.

In a study conducted by Malhotra (1982: 34) on consumers, it was found that the more information was given on the attributes of alternatives, the better the decision-making was. Correct choice declined with an increase in the number of alternatives, though not significantly. Applied more generally, this shows that when more information about the details of a specific decision is provided, then decision-making could improve. This is contrasted to an increase in the number of available decisions, which would decrease the quality of decisions after a point (Malhotra 1982: 35). Amongst consumers, the ability to process a certain (large) amount of information is not usually matched by the motivation to do so. It is likely that the same principle would apply in an organisational context; where there is a large volume of information to be processed, there is a mental unwillingness to do so, as the cognitive load is perceived to be too great. People are mentally lazy and look for shortcuts, possibly resulting in heuristics being used in an attempt to process the volume of information confronting an individual (Malhotra 1982: 35).

The way in which the information is structured has implications for information processing and for the quality of the decisions taken (Lurie, 2004: 473). Increased amounts of information lead people to be more selective in their acquisition of information (Lurie, 2004: 475). Decision-makers adapt the method and the amount of information acquisition in response to the way it is structured (Lurie, 2004: 484). With available information about the attributes for each alternative, decisions become more difficult with the increase in information processing that is required, consequently leading to a decrease in decision quality.

The effects of information overload can affect individuals in many different contexts, not only that of an organisation. However, though decision-makers at all levels can be affected by the problem, focusing on an organisational environment, managers are particularly susceptible to the negative effects of information overload. In addition to this susceptibility, it

is also managers that have the power to put in place measures that can help to prevent the effect from becoming a problem.

### 2.2.2 Managerial context

The leadership position in which managers find themselves means that the way in which managers deal with information overload sets the tone for the whole organisation (Dean and Webb, 2011: 2). Managers, no matter what level in an organisation they are from, are responsible for making decisions. These decisions often have an outcome that will have an influence on more people than just themselves. Likewise, these decisions are influenced by a number of people. Individuals or teams that report to a manager contribute information in various forms to the decision-maker. From the information received, the manager will need to decide what is important and what can be ignored, and how information from various sources can and should be integrated before making a decision based on the information. This process often occurs with little or limited time, as decisions need to be made quickly and frequently and have consequences for others, increasing the pressure on the decision-maker. In such a context, it is easy to see how information overload can occur, with lots of information from different sources needing to be collaborated and acted on under time pressure.

The fact that managers play a number of roles in an organisation, with decision-maker being just one of them, means that not only are the decisions under time pressure, but that decision-making activities have to compete with many other demands on an overloaded individual, further reducing the time able to be spent on the decision-making process. Managers receive more information from more sources through more channels than anyone else in an organisation, often receiving too much information, but not the right kind (Katzner and Fletcher, 1996 in Edmunds and Morris, 2000: 22).

In the last couple of decades, there has been a trend towards the flattening structure of larger organisations (Balls, 2012). Many middle managers have been removed, increasing the management gradient with more senior managers being closer to the operational activities of their organisations. This has resulted in more people reporting directly to the CEO and senior management. Consequently, the likelihood of information overload has increased, as there are more sources of information, more channels of information open to the managers and an increase in the number of demands being made on these decision-makers. The pressure that is placed on these managers and their accountability has increased, resulting in an increase rather than a decrease of the effects of information overload.

One effect that information overload may have had on management is the development of a style of management that has become known as management by exception (MBE). MBE is a style of management that has become popular in larger organisations. Using this style of management, managers' attention is only drawn to situations where there are serious deviations from the planned or expected results in an organisation. This style of management could have developed as a response to the increase of information in organisations, as a way not to deal with all issues, but only those needing the most urgent attention, with 'less significant' issues being delegated to others. This management style could also be the effect

of such one image decision-making as that resulting from the use of graphs or other visualisations (eg. The balanced scorecard). Managers are only exposed to the most important issues and can then take decisions around these central issues in order to steer the organisation back in the direction it should be going, thus maintaining the execution of the organisational strategy.

MBE can aid the reduction of information overload by leaving only important issues to be dealt with by managers, focussing their attention on the organisational strategy and on make good decisions in a few key areas, as opposed to spreading their attention too thinly. It also delegates tasks to other, less senior managers, thereby spreading the workload to distribute issues needing attention evenly, or to those best able to deal with the problem. This results in senior managers not having to deal with issues with which they are not familiar or which can be effectively dealt with by other decision-makers. On the other hand, such a management style could inhibit the reduction of information overload by focussing the attention of senior managers on what is going wrong, as opposed to trying to develop the organisation and better existing structures or processes. If an organisation wants to try and reduce information overload, a key area to focus on is in improving KM on an organisational level. A goal such as this may not be achieved under management by exception, as there may not be an explicit problem with the KM structures that would cause it to be brought to the attention of senior management. Such an area, along with other issues deemed 'less significant' may go under the radar of senior management and hinder the growth of an organisation. If the attention of management is on keeping the organisation on the 'straight and narrow', their efforts may not be focussed on growth, innovation and development. Being prepared to try new strategies in decision-making may not be of great importance to these senior decision-makers, thereby not effectively aiding the reduction of information overload, both on organisational and on individual levels.

The concept of information overload has implications for decision-makers in a variety of environments, in a range of management positions. Though the concept itself is not new, both its causes and its prevalence in society today, and particularly in organisations, are greater than ever before, and it is affecting and being affected by management styles in different organisations.

### 2.2.3 History and development

Information overload is a concept that has existed for many years. There are some that argue that there is evidence of referral to information overload as far back as the 1500's, where Gesner refers to the "confusing and harmful abundance of books" (Blair, 2003: 11). Another suggestion is that the concept came about at the time of Guttenberg and the invention of the printing press, when information became more easily available and able to be dispersed (Hemp, 2009: 84). Information sharing could take place on a larger scale, between people in more geographically dispersed locations. References were made to the overload that could result with the increasing amount of literature being published in the form of books (Hemp, 2009: 84). Savolainen would place the birth of information overload at the time of Simmel in 1903 (Savolainen, 2007: 612). Developments in communication systems in organisations

allowed for more information to be transferred (Edmunds, 2000: 20). Then the rise of paper documents in organisations followed, increasing the amount of available information. This has been followed by the development and subsequent ubiquity in the World Wide Web and the internet (Edmunds and Morris, 2000: 20). This has resulted in the problem of too much information and too many sources. The awareness of this concept has increased in recent years, as the amount and rate at which information, both new and old, is being made accessible has increased (Eppler and Mengis, 2003: 15).

Advances in technology have led to a more rich and complex information environment (Bawden and Robinson, 2008: 181). There is more information in more formats from a variety of media and communication channels. This diversity in information types and sources is equally as much the cause of information overload as is the increased volume of information (Bawden and Robinson, 2008: 181). Information from previously very different formats and sources are now all available in a limited number of media. Because of the various sources of information, and the internet giving almost anyone accessibility to contribute information, the validity of this information cannot always be relied on. The efficiency of a decision-maker in using information in their work is hampered by the amount of relevant and useful information that is available to them (Bawden and Robinson, 2008: 183).

With so many different sources of information online, it is not always reliable. Inaccuracies, partly due to the increasing number of participants in information creation, and a lack of a specific method to process and communicate information, could be causes. This is problematic for the information seeker, as they need to verify information before it can be used. In the verification process, more sources may be consulted, leading to information overload in a small task of trying to validate one piece of information. Not only does this result in more information being consulted, but further, it wastes the time of a decision maker. In an organisational context, where time is often limited, decision-makers are under time pressure, increasing the likelihood of information overload. Lucas and Nielsen (1980: 982) found that information overload also forces the decision maker to use more time organising information before it is able to be used in problem-solving. Irrelevant information can distract the decision-maker from the key areas of interest (Lucas and Nielsen, 1980: 982). This can lead to the wrong areas of information being focussed on and a general slowing down of the decision-making process.

The increase in information, and information overload in recent years can be analysed on two different levels; societal and organisational (Eppler and Mengis, 2003: 14). Both of these scales refer to information overload in a context where information originates from a variety of sources, including (primarily) the internet, books, journals, data, media, various forms of instant messages, mobile phones and face to face communication.

On a societal scale, the two primary reasons for an increase in information overload have been an increase in the production of information and in the distribution of that information (Eppler and Mengis, 2003: 14). The rate at which new information is being produced has accelerated. This has been enhanced by the fact that, due to technological advances, there has

been an increase in the number of people able to contribute to the generation of information. More money is being put into research and development by many different types of organisations to assist future growth and development (Eppler and Mengis, 2003: 16). In many first world countries, and in others, there has been a move towards the knowledge economy, where having access to information becomes a financial advantage (Powell and Snellman, 2004: 199). Many people have developed a thirst for knowledge and a desire to learn, believing that this will give them an advantage in the economic climate of today (Powell and Snellman, 2004: 201). Society is becoming increasingly educated. Technology is being used in new ways and easier communication networks have allowed the dissemination of information worldwide. The ubiquity of the internet in most developed parts of the world today has facilitated this increased participation in information creation by individuals and organisations from all over the world. This leads to the second cause of information overload at a societal level; the increase in the distribution of information.

The ease with which data can be transmitted across the internet and other methods of communication allows for a much broader group of people to engage in the sharing of information, with relatively basic levels of technical know-how. The channels of communication have increased too, and now include various forms of print and social media (such as television), telephones (landline and mobile) and the internet, which includes applications that support written (email), face to face (Skype), visual and social networking communication, amongst others. Search engines online provide an easy manner in which to facilitate the search for information. However, information overload can result from a combination of these causes. The ease with which people can share information broadens the group of people who have the means to publish information. The result of this is that not all information will come from reliable sources. This has resulted in the need for individuals to cross-check the information that they are exposed to in some cases, to determine the validity of the information they receive (Eppler and Mengis, 2003: 19). Such a process increases the information load and the amount of cognitive processing that needs to happen in order to find the desired information. In addition to this, the increase in the number of sources of information means that individuals often need to integrate information from various sources to get what they are searching for. Once again, this increases the cognitive effort required to process the increased information load. The increase in the production and dissemination of information on a societal level has caused an increase in the general level of information overload in the world today.

On an organisational level, there are multiple causes for the increase of information overload in recent years. These are usually a combination of the information itself, the information technology, the structure of the organisation, the receiver of the information or the tasks or processes that the information is required to complete (Eppler and Mengis, 2003: 14).

The information itself can be from an unreliable source, of a poor quality, incomplete, ambiguous displayed in a way that makes it more difficult to interpret, understand or remember. The structure of an organisation can determine who is likely to have contributed to information and how it is disseminated. The various people that contribute to the generation of information in an organisation each contribute something from their different

backgrounds, shaping the ultimate 'product'. Similarly, the people the information is exposed to are all unique, with different ways of problem-solving, different attitudes, experiences, and ease by which they are interrupted and distracted. The type of tasks required of decision-makers could be either routine, requiring little active thought or innovation, or complex and new, requiring adaptation and cognitive application to the task. The time in which the decision has to be made also affects the decision-maker.

According to Weick, reality in an organisation is socially constructed (Weick, 1995 in Sparrow, 1999: 142). The actions and interactions of decision-makers in an organisation work to construct reality. This gives power to individuals to change their environments in such a way as to reduce information overload. Both thought and social processes in decision-making are influenced by emotion. It determines where and to what degree the attention of managers is focussed, the levels of stress of individuals and their ability to recall applicable information in a decision context (Sparrow, 1999: 141). Decision strategies are influenced by emotion, which can play a bigger part in decision-making when people are under stress, as is often caused by the time pressure in organisations (Sparrow, 1999: 141). With much communication happening in real time, such as email, the time pressure on individuals may be increased, as communication delay cannot be used as an excuse in prolonging decision-making.

Automation has put more pressure on people to do everything faster (Meadow, 1998 in Edmunds, 2000: 21). Human and mechanical information processing cannot happen at the same speed and keep up with one another. In organisations in particular, a large volume of the information contributing to information overload comes from emails (van Zandt, 2004). The high number of senders of information can be blamed as being a cause of the problem. The awareness that the information is delivered to the receiver immediately creates the expectation of an instantaneous response (Sparrow, 1999: 145). This assumption by the sender that the email has been received as soon as it has been sent puts the receiver under more pressure to act faster, increasing the impact of information overload from email (Sparrow, 1999: 145). One can understand that one sender would not choose to overload another individual. However, it is the fact that messages and information from multiple sources crowd out that from other sources, that causes the overload (van Zandt, 2004: 543). It is in the interests of both parties not to induce or suffer from information overload by providing information that is easily processed to enable as efficient and accurate decisions as possible (van Zandt, 2004: 543).

The causes of information overload are not simply due to an increase in the amount of information and the accessibility of it, but also of the faster pace of the work environment and the increased time pressure under which many decision-makers in an organisational context find themselves. The effects that this problem of information overload can have on decision-makers are multiple and varied.

#### 2.2.4 Symptoms and effects of information overload

Information overload can manifest in different ways, depending on the context, the degree and the cause of the information overload. There is a difference between information overload and communications overload (O'Reilly, 1980: 685). Information overload involves a decision-maker receiving too much information to process in the available time, whereas communications overload involves the volume of communication sent and received that does not necessarily always communicate any information. There is communication for the sake of it, causing an excess of communication that needs to be filtered to seek that containing relevance. The modern information environment presents us with information forms in which the human senses and prior experience are ill-equipped to deal (Bawden and Robinson, 2008: 184).

On a societal level, the amount of information received these days, particularly in urban areas, can result in people living in cities ignoring low priority messages and allocating less time to each input (Milgrim 1970 in Eppler and Mengis, 2003: 19). A similar situation can be seen in an organisational environment, where time is usually short, urgent decisions are prioritised and services such as email have an automatic filtering function to block out some unwanted information (Milgrim, 1970 in Eppler and Mengis, 2003: 19). There is a general lack of perspective and cognitive strain in an organisation experiencing information overload. This lack of perspective suggests that decision-makers may focus mainly on the short term, meeting deadlines and operating under pressure. Elements such as strategic planning or long term decision-making may fall by the wayside and not be a priority.

On an individual level, those who suffer from information overload feel inadequate, as though they have an inability to cope (Sparrow, 1999: 144). This can be accompanied by high levels of stress. The potential of the decision-maker to make dysfunctional or inferior quality decisions increases under such conditions (Sparrow, 1999: 144). Potentially important details are omitted and there is a greater tolerance of error (Sparrow, 1999: 144). The effectiveness of decision-makers is reduced, along with a lack of perspective on the task at hand (Schick, 1990: 212). When faced with a large amount and high rate of information, decision-makers can experience stress and distraction, causing errors to be made, as the information acts like noise from which individuals are unable or struggle to distinguish relevant information (Klapp, 1986 in Edmunds and Morris, 2000: 19 and Savolainen, 2007: 613). These are all results of the inability of the mind to be able to process a given information load and the consequent feeling and effect on the decision-maker.

Information overload can hinder creativity and innovative thinking (Dean and Webb, 2005: 3). Due to a high cognitive load, available mental resources are utilised for information processing and leave little energy for creativity and search for new strategies. This can hinder personal growth, career progress and organisational growth. A further consequence of information overload in an organisational environment is the possibility of decision-makers ignoring a major part of the information supply (Savolainen, 2007: 614). As this information supply is likely to be largely operational, with information describing that which already exists, innovation is impeded, with little time available for the search of new possibilities and

opportunities, and the exploration of original ideas. Information seekers under overload conditions are often satisficers, not able or willing to expend the cognitive effort required to find the optimum solution (Savolainen, 2007: 614). The increase in information arriving from various and numerous sources throughout the day results in interruptions, which also decrease productivity (Hemp, 2009: 86). Decision-makers may not process information incorrectly, but distractions may lead them into processing the incorrect information (Glazer, Steckel and Winer, 1992: 223). Information overload can result in loss of control and a feeling of being overwhelmed (Bawden and Robinson, 2008: 183).

Cognitive inertia is caused by poor information structures (Sparrow, 1999: 143). Poor information structures do not enable managers to attend to the most important issues in their environments, to retrieve information effectively or to solve problems quickly. The decision-making process is hindered by poor information structures. Cognitive inertia can be caused by using old schemata to navigate new problems. Decision-makers need to be aware of the changes taking place in their business environments and must adapt to these changes, rather than processing information schematically. The inertia that could result from not doing so could collapse businesses and is an important strategic risk that needs to be managed. It is therefore essential both that decision-makers are aware of changes in their environment and that they have good information structures that allow them to respond to these changes in a timely and effective manner.

The poor information structures that lead to cognitive inertia implies that the structure of information can have a significant effect on the individuals to whom it is presented. Too much information for people to handle can have a negative psychological effect. Decision-makers may perceive the mental effort of processing information to be too high and consequently not even attempt processing in the first place, as it is easier to ignore than to make the effort to process it. This can result in vital information being scanned or entirely ignored. Details could be missed completely, which may have significant implications for decisions made and, when on a management level, for the organisation. It can also result in dysfunctional decision-making by overloaded decision-makers, which can be a major risk for organisations.

At a management level, information overload causes decision-makers to divert their attention to more irrelevant issues as they are blinded by too much information (Sparrow, 1999: 144). The potential for unjustified risk taking and error increases and decision-makers devote more time to information search and too little time to information processing and learning (Sparrow, 1999: 144). The Reuters survey of business managers showed that information overload causes loss of job satisfaction, damaged personal relationships (and in some cases, damaged health) and that important decisions were often delayed and adversely affected as a result of too much information (Bawden and Robinson, 2008: 184).

With an appropriate knowledge structure, one that does not result in information overload, managers can better encode and interpret information, attend to more meaningful events in their environment, make more accurate interpretations and quicker decisions, enabling a faster response to problem resolution (Sparrow, 1999: 145). In an organisational context, this

knowledge structure can refer to the ordering and organisation of information in such a way that a manager does not become overloaded by a deluge of information. The ordering and presentation of organisational information can thus enable more efficient decisions to be made. Limitations in the processing of information may lead to biases and errors in judgement (Glazer, Steckel and Winer, 1992: 214). These biases and errors could lead managers to focus on a certain set of activities at the expense of others.

Information in abundance generally leads to higher confidence in decision-makers and more certainty in the decisions that are made, but also in lower quality decisions that take more time (O'Reilly, 1980: 693). Decision-makers feel surer about the decision they have made because the increase in information they have received results in more knowledge about the decision they make, in addition to the decisions they have not taken. A better knowledge of what they have and have not decided on leads to more confidence in decisions made. The time taken to consider an increased information set does, however, result in a slower decision of a lower quality, suggesting a trade-off between time and accuracy.

Time wasting, anxiety, confusion, a feeling of incompetence, lower job satisfaction and an inability to use information to make a decision are some of the negative effects that information overload can have on individual decision-makers in an organisation. Though there isn't one solution for this multitude of effects caused by information overload, but there are some coping mechanisms that can be used to avoid or lessen them.

#### 2.2.5 Solutions and coping mechanisms

Due to the complex nature of the problem of information overload and the host of causes and contributors to the issue, there is no one simple solution to dealing with information overload. Rather, solutions should combine a number of strategies that are applied according to their suitability to the situation (Hemp, 2009). Measures taken to counter information overload require that the cause of the problem in a specific situation is addressed, necessitating the combination of different strategies to address the problem at hand. While the cause and context of the problem play a role in how information overload is addressed, there are some general findings about how individuals cope with an increase in the volume of complex information, based on the way in which decision-makers process information cognitively.

Pull and push technologies are other possible solutions to cope with information overload (Savolainen, 2007: 613). Pull technologies emphasise the use of refined search strategies for retrieving information, effectively filtering data to reduce information overload. Push technologies deliver information according to pre-determined filters, reducing information retrieval time, but also increasingly the possibility of receiving irrelevant information (Savolainen, 2007: 613). This strategy may save time, but may also cause the information seeker to have information delivered that may not be what they are looking for.

A filtering strategy focuses on the most useful information by removing useless information from the sources to which it is applied. An example of this is visualisation. A withdrawal strategy keeps the number of daily information sources to a minimum in order to protect from information overload (Savolainen, 2007: 617). While in the past, secretaries have been used

to act as a filter, the majority of filtering these days is done electronically (Sparrow, 1999: 145). Though some filters (eg spam bucket in email) already exist to try to curb information load in individuals, there have been suggestions of more electronic filters to try to limit information overload (Sparrow, 1999: 145).

Hemp (2009: 86), among many others, has suggested a new software application that visually associates related pieces of information on a computer screen as one approach to reducing cognitive load. However, it is necessary for decision-makers to trust the system if this method is to be used successfully. If this can be done, then integration of information can happen automatically, removing some of the processing from the cognitive load of individual decision-makers. Decision-makers may argue that the system will not always be able to associate information the way the decision-maker or the task demands, particularly when dealing with new or unrecognised information. Such a system also involves the ethical dimension of potential information overload 'solutions', such as trying to decide what information is to be considered important or worth prioritising, as what is important to one decision-maker or in one context may not be as important to another (Hemp, 2009: 89). This relates to the fact that inherent in the reduction of information or human interference in information processing is framing and biases.

Taking control of one's information environment is necessary to avoid information overload (Bawden and Robinson, 2008: 187). Schick (1990) suggests two strategies for avoiding information overload; either to decrease the information load or to increase the information processing capacity of an individual, through an increase in time allocated to a task. Similarly, Dean and Webb (2005: 5) advocate three steps for coping with information overload; to focus on what is necessary, filter the available information and forget about that which has not been included or used. This is simple enough in theory, but the problem lies in determining what is necessary and how to filter the information which is not. It is apparent how less information could be better than more, as the 'filtering' is already done by default, leaving the decision-maker with only just enough information to make a decision. Though these suggestions may be effective in curbing information overload, they are not always possible in an organisational environment. The information that one receives cannot always be reduced and time cannot be bought. It may therefore be more useful, in an organisational context, to examine ways to deal with high volumes of information that require processing under time pressure.

Under conditions of information overload, subjects in an experiment by Bettman adopted simplifying strategies or used heuristics to cope with a ranking task (Bettman, 1979 in Malhotra, 1982: 427). The research also found that the probability of information overload occurring decreases with the variability in attractiveness of choice options. As there is more variety in the relative attractiveness of options, the process of making a decision is eased, reducing task demand (Malhotra, 1982: 428). In an organisation, if one option is far more attractive or superior than another, the decision-making process is eased, as the choice becomes clearer to the decision-maker. This speeds up the decision-making process and will also increase the likelihood of satisfaction and confidence in the decision taken.

Satisficing has been noted as a popular heuristic for coping with large volumes of information (Bawden and Robinson, 2008: 185; Simon, 1990: 9). When there is a shortage of time in which to make a decision, people cannot afford to look for an optimum solution, as this can require the integration of all available information, costing time and possibly, money. What is often perceived as information overload may simply be work overload, with individuals having too much to do in the time available to them. Most people, most of the time, will practice satisficing in an organisational context (Bawden, 2008: 187). Sparrow (1999: 145) found that “the greater the complexity, the more the untrained person searches for and relies on habitual and routine cues”. This suggests that with higher volumes or an increase in the complexity of information, the human mind is more likely to use heuristics and mental shortcuts as a coping mechanism.

Where there is a larger selection of choices, people are more likely to find the solution they are looking for and therefore less likely to satisfice (Messner and Wänke, 2011: 9). When there are fewer choices, it is more likely that one choice will stand out as being superior or closest to the optimum, whereas with more, there could be (at least) two choices that are closely related and a compromise will need to be made, leading to a higher sense of dissatisfaction by the decision-maker (Messner and Wänke, 2011: 10). However, with more choice, there is more information to be stored in the memory of the decision-maker, which increases the chances of information overload being experienced. According to Messner and Wänke (2011: 12), simplifying a decision by not thinking and using heuristics is not the solution to increasing satisfaction, as it will not be any higher.

Michalos (1973: 115) argues that the least problematic technique for reducing information overload is by presenting visual displays of data. In such displays, there is often a focus on flow indicators rather than static indicators, making it easier (than in data) to see changes or patterns over time (Michalos, 1973: 120). Graphs are the most common way to show these trends or differences over time or space.

The way in which information is presented is, to some extent, an individual’s choice, resulting in the use of a wide variety of methods. One way that this could be overcome is by organisations standardising information presentation through the use of templates. If there is a certain standard way of data being presented in an organisation or an industry, this would make the process of reading that information more routine and less taxing on the cognitive effort required by the decision-maker. Information overload would be less likely to occur when organisational knowledge is well-structured. This could be done through emails, electronic filing and filtering, keeping data up to date and having clear channels of communication, amongst other measures. The organisational culture and the freedom of managers to process information independently of social factors are important in avoiding information overload (Glazer, Steckel and Winer, 1992: 225).

Aside from filtering mechanisms that can be used, both heuristics, as a cognitive simplification strategy, and graphs, as a visual simplification strategy can help in preventing information overload (Schick, 1990: 208). The structure or way in which information is presented affects how easily information is subsequently processed by an individual.

Different heuristics may also be used in different circumstances as a mental shortcut taken by decision-makers to reduce the cognitive load of information processing. These two lines of thinking will be further explored to investigate how they may be used as more general 'solutions' to the problem of information overload.

Both heuristics and visualisations can be used by managers, or any decision-makers, in an organisational context to reduce the cognitive load of information processing during decision-making. The exploration of cognitive processing will assist in understanding how a reduction or easing of cognitive load can help to reduce information overload in both of these coping mechanisms.

## 2.3 Cognitive processing

### 2.3.1 The concept

Cognitive processing refers to the way in which information, in this case from an external source, is processed by the mind until it can be acquired and understood by the brain. The information context and the way in which it is structured, as well as individual differences, play a role in cognitive processing and determine how much learning takes place. Cognitive load is the 'amount' of resources being used to process information in the brain. It is generated by searching through information for that which is relevant and blocking out noise. Cognitive load can obstruct skill acquisition, with such strategies often not resulting in learning (Chandler and Sweller, 1991: 294). Depending on how great or small this load is, the processing of information is either eased or not. The heavier the cognitive load, the more resources are going to be used in the processing of information, making it slower, more difficult and reducing the amount of information acquisition or learning. The heavier the cognitive load is, the more likely it is that information overload will occur. The way that information is presented to a decision-maker has an impact on the cognitive load, consequently affecting how different types of information is processed and thus what might be appropriate as a means of countering information overload.

Cognitive load theory presents a proposal of the capacity of the brain to store information, looking at the manner in which cognitive resources are focused and used during learning and problem-solving (Chandler and Sweller, 1991: 294). While this is an important factor that plays a role in cognitive processing and in the cognitive load of a decision-maker, it is only one factor. Cognitive load theory is based on the ability to digest information, and though cognitive processing is also about the ability to integrate information being presented and make a decision based on what is in front of the decision-maker, as opposed to what is stored in one's memory, it is still one factor that plays a role in processing. Research in cognitive load theory is based largely in education as opposed to organisational decision-making, but the principle of learning and information acquisition could be extended to such an environment.

Cognitive load theory is based on a model of cognition that includes working or short-term memory with very limited duration, storage and processing capacities for new information and with unlimited long-term memory as a knowledge base (Meyer, 1991: 221 and Kalyuga

and Renkl, 2009: 210). Working memory is the cognitive structure in which conscious processing takes place (Kirschner, Sweller and Clark, 2006: 77). This is the part of information processing that people are aware of, while the conscious mind is often unaware of the large amount of information in long term memory (Kirschner, Sweller and Clark, 2006: 77). The working memory is limited in its duration and capacity for processing new information (Kirschner, Sweller and Clark, 2006: 77). Because the working memory is limited, overload should be avoided. For example, when performing two tasks simultaneously, the cognitive load imposed by one task interferes with performance on the other (Sweller, 1988: 282). Also, if there is more than one source of information then learning is slower than if the same materials were presented using the same format (Chandler and Sweller, 1991: 296). The requirement to mentally integrate information imposes a heavy cognitive load. Cognitive load can be differentiated into two types: productive cognitive load is intrinsic and makes learning possible, whereas extraneous cognitive load interferes with learning (Kalyuga and Renkl, 2009: 210). It is the latter of these types of cognitive load that can result in information overload.

Extraneous cognitive load is when the problem-solving strategy interferes with learning and refers to the load that is imposed by the information itself. The way in which information is presented can often result in high levels of extraneous cognitive load that influence the degree to which learning can be facilitated (Chandler and Sweller, 1991: 294). It should therefore be presented in ways that do not impose a heavy load. It is often the case that problem-solving does not do this (Chandler and Sweller, 1991: 295).

Conventional problem-solving uses a means-ends analysis of a problem, where an end goal is identified and a path mapped out of how to achieve that goal (Sweller, 1988: 259). This requires a large amount of cognitive processing capacity which is therefore unavailable for the acquisition of schema, or already understood information. Schema “are large, complex units of knowledge thought to organise much of what people know about general categories of objects, classes of events, and types of people” (Schank and Abelson, 1977 in Meyer, 1991: 231). They help people to make judgements, understand their environments and cope with information processing demands (Anderson, 1980 in Meyer, 1991: 231). Schemata are incomplete knowledge structures (Meyer, 1991: 231).

The mechanisms for problem-solving and for schema acquisition are quite different, with the result that this cognitive effort may not assist in schema acquisition. The cognitive load thus interferes with schema acquisition (Sweller, 1988: 261). In these conditions, if people struggle to gain access to knowledge that is available and already understood, heuristic decision-making may be more likely. Decision-makers would resort to this simplified method of decision-making rather than trying to apply schema under conditions of overload. There is evidence suggesting that conventional problem-solving through means-ends analysis causes a heavy cognitive load (Sweller, 1988: 266). Problem-solving activity via means-ends analysis usually leads to a solution and not to schema acquisition (Sweller, 1988: 260). The result of this cognitive effort is a solution, as opposed to learning. When learning takes place, there is an understanding of the situation and the problem that could allow the decision-maker to draw on similar elements of experiences from the past or to pick up on similarities from other

situations that could assist in problem resolution. If the process is goal orientated, this is unlikely, as the problem situation is likely to differ in at least one way from other problem situations and the same goal or problem-solving processes will not be applicable. Learning therefore helps decision-makers in furthering their knowledge in an area and their problem-solving techniques, helping to develop schemata that can be applied to problems in the future to reduce cognitive load.

The goal of the problem to be solved or decision to be made also plays a role in the cognitive load. There appears to be more excess cognitive capacity available after solving a problem without a specific goal than a conventional means-end problem (Sweller, 1988: 282). A problem that can be laid out with a more general goal rather than a very specific one is more likely to aid learning than one with a very specific goal. This also allows the decision-maker to draw on schema and apply existing knowledge to situations. The use of such knowledge would reduce the cognitive load of the decision-maker, as they would not be analysing a situation as though it were completely new, with no prior knowledge applicable to it. Of course, this may be the case in all problems, but generally, those problems that have less defined goals will aid learning and in so doing, reduce cognitive load.

There are different theories about how much information the working memory can hold before it reaches a point of overload. Even when the contents of a problem situation are not complex, one's short-term memory can hold only a limited amount of information. It has been proposed that this is only about seven chunks of information (Anderson, 1980 and Miller, 1956 in Meyer, 1991: 221). When information processing begins, the capacity may even drop to two or three chunks of information (Lloyd and Feallock, 1960 in Meyer, 1991: 221). Malhotra (1982: 427) found that individuals can't handle more than ten items of information simultaneously without experiencing dysfunctional effects, with the short term memory only holding about seven chunks of information. Another suggestion is that individuals seek simplifying information processing techniques when choice exceeds five and there are other studies that show that the number of chunks of information that can be processed without overload occurring is between four and nine (Kirschner, Sweller and Clark, 2006: 77 and Miller in Tegarden, 1999: 13). Though there may be differing ideas between researchers on exactly how much information can be held, there is agreement on one point; that the human mind has a limited capacity for processing information and that after a certain point, information overload, with negative effects, occurs.

There are certain techniques that are designed to reduce cognitive load, for example by integrating textual explanations into diagrams or by information being displayed in images as opposed to verbally, as verbal representations use serial processing of information whereas images use parallel processing (Kalyuga and Renkl, 2009: 210). It is also possible to increase the brain's short term storage capacity by packaging many smaller chunks of information into fewer larger ones (Anderson, 1980 and Newell and Simon, 1967 in Meyer, 1991: 221).

Studies with more advanced learners showed that with the development of knowledge in an area, techniques such as the integration of textual explanations into diagrams, often became unnecessary or even detrimental, meaning that for such learners, eliminating redundant

representations was more effective than providing them (Kalyuga and Renkl, 2009: 210). Therefore, in experts, processing additional explanatory material could induce unnecessary working memory load and distract the decision-makers from the central concepts and principles being presented. Shanteau conducted research that was counter to this, where experts were more able to block out noise than inexperienced decision-makers in the same field (Shanteau, 1992 in Astebro and Elhedhli, 2006: 396). However, other studies show that the information available to the decision-maker and their level of training or experience is not related to the accuracy of forecasts (Astebro and Elhedhli, 2006: 396). Depending on the way that the information is presented and the content of the information, certain people may find it easier to process than others. This is connected to cognitive fit theory and to the decision style of the decision-maker involved.

The effect of cognitive load theory is explained by imbalances between the learner's knowledge base and the instruction that is provided, a similar concept to cognitive fit theory (Kalyuga and Renkl, 2009: 210). In order to optimise available cognitive load, the appropriate instructional support should be provided to non-experts, while unnecessary guidance should be removed as the learners become more knowledgeable about a specific domain. This applies more to a process of explicit learning than to decision-making. If this were the case with decision-making, decision support systems to experts would become redundant. However, there is a distinction between learning and decision-making. Absorbing information involves actually acquiring the information to contribute to the knowledge base, while taking a decision based on evidence involves using an existing, learned knowledge base in combination with what is being presented. While learning is important for the understanding of information and the development of schemata, decision-making is most often the primary focus in an organisational context, as opposed to learning. This would mean that when it comes to experts, they may still benefit from guidance in decision-making, with their level of experience not automatically resulting in superior decision-making.

The problem of information overload arises partially from the problem of attention. Cognitive attention is a limited resource and the way that decision-makers choose to spend it should be carefully managed. A large body of research that is connected to information overload and cognitive processing deals with attention, specifically with the problem of task interruption. Where tasks are interrupted, decision-makers take longer to process information. Cognitive processing is slowed down as other tasks demand attention and cognitive effort too. When attention is temporarily switched to another task, the decision-maker may take longer to return to the task at hand. Such interruptions include breaks, emails, distractions, interruptions from information and people, and discrepancies in information. All these task interruptions divert the attention of the decision-maker from the task at hand, slowing down the decision-making process.

The psychological theories on attention under search play a role in decision-making in organisations. March (1994: 23) went so far as to say that decision-making is the study of search and attention. How decision-makers allocate their attention affects the information that is available and therefore the decision that is subsequently made (March, 1994: 23). Information overload is partly a problem of attention, with decision-makers having too many

sources of cues that are demanding their attention than the time or resources that they have available to attend to these. Attention is central to framing, agenda setting and processing. In a world where individual information overload is not uncommon, there are more activities to do than time permits, more factors demanding the attention of decision-makers than they have time to attend to (March, 1994: 24). Where and when the decision-maker chooses to focus their attention will play an important role in how information is framed, processed and what decision is ultimately reached.

Decision-makers are faced with constant choices about where to focus their attention, on what cues, and when they do so; how they prioritise the cues in their environments. For example, in organisations, there is often a tendency to prioritise short-term issues over long-term planning and strategic decisions (March, 1994: 24). Who attends to what issues also affects the decision. For example, managers may decide to delegate certain tasks to other decision-makers, which will result in the decision being processed differently and a potentially different decision outcome. Decisions are affected by the way in which decision-makers attend or fail to attend to preferences, alternatives and cues (March, 1994: 24).

When deciding where to focus their attention, decision-makers need to weigh up the costs of focussing their attention on one factor in terms of the benefits of what they may get from rather spending it on another. Because information is costly in terms of processing and time resources, it could be assumed that rational decision-makers would look for ways to minimise the costs of search, processing and attention (March, 1994: 25). Both the approaches of visual representation and fast and frugal heuristics minimise these costs, reducing the attention required to be expended on a decision.

Visualisation focusses the attention of the decision-maker on certain aspects of a data set by representing a selection of that. This eliminates some of the choice for the decision-maker. By directing the attention of the decision-maker, processing is quicker and lighter. Fast and frugal heuristics uses only a limited number of cues to make decisions. The way these are prioritised and the cues that are given attention, unlike visualisation, are left more to the decision-maker to choose. However, these can be influenced by the organisation to increase the likelihood that some cues will be given attention over others.

When referring to the biases that result from any decision-making in which human choice is involved, the problem of attention is also relevant. If the decision-maker were not to use a specific technique for reducing overload in their decision-making, such as the two explored in this study, then biases would still arise. Satisficing would take place, as decision-makers would be too inundated with information to be able to process it all and consider all the available options. Satisficing assumes both that aspirations adapt to performance and that performance adapts to aspirations (March, 1994: 30). In the prior case, decision-makers learn what to expect based on past performance. In the latter, the performance of the decision-maker depends on what s/he expects. Expectations or aspirations may determine how hard the decision-maker works or tries to attain those. This relates to the concept of slack, or the difference between actual and potential achievement. For example, when actual performance is lower than potential performance, there are unutilised resources. This may be done

intentionally to build up a reserve for challenging situations. Slack can be managed to lower targets and avoid upward aspirations (March, 1994: 30). Biases in the decision-making process are inherent, and decision-makers may be more susceptible to them when attention is under pressure, a likely scenario given the scarcity of the resource in organisations.

The way in which human beings process information cognitively varies from person to person. This is not only due to inherent differences in the way one's brain functions, but also due to the way in which information is presented and to other environmental factors that play a role in determining the context in which information is received (Tversky and Kahneman, 1986). The way in which information is presented has an effect on how that information is received and processed by people and thus on how much learning actually takes place; how much of that information is able to be stored and recalled. It may be possible to reduce or to counter the negative effect that information overload has on the ability to retain information through the way in which the information is presented.

Decision-makers use different cognitive strategies to acquire information. These strategies are strongly influenced by the structure of the information presented (Bettman and Kakkar, 1977 in Jarvenpaa, 1989: 286). Though individual factors do influence decision-making, this is not to say that individuals approach problems with one strategy that is specific to them. There are factors that are common to information processing amongst decision-makers from different backgrounds. One of these factors is the way that people extract information from a non-verbal source, a process consisting of three stages: external identification, internal identification and perception of the correspondences (Green, 1998: 5). The extraction of information takes place using two classes of visual variable: planar (spatial) and retinal (size, colour, shape, orientation, texture and brightness) (Green, 1998: 6). For efficient visualisation, perception must be immediate and the decision-maker should not need to scan sign by sign. Only planar variables permit all levels of perceptual organisation. This suggests that spatial dimensions play an important role in data visualisation and the effectiveness of perception. In visual theory, spatial location is also the key attribute that is essential in the reassembly of information in the mind in order to form object perception (Green, 1998: 12). This perception can then be used to formulate a problem representation and a strategy for solving the issue.

Decision-makers are also highly adaptive to the varying demands of tasks (Payne, 1976: 367). In a model known as the additive model, it is shown that the dimensions in an alternative in a choice set are evaluated separately to derive a value for each (Payne, 1976: 367). Different dimensions are then combined in an additive fashion resulting in an overall value for that alternative. After these have been compared, the alternative with the greatest value is chosen, implying that the additive model is compensatory. The amount of information that was searched by the decision-maker declined as the number of alternatives available increased and as the number of dimensions per alternative increased (Payne, 1976: 373). Whether search was done in an intra- or an inter-dimensional way depended on the individuals. One possible explanation for the differences in information search may be in how the decision-maker represents the knowledge acquired about the alternatives in the decision task. This shows that it is not only the structure of the information that affects the way that

information is processed, but the inherent processing capabilities and methods of each individual decision-maker. These inherent factors will play a role in determining how information is processed, in ways that relate to the way that it is presented, but are not necessarily able to be controlled by the presentation format, as they differ from person to person.

### 2.3.2 Information structure and context

The way that information is structured and presented, and the context in which this takes place are all important factors that need to be taken into consideration in determining how successful cognitive processing of the information by the decision-maker may be. There are two aspects to the presentation of the information, the first being the actual nature of the data and its characteristics; how that may affect processing, and the second being the way in which the data is then structured, determining the format in which it is presented to the decision-maker.

#### Nature of data

When considering the presentation format of information, Green (1998) shows that the human mind is poor at gaining insight from data that is presented in numerical form. Decisions that are based on numerical data can be strongly biased by the cognitive heuristics that can be used in analysing data (Hutchinson, Alba and Eisenstein, 2010: 627). When dealing with multidimensional data, such as that often found in complex decision-making in organisations, image theory suggests some ways of getting around the limitations in perception of this data. Providing different views on the same data can aid the reception of information; presenting data in different ways, integrating information that has been distributed over space and time to counter the limitations of attention and memory that constrains cognitive processing (Green, 1998: 3). This type of integration is usually found in graphs, assisting decision-makers in processing. Although data values themselves have no position, colour, symbol, or behaviour, graphs can help decision-makers to perceive patterns and relationships that might not otherwise be evident and to meaningfully relate these to the original data (Wainer and Velleman, 2001: 316).

In studies based on consumers and choice processing, it was found that consumers may focus only on information relevant to choice, with other information receiving relatively little attention (Biehal and Chakravarti, 1982: 439). When processing choice attributes, it was also found that information in memory was much lower than when the choice was based on external information. This suggests that decision-makers would be more likely to base a decision on information that they are presented with, as opposed to using knowledge they already have. Such decision-making may encourage the use of heuristics, as decision-makers are not making a decision based on internal existing knowledge, but rather on what is in front of them. This also suggests that the decision-making would occur under time pressure, again, a factor encouraging the use of heuristics. Consequently, the way in which information is structured plays a significant role in how it is processed. In an organisational context, this could imply that if information is presented to decision-makers, it could potentially be more

persuasive than knowledge already known by the decision-maker. If visual presentations require relatively little cognitive processing, as opposed to other forms of data presentation, this increases the power they have for decision-makers in group contexts.

### Structure of data

It can be argued that the ability of the mind to process information depends on the format in which it is presented (Bettman and Kakkar, 1977 in Jarvenpaa, 1989: 286 and Schwenk, 1988). The way in which information is processed varies from person to person, but the ability of the mind to process information is dependent on the structure of the information presented to the decision-maker. Though information may be readily available, the ability of the mind to process it, based on the way in which it is structured, is equally as important (Bettman and Kakkar, 1977: 240). This is one of the major issues with information overload in organisations today. There may often be an abundance of information available to decision-makers, but not in a format that is conducive to the volume or complexity of it to be able to be processed effectively by the human mind. The information that is available needs to be in a format that can be easily processed in order to enable the receiver of that information to acquire it. If certain methods of processing information are easier or more effective, information should be presented in a format that is congruent with those methods of processing (Bettman and Kakkar, 1977: 240).

Information used in an organisational environment often consists of data that has been collected over space or time, or both. Decision-making will then be based on three sub-tasks that are the acquisition, evaluation and learning of information (Einhorn and Hogarth, 1981: 9). The strategies that the mind uses to acquire information are strongly influenced by the structure in which the information is presented (Bettman and Kakkar, 1977: 234). This is contrary to the notion that decision-makers have preferred strategies which they apply to all types of information, as Bettman and Kakkar (1977: 239) found in a marketing study based on consumer choice. The ability of information to be processed, or its 'processability', rather, depends on its format and the way it is structured. If certain methods of information processing are easier to execute or result in more effective processing, then information must be presented in a format congruent with those methods. The processability of information is just as important as its availability (Bettman and Kakkar 1976: 239).

Depending on the format of the information, the strategies used for acquiring that information will vary. Not only this, but the type of information processing during acquisition affects the way that information is organised in one's memory, as well as the subsequent retrieval of that information (Biehal and Chakravarti, 1982: 431). In addition to this, the differences in learning goals also affect the way that processing takes place at acquisition. For example, whether the decision-maker needs to be able to recall information at a later stage or to be able to recognise it has an effect on how information is processed when it is acquired (Biehal and Chakravarti, 1982: 431). Both the presentation format of information and the learning goal affect retrieval and choice processes (Biehal and Chakravarti, 1982: 431).

When data is presented in the form of models, this can compensate for the relative cognitive weaknesses of managers (Bruggen, Smidts and Wierenga, 1998: 645). According to Dawes, people are bad at integrating information from diverse and incomparable sources, whereas models are good at such integration (Dawes, 1979 in Bruggen, Smidts and Wierenga, 1998: 646). This is the key to performing well in probabilistic environments. Bounded rationality states that in processing information, human beings show limitations in their computational capabilities and use of memory. Models can enhance computational abilities or else perform these themselves. Too much information forces the decision maker to spend time organizing the information instead of solving the problem. Irrelevant information distracts and diverts attention from key variables.

The framing of a problem situation affects the way that it is processed and interpreted, and thus the way that information is received. Cognitive fit theory states that problem structuring is the outcome of the relationship between the problem representation and the problem structuring task, which is characterised by the type of information each emphasises (Vessey, 1994: 107). When the types of information in each match the way the task is structured, then the decision-maker can use cognitive processes that emphasise similar types of information to solve the problem. The solving of a problem is the outcome of the relationship between the problem representation and the problem task (Umanath and Vessey, 1994: 803). This relationship is determined by the type of information emphasised by each. The correct matching of the problem representation and the task can lead to the consistent use of problem-solving processes and the formulation of consistent mental representations, leading to more effective and efficient problem solution (Umanath and Vessey, 1994: 803). As long as there is a complete fit of representation, decision-makers will take more accurate decisions (Vessey, 1994: 109).

Spatial and symbolic processing is what characterises the difference between graphs and tables in terms of how decision-makers process the information (Vessey 1994: 105). The nature of these two types of tasks allows them to be solved differently, cognitively processed in different ways dependant on the format in which the data is presented. Spatial representations facilitate processing the information they contain at a glance, and different elements are not processed separately or analytically (Vessey 1994: 105). They are better represented by graphs and are important in aiding perception and acquisition of information in the human mind, emphasising relationships between different elements of data (Green, 1998: 4 and Vessey, 1994: 105). Relationships that an individual would usually need to induce from data through inferences drawn as a result of cognitive processing, would be displayed in a graph without any mental effort required to make these relations. Symbolic representations facilitate the extraction of particular data values (Vessey 1994: 105). Tables are used during analytical processes, where the individual values need separate attention and analysis, utilising symbolic processing (Umanath and Vessey, 1994: 805).

Decision-making consists of three interrelated sub-tasks: information acquisition, evaluation, and learning (Einhorn and Hogarth, 1981: 9). The first two sub-tasks are relevant in analysing decision-making with graphs and tables. In the processing of spatial representations, the problem area is assessed as a whole (Vessey 1994: 105). More complex spatial tasks involve

perceptual evaluation. Perceptual evaluation requires less effort than analytical processes (Vessey 1994: 106). Decision-makers therefore have little incentive to use analytical evaluation processes to solve a spatial problem. Complex symbolic tasks involve analytical evaluation, so decision-makers may be tempted to use perceptual rather than analytical processes to reduce the effort involved. Complex tasks have high cognitive demands and place strain on the cognitive resources of a decision-maker, increasing the cognitive load (Vessey, 1994: 106). When cognitive fit applies, an effective and efficient problem solution can be reached. There is no incentive to use tables to support spatial tasks and vice versa. Generally, perceptual processes lead to fast responses while analytical processes lead to accurate responses (Vessey, 1994: 108).

For example, an experiment was conducted to determine whether graphs performed better than tables on spatial tasks with a requirement for accuracy and whether tables performed better than graphs on symbolic tasks with a requirement for time. Accuracy with graphs was found to be better than with tables on spatial tasks (Vessey, 1994: 109). Accuracy with tables was found to be better than with graphs on symbolic tasks under conditions of time pressure (Vessey, 1994: 109). This relates to cognitive fit and the fact that symbolic tasks may be better represented by tables, whereas spatial tasks are better represented graphically. Decision-makers were not induced to change their strategy when cognitive fit existed, showing the robustness of strategy choice when information is given in a particular format. Cognitive fit may occur in tasks in two situations, when processes required to support information acquisition and evaluation are similar (and supported by both tables and graphs respectively) or they don't match and neither graphs nor tables will result in performance advantages (Vessey, 1994: 109). No single strategy will be better on both accuracy and effort than all others during complex tasks (Vessey, 1994: 111). A trade-off between performance on speed and accuracy means that there are unlikely to be advantages in using either graphs or tables all of the time. Cognitive fit results in the use of an optimal strategy, while more complex decision-making allows for the use of a number of different strategies that differ on speed and accuracy. The inherent complexity of a task prompts decision-makers to conserve effort by using perceptual rather than analytical processing techniques (Vessey, 1994: 115). This suggests that the use of graphs is preferred to reduce cognitive load and decrease the chances of information overload from occurring. This is often the case even if it means forgoing some accuracy (Vessey, 1994: 115). Studies show that when strategy shifts do occur, they are biased in favour of graphs or perceptual methods of processing (Vessey, 1994: 116).

The reason for this may be due to the fact that information is processed in different parts of the brain and the form in which it is presented influences how and where this is done; the left and right hemispheres of the brain represent information in different forms (Meyer, 1991: 223). There are some benefits of representing information in two forms concurrently. Dual representations of problems facilitate heuristic search (Meyer, 1991: 224). This suggests that, for example, information that is presented visually with accompanying text may encourage the use of heuristics. Visualising data involves encoding information to produce graphic

representations and decoding the graphic representations to produce visual data that can be analysed (Meyer, 1991: 224).

When cognitive fit exists, then this means that if the task type is spatial and the way that that information is presented is also spatial, then the processes used in the perception of the information will be more effective due to the match of task type and task processes (Vessey, 1994: 105). The same applies to symbolic processing. The cognitive fit of information type to the type of display and processing of it results in easier reception of information and thus better decisions (Vessey, 1994: 108). Processing will also be faster, assisting in handling higher volumes of information.

Integrating data from different time periods utilises cognitive resources, is time consuming and error prone (Vessey, 1994: 106). Sometimes decision-makers need to reference the underlying data. Graphs are useful in that they support perceptual problem-solving processes which provide integrating capabilities (decreasing the required mental effort), but also preserve the underlying data (Vessey, 1994: 106). Symbolic data provides values but no integration, therefore requiring an increase in mental effort required to process the data. Mental effort necessary to process the information is lower in graphical representation than in symbolic representation. This shows that graphs have a higher likelihood of reducing the chances of information overload from occurring, as opposed to the use of tables. The accuracy of prediction is also higher with graphs than tables (Vessey, 1994: 106).

When data is presented graphically, the graphs must be easy to interpret, making obvious what they are displaying, while focusing the attention on the data (Eick and Wills, 1995: 5). The inter-relationships within our perceptual systems for analysing size, colour and motion are poorly understood. It is, however, known that the formation of an image takes longer if there are colour differences that must be ignored (Green, 1998: 22). It is important to keep graphical displays as simple and uncomplicated as possible, including the use of as few colours as necessary.

Researchers have argued that data presentations using appropriate graphical formats can greatly enhance data comprehension, which helps to reduce bias (Lurie and Mason 2007; Wainer and Velleman 2001). Inferences that are based on data are subject to strong heuristic based biases that are not reduced by graphical presentations of the data, real world experience, or explicit training. Graphs should be accompanied by some kind of an explanation or analyses, whether verbal or written, to contextualise the information presented graphically.

Schwenk (1988: 41) has found that there is a link between an organisational environment, its strategy and structure. The role of cognition in the way that issues are diagnosed and problems formulated was explored. Subjective factors of individuals influence an organisational environment and the way that the organisation is perceived (Schwenk, 1988: 41). These two factors, in turn, influence strategy formulation. This research focuses on the cognitive structures and processes that may be common strategic decision-makers in organisations.

Choices are made according to the way that people conceptualise their environments. Because the visualisation of data often integrates information or shows relationships, it is also a useful method of presentation to use in a group to aid mutual understanding of how the problem is represented. Decision-making in organisations will happen in groups the majority of the time, or at least in consultation with other people. This means that there needs to be a shared understanding of how decision-makers conceptualise their decisions. The social nature of decision-making means that visualisations can be a good way of explaining one's thoughts on an issue, as it should be able to be understood by others who may not have the same background as the creator of it. Such visualisations of thinking processes can help to direct information search, as well as making decision-makers aware of external factors that affect strategy choice (Weick, 1979 in Schwenk, 1988: 46).

### 2.3.3 Background and personal differences

The differences in people and the way that each person understands and processes information uniquely, as well as the biases that people in general have in interpreting information, combined with the structure of the information and the nature of the data will result in differences in understanding between people, even when presented with the same data.

The way in which human perceptual abilities have evolved mean that certain survival-enhancing perceptions have been improved (Wainer and Velleman, 2001: 316). People see edges and straight lines well, and understand the relative slopes of lines easily (Wainer and Velleman, 2001: 316). Areas and sizes can be easily compared visually unless distractions are caused, for example by illusions of depth or volume (Wainer and Velleman, 2001: 316). "Well-planned layouts, straight lines, starkly different colours, areas of simple shapes, and smooth motion facilitate understanding and perception in graphs" (Wainer and Velleman, 2001: 316). The designers of visualisations can take advantage of human perception by arranging the points and symbols representing the data in such a way that exploits humans' perceptual capabilities.

When producing graphs, data should be encoded in such a way that the visual decoding involves tasks where performance is better with increased accuracy (Cleveland and McGill 2009: 828). This will optimise decision-making, taking into consideration as much of the available data as possible, without the cognitive effort otherwise involved in such a process. Graphical perception involves the visual extraction of quantitative information from a graph. Humans' visual systems are better at judging angle rather than slope (Cleveland and McGill 2009: 828). If the aim of the graphics is to increase the accuracy of the perception of patterns in data, the designer should select options that encourage this (Cleveland and McGill, 2009: 830). Even if quantitative information is encoded geometrically, the visual system may be unable to detect the information (Cleveland and McGill, 2009: 831). The visual perception system tends to extract minimal distances, another aspect that is important to bear in mind when designing graphics (Cleveland and McGill, 2009: 831).

Cognitive styles can be described as "the characteristic, self-consistent modes of functioning which individuals show in their perceptual and intellectual activities." They can range on a continuum from high analytical to low analytical. Low analytical decision-makers are more susceptible to the use of heuristics than those with a high analytical cognitive style. Decision-makers show a preference for compatibility between cognitive style of a decision-maker and the type of decision aid used (Hunt et al., 1989: 440). Benbasat and Dexter showed that low analytical decision makers have the most to gain from decision aids (Benbasat and Dexter in Bruggen, Smidts and Wierenga, 1998: 648). Time pressure increases the likelihood that a decision-maker will pursue one strategy only; a simplifying strategy. Time pressure will have a negative effect on decision quality and consequently on performance, since managers are not able to use all available information. Time pressure causes less information to be used, favouring the use of heuristics, which provide managers under pressure a simple way of dealing with a complex world (Bruggen, Smidts and Wierenga, 1996: 333).

With the increase in information confronting decision-makers, people are forced to spend time organising information instead of solving problems and taking the decisions they need to. The whole process of making a decision can take much longer, as there is more information that needs to be processed before a decision can be taken. Individuals trying to process information get distracted from key parts of the data by noise (Lucas and Nielson, 1980: 982). Not only are managers overloaded with information for decisions that need to be taken, but decision-making is just one role that managers play in an organisational context. Often under pressure to perform a number of different tasks, these decision-makers are exposed to potential schedule overload too. The decision context has an effect on how decisions are made, as do personal and background differences that influence the way decision-makers respond to information and solve problems (Lucas and Nielson, 1980: 986).

Decision-makers can overestimate the value of information that confirms their expectations, while undervaluing disconfirming information, a situation known as overconfidence (Schwenk 1984: 116). If the current strategy being used is successful, the decision-maker may ignore information that suggests gaps between performance and expectations. Biases can play a prominent role in decision-making, including the possibility of generating limited alternatives due to time pressures or expense, repeating errors that are made in one phase of cyclical strategic decision-making is cyclical and magnifying them at another if evaluation is not done properly. Inherent in both visual representations (reductions of information) and in heuristics, biases are a given limitation of trying to ease cognitive processing or reduce information overload.

## 2.4 Conclusion

Information technology has led to improved capabilities in the collection, storage and dissemination of data, and there is no sign of this slowing down (Lurie and Mason, 2007). Although an increased amount of data can lead to more informed decisions, it can also be overwhelming. Decision-makers in every type of organisation are faced with daily decisions that are taken on the basis of data and information they receive. The growing amount of information that is available means that more information needs to be processed for a well-

informed decision. As most organisations are accountable to various stakeholders, the types of decisions they take need to be well-informed and consider as much of the current information relating to a decision as possible. This increases both the volume of information that needs to be considered by decision-makers and the pressure on them to make good decisions. Information overload, on both an organisational and an individual level is therefore an increasing and relevant problem for which techniques of coping with them need to be sought out and employed.

By reducing the cognitive load of the decision-maker, cognitive processing is eased, in turn reducing information overload, as information is better and more easily dealt with by the mind. There are various ways that the cognitive load can be reduced, but the two that are focussed on are visual representations and fast and frugal heuristics. Visualisations are deliberate and selective reductions in information. Because they simplify and integrate information automatically to present one image to the decision-maker, they reduce the effort and energy that would otherwise be required by the decision-maker to process all the data that underlies the single image. The way in which the information is framed therefore has an impact on how it is interpreted by the decision-maker and the cognitive biases that the decision-maker is susceptible to. There is always choice in visualisation, meaning that it is always going to be framed in a way that will determine the outcome of the decision. The way information is framed has an important impact on the decision outcome. Despite the fact that images may not have an inherent advantage over tables or words, they can play a role in reducing information overload in that they integrate information, decreasing the amount of cognitive effort required to process information without such decision aid. Even if they only act as decision aids, accompanied by words or an explanation, they reduce cognitive load, making the given information more easily understood and processed.

Fast and frugal heuristics use often subconscious, automatic mental processes to take quick decisions based on little information, both when there is little given information and when information is selectively chosen from a larger body of that which is available. Their use is largely unplanned and intuitive. There is room for learning from heuristic results and structuring the process more to enhance their use in appropriate settings with appropriate information. Their use can be guided, and the deliberate and facilitated use of heuristics might help to effectively cut through the large volume of information faced by organisational decision-makers under certain conditions, as do graphs in providing one image to the decision-maker that is an integration of data. When only certain information is considered, the cognitive load is significantly reduced as opposed to situations where all available information is considered. This technique of decreasing cognitive load though the limitation of considered data also, however, conducive to biases in decision-making, with heuristics being inseparably associated with cognitive biases. Satisficing becomes inevitable, as not all information can be searched for an optimal solution, and that which is chosen to be considered will determine the outcome that is reached.

Visual representations are deliberate and planned and heuristics are largely unplanned and intuitive, and though both have limitations in their ability to reduce the effect of information overload on decision-makers, they both also have value in affectively addressing the problem.

In decreasing the cognitive load of decision-makers, these techniques facilitate cognitive processing of the information, thereby reducing the negative effects of information overload. Facilitating these methods of addressing information overload on an individual level would be good knowledge management structures on an organisational level. With appropriate organisational structures to reduce information overload, a reduction on an individual level would be aided.

## Chapter 3

### VISUAL REPRESENTATION

#### 3.1 Introduction:

##### 3.1.1 Nature of the topic under discussion

The topic of the visual representation of data is a very broad and general area. There has been much research conducted on it, as it has many sub-divisions according to the type of visualisation and how it is then applied, or its context. Much of the research is based on case studies or empirical evidence from studies conducted. Research on the topic of oobeya rooms has thus far yielded relatively little research or available case studies. This may have to do with the fact that this approach is still gaining popularity and is a relatively new concept to the Western model of organisational management. This chapter aims to look at how visual representation can reduce information overload through a reduction in cognitive load. It also shows how biases are inherent in this planned and structured approach to decision-making, but that it can nonetheless be used for effective decision-making.

##### 3.1.2 Parameters of the topic

The chapter concentrates more on visualisation in the knowledge economy, in a general organisational context as opposed to a factory environment. The focus is therefore on graphs, with the balanced scorecard and oobeya room being investigated too. Graphs are widely used forms of visualisation in organisations. In a management context, different types of visualisations (used for visual management) include the balanced scorecard and the oobeya room, amongst others. This chapter does not provide an exhaustive analysis of all the various forms of visualisations that are utilised by management in organisations. It is limited, first of all, to the use of graphs and the visual presentation of statistical data, as these are commonly used in organisations across industries worldwide. The oobeya room and the balanced scorecard were also selected. The oobeya room is a newer, different way of approaching visual (project) management focussed on information as opposed to factory work. The balanced scorecard is a popular, more established form of simplifying information visually in organisations. The chapter given specific attention to the origin of graphical presentations as a subsection of visual representations, as it is assumed that data being recorded simply as numbers or in tables has been the default method since before graphs became popular.

##### 3.1.3 Basis for the selection of the literature

Literature for this chapter was selected according to its relevance to the subjects of visual management in the knowledge economy, the use of graphs in management, the use of data in managerial decision-making and dashboard development. Particularly, general information on the balanced scorecard and how it may relate to cognitive processing of data was looked into. In the absence of hard data on the oobeya, informed speculation has been made in its relevance to the broader context.

### 3.1.4 Problem and scope and variables included

The problem in organisations is that many decision-makers are confronted with information in the form of data or reports. This is information that still needs analysis and can often be cognitively taxing on the decision-maker and even off-putting at times, with decision-makers anticipating the expected cognitive load and effort required to process such information. With the human brain trained to understand visual signals in everyday life (for example, road signs when driving, no smoking signs etc), the simplification or representation of data visually may be able to assist with the processing of information and in reducing the cognitive load of the decision-maker. In applying this concept to organisational decision-making, the way in which data is represented, which affects its impact on decision-making, is explored. The value and the limitations of visual representation are applied to reducing the problem of information overload. The variables that are included are the type of data, the context of it, the people who are exposed to it, the format in which it is chosen to be represented and the manner in which it is manipulated to get to that form. These all affect the way and degree to which it is learned by decision-makers.

### 3.1.5 Organisation of the review

The chapter begins with a history of visual representation, describing what it is and how it developed in an organisational or decision-making context. Following this is a discussion of the trends and important issues in data visualisation, including critiques of visualisation as a method of representation. Dashboard development as a feature of visual representation is then explored, beginning with a history of the process and followed by a comparison of graphs and statistical data. This section ends with a look at two examples of dashboard development, the balanced scorecard and the oobeya room, before the chapter concludes.

## 3.2 History of visual representation

Visual representation goes as far back as ancient times, when pictures were used to represent ideas and there was an abundance of graphic displays (Wainer and Velleman, 2001: 306). For example, from as early as 1400 BC, there is evidence of Nilotic surveyors, a system of lines representing graphs that enable precise placement of data points (Wainer and Velleman, 2001:306). This made sense as a ‘universal’ form of communication that bridged cultural and language differences by representing an idea according to how it was perceived by an individual or group. This simplification of an idea that comes from representing it visually enabled it to be easily understood by more people from different backgrounds, who may not otherwise have been able to understand an idea. This misunderstanding may arise from differing levels of knowledge or language barriers (whether within or between languages). When applying visualisation to a work environment, whether it is in an industrial or an organisational context, the idea is similar to what it was originally; that people who do not necessarily know the detail behind the idea are able to get an overview or develop a basic understanding of it by glancing at a visual representation.

Visual representation of data goes back beyond the concept of visual management. The application of visual representation techniques to a managerial context, and the subsequent

adaptation of these techniques to management were developed more recently. First, they were applied to production during the industrial era and more recently, there has been an increase of visualisations in both the public environment and in organisations in the context of the knowledge economy (Eckerson and Hammond, 2011: 13).

In an industrial context, visual management is applied differently to an organisational context. Whereas factories use signals, lights and signboards (Tezel, Koskela and Tzortzopoulos 2010: 3), organisations tend to use different types of graphs and other recognised methods such as the balanced scorecard or the oobeya room. These two contexts in which visualisations have been applied to management have developed in different ways.

William Playfair was a Scottish engineer and political economist, who was believed to have developed the first recognised bar, line, and pie charts in the late 1700's (Eckerson and Hammond, 2011: 4). Previously having been used only in the natural sciences, Playfair adapted statistical graphs and applied visual methods to data in the social sciences, particularly to his areas of interest, economics and finance (Wainer and Velleman, 2001: 312). According to Playfair, "On inspecting any one of these (bar, line or pie) charts attentively, a sufficiently distinct impression will be made ... and the idea which does remain will be simple and complete" (Eckerson and Hammond, 2011: 4). The use of graphics in organisations today follows a similar logic. For almost 200 years after Playfair applied graphics to the social sciences, the use of graphics remained static (Wainer and Velleman, 2001: 314).

Tukey's *Exploratory Data Analysis* changed this landscape (Wainer and Velleman, 2001: 314). Terms like data mining became more common and the software for data analysis and data visualisation was developed. The graph became no longer a static object that was first constructed and then studied further. Rather, the ease with which graphics can be manipulated has made it a dynamic 'partner' in decision-making (Wainer and Velleman, 2001: 314). With graphics, it is easier for the eye and the brain to understand what is happening in the data, as trends and patterns are made evident (Eckerson and Hammond, 2011: 5). In so doing, they are able to assist the decision-maker by increasing business insights, productivity, and the rate of user adoption in making a cultural impact and an impact on purchases, assisting with analytical tasks and departmental functionality (Eckerson and Hammond, 2011).

With the visualisation of data, decision-makers can immediately identify issues needing attention and then take appropriate action (Eckerson and Hammond, 2011: 7). In text-based reports and spreadsheets, trends and issues can remain hidden among vast quantities of numbers and text. This limits decision-makers in their ability to exploit data and use it to its full potential. Some kinds of graphics have also placed boundaries on the people using them, as traditionally, graphics have been limited by the static, two dimensional pages or screens upon which they appear. However, technology is allowing for them to become increasingly more interactive, allowing decision-makers to manipulate data and enabling them to delve deeper into a particular area or data represented by the graph (Wainer and Velleman, 2001: 315). This interaction with graphics encourages better understanding of the underlying data.

Because of this power to communicate, data visualisation is becoming more prevalent in business environments (Eckerson and Hammond, 2011: 5).

In a factory management context, other types of visualisation methods were used to improve efficiency. The basic concept was also based on visuals and was used to assist decision-making at a management level in manufacturing plants. With the increase in workflows involving information as opposed to materials, and the rise of the knowledge economy and knowledge work, the same principle of visualisation was applied in an organisational context, where the use of graphs once again became popular in decision-making. Methods of management using visual aids developed, including the balanced scorecard, business process mapping, pareto diagrams, flow charts and the oobeya room, amongst others.

Visual management can be described as an approach that makes use of one or more “information giving, signalling, limiting or guaranteeing visual devices to communicate with ‘doers’ so that (organisations) become self-explanatory, self-ordering, self-regulating and self-improving” (Galsworth, 1997 in Tezel, Koskela and Tzortzopoulos, 2004: 2). This idea of using visualisations in management was applied to the factory during the industrial era to aid supervisors and improve efficiency in the production line.

In 1935 just-in-time thinking was applied to production. Visual management comprises an important part of this method of management, with Kanban signals, call lights and digital display boards being used as signals for managers (Kattman et al, 2012: 8). From the mid-1940’s through to the 1970’s, Toyota in particular, developed visual management practices in their production systems (Adler et al 1999; Tezel, Koskela and Tzortzopoulos, 2004: 3). This began with a visual display of the procedures workers were meant to be following being posted to their work stations, enabling management to see at a glance whether or not workers were doing their jobs correctly (Tezel, Koskela and Tzortzopoulos, 2004: 3). In the mid-1950’s several aspects of workplace structuring and visual control began to develop in Japan (Fabrizio and Tapping, 2006 in Tezel, Koskela and Tzortzopoulos, 2004: 3).

With the infrastructure that had been developed during the industrial era, the economic focus gradually shifted towards advantages that had been gained from development methods and the trade of information (Castells, 2000: 101). The transition to the knowledge economy in many first world countries saw the rise of organisations that traded in information. With more information being generated, available and needed for decision-making on an everyday basis, the concept of visualisation of information was applied to this new work environment. Visual representations of masses of data became a way of simplification to aid understanding and processing by decision-makers in organisations. Organisational culture has shifted in this application of visual representation to knowledge work. Eckerson and Hammond (2011: 3) argue that in putting data that was previously only available in a tabular format into graphs, business has become more analytic and data-driven. Because graphs are more visually appealing than tables, they help decision-makers to explore the data, empowering them by providing new information and insights into the numbers (Eckerson and Hammond, 2011: 3).

Graphs provide powerful tools for analysing data. Theory can then be used to order the data for communicating quantitative information (Cleveland and McGill, 2009: 828). Since the computer graphics revolution in the 1960's, there has been an increase in the amount and availability of graphics software (Cleveland and McGill, 2009: 828). With this increase in their use, research has been conducted around graphs and their use.

### 3.3 Trends in data visualisation

Since there has been an increase in visual representation of data in organisations, research has been conducted focussing on a broad variety of elements in the field. This contains some general findings on the subject, including evidence for the use of graphs and their advantages, as well as some critiques of data visualisation.

Visual representation directs the attention of decision-makers to a certain set of data that has been selected to be represented in a particular way. This is a planned and structured way of focussing attention on those cues that are regarded as important by an organisation, assisting the decision-maker in processing the information as well as enabling organisations to use this as a method of agenda setting. Data visualisation is one component of visual analytics. Data visualisation models can help decision-makers to gain insights from large and complex data sets (Russell, Chiu and Korde, 2009: 1045). The term data visualisation refers to “the use of computer-based, interactive visual representations of data to amplify cognition” (Russell, Chiu and Korde, 2009: 1045). It is interesting to note that this definition includes the fact that data visualisation specifically aims to aid cognition, implying that in its use, cognitive processing is eased or lessened. Visualisation can be described as consisting of two processes: data presentation and data exploration. If the visualisation of data is represented effectively, it allows users to instantly “identify the trends, jumps or gaps, outliers, maxima and minima, boundaries, clusters and structures in the data” (Russell, Chiu and Korde, 2009: 1047).

Having been a common method of data presentation in biology and medicine for many years, it is argued that there can be a lag of up to ten years in business on advances made in visualisations in these other fields (Lurie and Mason, 2007: 160). Graphic displays enable decision-makers to “make use of the uniquely human ability to recognise meaningful patterns in the data” and to see “patterns in data that would never have been picked up with standard statistical methods” (Kolata, 1982: 919 in Lurie and Mason, 2007: 161). Visualisation tools process raw data before decision-makers do. This both helps to reduce the amount of processing needed by decision-makers and allows for certain aspects of the data to be made prominent. The danger in the visualisation of data, as opposed to tabular data, is that it may preclude some of the data from being processed or made visible. It is chosen and processed according to certain filters, and not always left up to the decision-maker as to what is important or not. This affects the framing of the data and makes the decision-maker more susceptible to biases, but this graphic representation may be more effective in general.

People like to process quantitative information in graphic form (Pinker, 1990: 73). This is evidenced in the number of ways in which information can be presented in pictorial forms.

Graphic formats present information in a way that is easier for people to perceive (Tegarden, 1999: 9). Graphs are an effective form of communication because they exploit general cognitive and perceptual mechanisms effectively (Pinker, 1990: 74). Though graphs can do this, it is not necessary that they do, and Whinston and Zhang (1995: 3) make the point that the way in which the information is presented should support human activities and processing abilities, improving the entire problem-solving process.

Data visualisation supports the exploration of data, enabling data to be integrated in new ways, so that patterns and trends may become evident that would not otherwise have been noted. This can lead to information being viewed in a different light and the subsequent generation of new ideas. Looking at data in a familiar way can result in a linear way of thinking and certain characteristics of the data could be overlooked as a result. Focusing on certain areas only may result in some areas of a project being left out or ignored altogether. Managers need better visual literacy to understand, manipulate and effectively use the materials that are available to them. Visual representations that articulate and communicate a strategy are not only representations but they become the strategy, promoting innovation. Depending on the objective of the visualisation, different kinds of visual tools should be used in accordance with their objectives. The way that this information is presented and received plays a large role in how effectively it is processed.

Though the benefits of technology allow for endless possibilities in data visualisation, the benefits of information in an electronic environment such as a business context are often not realised, because managers are increasingly overloaded with information (Lurie and Mason, 2007: 160). Much of the information that is received by managers is symbolic, presented as numbers and text (Lurie and Mason, 2007: 160). Humans have evolved visual and spatial skills, including the ability to detect edges and discontinuities, elements that stand out over others, variations in colour, shape and motion, pattern recognition and the retrieval of information using visual cues (Kosslyn, 1994 in Lurie and Mason, 2007: 160). The age old saying, ‘a picture is worth a thousand words’ has been adapted to “a picture is worth a thousand rows (of data)” (Youngworth, 1998 in Lurie and Mason, 2007: 160). Visual representations can improve the problem-solving capabilities of decision-makers by enabling the processing of more data without overloading the decision-maker (Tegarden, 1999: 9). This could prove to be a significant help in aiding decision-makers faced with large amounts of data in organisations today, easing the processing and allowing for better decision-making. However, visual techniques are numerous and need to be used appropriately if they are to meet their goal of aiding decision-makers.

Visual techniques include using colour, size, shape, texture, orientation, and brightness to portray different dimensions of data. Distortion approaches to highlight some data in a certain context, graphic portrayals of hierarchical and network relationships and interactivity can all be used to display data visually, and may also cause biases in the decision-maker (Green, 1998 in Lurie and Mason, 2007: 161). Because of this, data that has been processed to be presented visually can also be used to drive particular agendas or propagate certain ideas in an organisation. For example, a management team could hide an underperforming aspect of a favoured project by emphasising positive data and thereby secure continued funding for a

project that, evaluated using another method, should be stopped. In this way, the visualisation of data is selective about which data is chosen, depending on the target audience. The audience can be intentionally biased by the presented information too.

Target audiences could comprise a variety of people and there are studies that have concluded that it is important to consider the personality type and background of the decision-maker when assessing the benefits of colour coding in graphics (Benbasat and Dexter, 1985: 1361 and Lucas and Nielsen, 1980: 991). A parallel argument is made by Simkin and Hastie (2007: 454), who recommend that the designer of the graphs should bear in mind for whom they are intended and plan accordingly, as the adeptness of decision-makers in decoding information from graphs varies from person to person. However, in an organisational environment, it is almost impossible to take into account personality type and decision-making style of individuals in designing graphs. Not only does the designer of the graph not know who may be exposed to the graph or their personality type, but the graphs may often be for more than one person or for groups of people. While the general type of person (taking into account their field and position) may be taken into account, even this is problematic, as groups may consist of managers or decision-makers on different levels from different backgrounds with varying degrees of knowledge about the topic at hand. Research on cognitive load has further suggested that managing cognitive load by adapting to the needs of individuals is generally difficult because of the variety of characteristics of the many people involved (Kalyuga and Renkl, 2009: 211).

According to a study by Lurie and Mason (2007: 161) on marketing managers and consumers, people are likely to be affected by two characteristics of visual representations: firstly, the visual perspective, which is determined by task variables, such as its level of interactivity and the availability of contextual information and secondly, the information context, which is determined by context variables affecting the vividness, evaluability and framing of information. The context given or the amount of detail provided determines the extent to which decision-makers are able to keep both levels (broad and narrow) in focus at the same time and is likely to influence how information is accessed and evaluated. Visual representations that provide more context rather than more detail and enable more alternatives to be displayed may lead to more selective decision processes as decision-makers can more easily eliminate alternatives from consideration (Payne, 1976 in Lurie and Mason, 2007: 165). By providing an overview as well as detail, the decision-maker's understanding of the visualisation can be improved. Visual representations that provide contextual information should lead to more consistent preferences than those that do not, but such representations are likely to involve greater cognitive effort and more time (Lurie and Mason, 2007: 165).

What may be more effective for some, may be less effective for others, but there is the argument that interactivity significantly improves static displays (Eick and Wills, 1995). The clarity, robustness, power to combine views and leverage the value of one view in another, as well as the increased possibility that comes with being able to display some data only by interactive means all help to give interactive displays an advantage over static visual displays (Eick and Wills, 1995). In an organisational context, technology may not always allow for

this, but interactive displays would be beneficial when possible. No matter how they are presented, graphic displays should be easy to interpret and should display three characteristics; it should be obvious what the graph is displaying, the graph should focus attention on the data and it should contextualise the data (Eick and Wills, 1995: 5). “The purpose of an interactive graphical display is to use graphical elements to encode the data in such a way as to make patterns apparent and invite exploration and understanding of the data by manipulating its appearance” (Eick and Wills, 1995: 5). Interactive graphics allow for exploration by users by offering the opportunity for decision-makers to continuously change search goals and parameters as more is learned about the data. Information can be continuously updated, aiding the decision-making process (Russell, Chiu and Korde, 2009: 1047).

Tversky and Kahneman have famously proposed a categorisation for thinking about the way decisions are made. This helps to illustrate how the mind may react to the presentation format. System 1 is unplanned, intuitive, unconscious and automatic (Over, 2004: 10). System 2 is slower, more costly, rational and conscious (Over, 2004: 10). In such an instance, system 2 thinking is more likely to be used, therefore taking up more time with increased consideration. The effect of biases is therefore likely to be reduced, though the provision of more contextual information could also overload the decision-maker, encouraging the use of system 1 thinking and increasing the effect of biases. Visual reasoning usually works more effectively when relevant information is shown side by side and the more detail is provided, the greater the decision-maker’s understanding will be (Tufte, 2009: 2). There is a constant battle between reducing biases in decision-making and the time element, making decisions faster. If the aim is to reduce the biases, there is thus a need for a balance between an increase in the amount of information that will encourage system 2 thinking and not overloading the decision-maker. If the aim is to make faster decisions, the information should be kept to a minimum, without simplifying so much that biases significantly deteriorate the quality of the decision-making.

The context and the way in which a problem is presented are vital in determining the likelihood of success of a visualisation. The context of information takes into consideration the vividness, framing and evaluability of data. The degree to which graphic information is made vivid may increase its use in decision-making. When visualisations include both text and graphics, the graphic information is likely to receive more attention (Lurie and Mason, 2007: 168). Shapes and colours may be vivid if they stand out from the background because they are unique, they display a distinct contrast, they have the greatest variation in size or they have the greatest value to decision-makers. Those shapes and colours that occur less frequently are also more likely to receive attention because they stand out more due to their difference from the rest. Vividness tends to increase attention to presented data, as opposed to other forms of data, such as information recalled from memory (Lurie and Mason, 2007: 167). A common error made by decision-makers is to overestimate the relative frequency or probability of more vivid information, resulting in a bias towards such information.

By changing the presentation of a given problem, visual representations may accentuate biases and the use of heuristics in decision-making (Lurie and Mason, 2007: 161).

Visualisation tools that make it easier to see changes in percentage terms (for example, pie charts) may lead to greater segregation of losses and gains than visualisations that encourage absolute comparisons (such as line graphs). Generally, visual representations are likely to change the anchors that decision-makers use (Tversky and Kahneman, 1974 in Lurie and Mason, 2007: 170).

In management, visual representations are used as objects in practical activities and projects (Whyte, Ewenstein, Hales and Tidd, 2008:75). Within organisations, attention is drawn to aesthetic and kinaesthetic forms of knowledge, that which is derived from the look, feel, smell, taste and sound of things and from physical interactions with them. Visual representations are made with the intention of conveying meaning. Organisations today explore new ideas and exploit old knowledge. If managers can recognise the role of sense-making at a strategic level, it can allow for the deliberate construction of narratives that reflect the goals or vision of the organisation (Whyte, Ewenstein, Hales and Tidd, 2008: 77). In project-based or project-led organisations, the visualisation of data provides a bridge between project work and wider organisational processes (Whyte, Ewenstein, Hales and Tidd, 2008: 79). It is important that team members share ownership of and responsibilities for certain elements in the visualisation process, to ensure accurate representation that includes an integration of data.

While it is known that the way that information is framed has an effect on how it is perceived and processed by decision-makers and that visualisations of data are easier to process, there is a lack of knowledge about when to use what type of visualisation (Tegarden, 1999: 16). In some cases, a table or raw data is a more effective way of communication than is visualisation. This depends on the type of data, for example whether the task presentation and the task requirements fit, whether the data is trended or not, whether it is processed spatially or symbolically, and the content of the data itself (Eckerson and Hammond, 2011). Visualisation may sometimes be the best way to display data, but this is not the case in all circumstances for all types of data and all decision-makers. It may be misused and potential problems include poor visual design and visual overload (too many colours, graphics, styles etc) (Few, S, 2003). When presenting data visually, the display should show comparisons, contrasts and differences (Tufte, 2006). It should illustrate causality, the mechanism and systematic structure of data, and be accompanied by an explanation. Further, illustrations should completely integrate words, numbers, images and diagrams, thoroughly describing the evidence (Tufte, 2006: 130). The quality, relevance and integrity of the content of presentations are key in determining their level of success (Tufte, 2006: 132).

### Critique

Like anything, visual representations of data comes with both advantages and disadvantages. Some of these disadvantages have been criticised in other research, while some are inherent in the reduction of data that is necessary when displaying information visually. The use of graphs as a method of display has been discussed and critiqued in the literature, as one of the more common forms of visual representation of data. In addition to this, other forms of visualisation have their own limitations, and there are more general limitations that apply to

the process that goes into any type of visual representation of data, the selective reduction of information required to produce the visual. Visualisations can also be problematic for management by exception, a management style that has become popular in organisations.

Graphs are widely used methods of representing data, in organisations, amongst other contexts. It has been suggested that the increase in the use of graphs in organisations today simply corresponds with the increase of available data and has not actually increased in relation to other methods of data display (Wainer and Velleman, 2001: 312). While the rise in information may be partly responsible for the increase in the use of graphs, there has in fact been a rise in the use of visual representation of data, with graphs being common in organisations (Lurie, 2007: 160). This would suggest that there has been an increase in the use of graphs in relation to other forms of representation.

A possible reason for the increase in the popularity of graphs is the variety in different types, allowing them to be used flexibly, according to the type of information that is available. Benbasat and Dexter (1985: 1362) believe that “in order for graphical (or any other type of) reports to improve decision making they should be in a form to directly assist the decision task”. This is in line with cognitive fit theorists’ way of thinking. Problems could arise when graphics are not used appropriately for the type of information that needs to be represented. It was further found that there was no significant benefit for the use of graphs over tables. This could be due to the nature of the task that was given in the research, and the type of information. It is possible that the quality of the graph or the type of information displayed was not good or well-suited to the data.

Claims have been found in some journals about the benefits of colours and graphics, but these have not been substantiated by experimental work (Benbasat and Dexter, 1985: 1348). It may be that inconclusive or conflicting results are not always reported in the literature. Though colours and graphics may be beneficial, improving clarity of data for decision-makers, they need to be used correctly, otherwise could confuse viewers, highlighting unimportant aspects of data sets.

In an experiment conducted by Chan (2001), it was found that although information overload causes a decrease in decision quality, the use of graphs instead of tables does not necessarily reduce information overload. Chan found that the use of graphs as decision aids did not improve decision-making performance under information overload more significantly than the use of tables. The data from the experiment did reveal a trend that more graphs tend to be used in summary reports to make them easier to read. This reveals that in terms of integrating information and simplifying large amounts of data, graphs may have an advantage over other forms of data presentation. Graphs have become more popular in organisational environments and are being used, as an alternative to tables, as inexpensive decision aids to display data (Chan, 2001: 419).

It has further been suggested that graphs can reduce cognitive effort by shifting some of the burden to the visual perception system (Chan, 2001: 419). Processing information displayed in graphs becomes a perceptual process, as opposed to an analytical process. Chan’s

experiments found that a high information load did decrease the quality of decisions that were made under that load, but that graphical presentation doesn't improve decision quality under such conditions. This suggests that graphs may not improve decision quality under conditions of information overload. They may, however, decrease the information load. In studies by Lucas and Nielsen (1980: 991) investigating managers, it was found that the benefits of graphics were disappointing, having a relatively small effect on decision-making compared with all of the other factors which affect managers. Because this study was not specifically focussed on the benefits of graphics compared to other forms of information, but rather their benefits compared to other organisational factors, the results are not conclusive in the context of this study.

Whinston and Zhang (1995: 2) found that there are two significant limitations of statistical graphs. The first concerns the fact that the data that is graphed must have controllable size or dimensions (Whinston and Zhang, 1995: 2). Its parameters must be clearly defined. With some large data sets, it is difficult to know when to create parameters, as the selection further increases the likelihood of biases in the decision-maker. The selection of parameters plays an important role in the framing of the data. The second limitation is that general representations are not easy to apply to a specific domain (Whinston and Zhang, 1995: 2). The way that data is represented visually depends on the type of data that it is, and may not always be appropriate for other areas. Representations of more general data may not be able to be represented in the same way as more domain-specific data. There is no specific model that can be used to represent the data in order for decision-makers to understand it objectively (Whinston and Zhang, 1995: 2). Data that is represented in a model will always have been filtered or selected to represent it according to certain criteria or from a specific perspective. The problem comes in trying to decide how to represent data in a way that is compatible to the nature of its content, so as not to misrepresent it.

When decision-makers are presented with a particular visual representation, they may assume that the variables represented are the most relevant and that that particular representation of the information is the best. However, it is important for decision-makers to remember that this information has been framed in a certain way, and to try and see the information presented in a different, or in multiple formats. Viewing data graphically enables faster identification of trends but also less accurate assessments of differences, which may be subtle, especially in smaller data sets (Lurie and Mason, 2007: 172). Visualisation tools have the potential to offer managers ways to become more efficient, reduce costs, gain new insights, make data more accessible and increase decision confidence, but at the same time, cognitive biases may be accentuated (Lurie and Mason, 2007: 172).

The volume and nature of data can pose significant management challenges, such as the "data rich-information poor" problem, meaning that the massive amount of data available to management will result in information overload unless it is well organised and supported by appropriate methods of reporting (Russell, Chiu and Korde, 2009: 1047). If data is not put into an appropriate visual format, confusion and stress could result for the decision-maker. Sometimes, when integrating data, there can be a focus on individual areas, as opposed to looking at the bigger picture. Selection and filtering are needed to help management to absorb

the content of visualisations faster and to improve the quality of the insights obtained (Russell, Chiu and Korde, 2009: 1060). At the same time, these selection and filtering mechanisms accentuate biases and frame the data in a particular way. In addition to this, it is necessary to allow users to adjust the content of visualisations to suit their own cognitive style and to assist in the identification of specific issues.

Though visualisations simplify through a reduction of information, thereby reducing the likelihood of information overload being experienced, this comes with its own dangers. Visualisation is a planned and structured reduction of data and information. The data that is represented is selected according to some criteria, and by definition therefore excludes other data. Further, it is structured in a certain way, and though this may make it easier to understand for decision-makers, it does leave such decision-makers susceptible to the framing bias. The represented data is not only selected from a larger data set, possibly not representing the whole 'picture', but it is also framed in a certain way. This could be done intentionally, in order to create a certain favourable image for a group within an organisation (or the organisation as a whole to external stakeholders), or not, but it is inherent in the process of creating visual representations of data. There is an element of choice in the process. This choice in the selection of data may be systematically right or wrong for a period of time, and then no more. The interests of stakeholders, the purposes that visualisations serve and the business environment or context do not remain constant, and for these reasons, reductions that may have been right or wrong for a period of time may cease to be so all of a sudden.

While visual representations do leave decision-makers open to framing, they are likely to be susceptible to biases in any case due to the load of information that they need to process. Biases are an inherent limitation in information processing. Without the visualisations and simplification of data, decision-makers would be forced to process a volume of information they are incapable of doing, leading them to satisfice and use heuristics to deal with the information load. Heuristics are necessarily associated with biases. The alternative of using visualisations to reduce the amount of information and simplify it, come with a different set of biases, such as framing, that are likely to influence the decision-maker. Biases are inevitable in decision-making, and though visualisations do make decision-makers more susceptible to certain biases, they would be subject to other biases if not using visual representations.

Management by exception (MBE) has become a popular form of management in organisations and could be a problem for visualisation tools. It can be seen both as a technique for control and one for motivation (Ryszard, 2007). The control aspect in particular works well for project management and other short-term work where the scope is fixed and there is a specific task where implementation is important and needs to be controlled. However, this control can become limiting in general management practices in organisations. When there is deviation from a plan, managers may be short sighted in simply trying to rectify the situation by getting the organisation 'back on track', as opposed to being able to adapt to the situation, which may require a change in strategy. Similarly, when innovation is required, managers practicing this style may be unable to see past the plan or strategy that

already exists, hindering the creativity that may be required for development and rendering the organisation unable to adapt to a changing environment. This could result in a problem for visualisation tools.

Because visualisation tools provide a summary, or one-image type of aid for a decision-maker, they complement MBE. Organisations that use visualisation tools therefore need to be aware of and careful to avoid falling into the trap of using MBE. With simplified summaries of the state of an organisation, it is easy to disregard or be unaware of smaller issues, and could result in attention only being drawn to them once they have become bigger, more serious issues that need the attention of top management, this is a risk that organisations need to be aware of and manage when using visualisations of data. MBE could also be a problem for visualisation tools. At the same time as providing an overview of different areas of an organisation, managers might disregard much of this information, being uninterested unless it shows problems. Management by exception may be problematic for visualisation tools in that it is possible for such managers to ignore or manipulate data to look as though it should and that the organisation is following a particular strategy, meeting particular goals, when in fact it is not. Visuals can be manipulated to make it look as though everything is as it should be and there is nothing for management to worry about until there is actually a big problem.

Visualisations could also be used to make forecasts or projections based on data from the past. This is schemata-based information processing and not a reflection of reality. Managers may therefore respond unnecessarily to such scenarios. If managers are only interested in when there are issues to be dealt with, this could be a problem, as visualisation gives constant updates on key parts of a business and managers in MBE are not interested in that, but only in when things go wrong. They have no interest in other taking actions in other areas, potentially ignoring warning signs or other important aspects of the business. Visualisation could also be a problem for MBE by enabling those creating the visualisations to manipulate the data to give the image that things are going well in order to cover up areas that are not doing as well as they should, in order to avoid consequent action from management.

There are advantages and disadvantages of using tables and graphs and other types of visual representations. This is dependent on the type of information being represented and on the way that this is done once a choice has been made. Some data is better suited to tables. However, when data is able to be presented graphically and is done well, then there is a benefit gained from a reduction in processing for the decision-makers using the visual representation.

The critique of graphs and tables and the realisation in the limitations thereof has led to innovation. One such sub-group of visualisation is dashboards. Dashboards are a feature of visual representation and developed as a visual representation of multiple areas of focus, presented at one time.

### 3.4 Dashboard development

#### 3.4.1 History and concept

Dashboards in organisations were designed as decision aids to give management an overview of organisational performance at a glance (DeBusk, Brown and Killough, 2003: 215). The concept is based on a dashboard in a car or aeroplane that gives the driver an indication of performance in various different functions in the car or plane. By looking at these indicators, the driver can quickly assess the performance of the vehicle and make any necessary corrections (DeBusk, Brown and Killough, 2003: 216). The same concept is applied to dashboards in organisations, with management being the chief decision-makers responsible for ‘driving’ the direction of organisations. By looking at the dashboard, they are able to assess the performance of the organisation and make the necessary decisions to correct or maintain this performance.

After decision support systems became more popular, dashboards began to emerge. Organisations could make their own dashboards that integrated information from various parts of their business. These days packages are available that can be purchased and are designed to create dashboards for the user. An example of a dashboard is below.



*Diagram 1*

Visualisation designers are “melding the skills of computer science, statistics, artistic design and storytelling” (Segel and Heer, 2010: 1). It is important to find a balance between different elements that the creators of data visualisations integrate. This is especially so due to the susceptibility of decision-makers to cognitive biases when looking at visualisations. In order to find this balance, the graphics should provide a narrative structure for the data, while simultaneously combining elements that take into consideration the viewers of the visualisations. In providing some structure in which the needs and perspectives of viewers are incorporated, interactive exploration and social sharing is enabled (Segel and Heer, 2010: 9).

The biases that visualisation leaves decision-makers susceptible to should be an important consideration in the decision of whether or not to present data visually. The gains in communication need to be weighed up against the losses in ‘objectivity’ that comes with visual presentation. On one hand, the decision-makers gain integration and simplification from using visual methods of communication, but on the other, the data that is selected for visual representation, that which is chosen to be presented or combined with other data in a certain context, can cause decision-makers to be subject to cognitive biases. No data is

completely objective and although visualisation may encourage cognitive biases, there are likely to be biases induced in most forms of presentation, to some extent. If this is accepted, then the benefits of visual presentation may outweigh the loss of 'objectivity'. However, some organisations or decision-makers may find that this risk is too high and that data should be presented in its most raw form, despite the potential consequences for cognitive load and processing on decision-makers. Even for such organisations, under conditions of cognitive overload, biases and heuristics will necessarily be present in the decision-making process and there can be no 'objectivity'.

The aims of visual displays are both to understand the data and to communicate these findings (Fuchs, 2005: 1). "Dashboards and scorecards can leverage new tools that are available, in order to provide users with actionable information so they can more effectively execute the organization's key strategic objectives, plans, and business processes" (Eckerson, 2005 in Fuchs, 2005: 1). The strength of the dashboard is also its limitation. The dashboard may be used correctly and to good effect, having enormous capacity to clarify tasks and objectives for staff (such as highlighting weaknesses in a product range or the geographic area in the performance of a sales team). However, if it is badly used or deliberately manipulated, the result can be obfuscation, diversion, inappropriate use of resources, incorrect conclusions being drawn etc, and in particular could be used by managers with their own agendas to consolidate power bases, influence investment decisions and project approvals, and hide failures.

Often dashboards provide only a high level business overview that is measured against predefined criteria (Fuchs, 2005: 1). While this is helpful in the simplification of information, causing a reduction in cognitive load, and in giving the viewer a good idea of the overall situation, sometimes more detail is required. Due to the often static nature of such a visualisation, users are prevented from asking and answering new questions and consequently from seeing new relationships between different types of information (Fuchs, 2005: 1). However, this only applies to a certain extent. A dashboard or a scorecard can integrate information or relate it in a way that viewing different aspects of it separately cannot do. In this way, new, different and more relationships can be established between separate pieces of data. The fact that these displays are not interactive does provide some limitations to further exploration, but does not mean that there is no exploration. It means simply that exploration is more limited than if the display were interactive. An example of this limitation would be the lack of ability to delve deeper into a particular section of data underlying the graphic.

Silveira et al (2010) conducted a study on the use of dashboards in compliance governance and some of their findings may be generalised. It was found that the dashboard is targeted at several different classes of users (Silveira et al, 2010: 2). Managers, especially those in more senior positions, are interested in a much broader set of compliance regulations. In an organisational setup, managers in senior positions are similar in usually wanting a broader overview of the situation in their organisations, with the possibility of being able to go into more detail in a specific area should they choose to. The real time information provided on an interactive dashboard allows managers to detect problems as they happen and identify the

causes, so that they can correct them before they become significant issues (Silveira et al, 2010: 2). Once problems have been identified, then the root of the problem can be addressed.

The main challenges in building the dashboard are more conceptual than technological. Each page of the dashboard should be “concise and intuitive, yet complete and expressive” (Silveira et al, 2010: 6). A user should immediately be able to identify the key information on a page, but also be able to look further into details if necessary. This is where the interactivity of a dashboard becomes useful. This is particularly necessary if there is a desire to avoid the danger of being misled and biased by the information. Interactivity would be ideal if it allowed the user to create their own relationships between elements, and not only those suggested by the designer. There is a need to structure the interaction of users with dashboards too, such as the amount and position of the graphical widgets for indicators, tables, summaries etc. These should be chosen with the capabilities of our short-term memory in mind, and the limited amount of data that can be processed before overload is experienced (Silveira et al, 2010: 11).

A criticism of dashboard-based decisions is that they are often made and executed by management, but that the decision-making process is never passed down through the organisation (Fuchs, 2005: 1). It has been argued that it is a centralised decision-making process that excludes the majority of the people it affects. The suggested measure to counter this is to provide a visual, interactive dashboard for decision-makers to be able to work with (Fuchs, 2005: 1). The detailed data behind a dashboard should be available interactively so that the decision-making process is not interrupted by prolonged response times (Fuchs, 2005: 3). By being interactive, the decision support provided by the system is continuous. Data can be continuously updated to provide timely and accurate information to decision-makers. This can help to avoid poor decisions from being made, something that could result in stagnation of business growth and development. It is important that every decision is “measured and clearly communicated so the quality of the decision and the quality of the process behind the decision can be validated and optimised” (Fuchs, 2005: 6). Visual interactive data can constantly improve an organisation’s decisions in a measurable way (Fuchs, 2005: 6).

Cognitive maps could be viewed as a type of dashboard, helping to direct information search and clarify the state of an industry or external factors that may affect strategies (Schwenk, 1988: 46). These illustrations can show the way in which decision-makers conceptualise their environment, by way of which choices are made or seen as being available (Schwenk, 1988: 47). Analogies see decision-makers drawing from similar past experience. They are more likely to influence problem formulation when shared with other decision-makers (Schwenk, 1988: 47). There are two ways to understand a strategic problem: to analyse the data and then develop a schema or to analyse the data and then apply a previously developed schema (Schwenk, 1988: 48). In approaching a problem, the different backgrounds of decision-makers will be evident as they will attend to different features of problems and focus on different cues (Schwenk, 1988: 48).

The problem faced by decision-makers these days is often not information retrieval itself; there are various technologies that can assist with that. What are required are the methods and machines that will allow people to elicit more information more quickly than otherwise possible (Card, Mackinlay and Robertson, 1991: 1). The way that information processing systems generally tend to be organised is in such a way as to minimise the cost of information, or reduce the information load as much as possible (Card, Mackinlay and Robertson, 1991: 1). The problem for decision-makers is in accessing information once it has been retrieved and in knowing how and what to use once it has been accessed (Card, Mackinlay and Robertson, 1991: 2). A common solution is an organisation that adjusts the cost structure of information to the requirements of the work processes that use them (Card, Mackinlay and Robertson, 1991: 3). An example of this could be a space like the Oobeya room. Making information explicit is important, as people do not always know what is available on a system, so cannot necessarily look for a certain piece of information. Sometimes the presentation of certain information to the decision-maker will generate creativity in search or will present ideas that lead them to certain aspects of the data or information. While having information available in such a way may help to generate innovation and creativity, its presentation will be subjective and may lead the decision-maker to be more susceptible to cognitive biases.

Dashboards allow for easier viewing of a decision problem, a simplified version for the decision-maker to look at and understand. It draws the attention of the decision-maker to important aspects that need to be focussed on. This saves times and cognitive effort, but is limiting in that it may not provide decision-makers with enough information to make a well-informed decision with and it does encourage the emergence of particular cognitive biases. With an understanding of why dashboard representations may assist decision-making, the two broad ways of representing data, graphically or symbolically, and their various attributes can be explored. This will provide a better understanding for which type of representation may be more effective under what circumstances.

#### 3.4.2 Different representations: Graphic and symbolic

As seen in the example of the dashboard, many dashboards comprise various graphs and tables, displaying key performance indicators. For this reason, a thorough understanding of the advantages and limitations of both graphs and tables is necessary, so as to use the means most effective in the context. With the graphics technology available today, graphic support can be provided for many aspects of decision-making. This flexibility creates a problem. It has been shown that the format in which information is presented may actually change the decision strategy that is used (Bettman and Kakkar, 1977). The decision strategy refers to the method by which people acquire and combine information to make decisions (Jarvenpaa, 1989: 286). The decision strategy that is chosen usually corresponds to the type of information available, with an appropriate strategy chosen that will best attend to the decision problem. The choice of this strategy can cause stress for the decision-maker, and it affects the decision outcome.

Graphical and tabular reports should be evaluated within a great variety of task settings to identify where their comparative advantages may lie (Benbasat and Dexter, 1985: 1349). In experiments done on the effects of colour and graphics, subjects with multi-colour reports outperformed those with mono-colour reports, with multi-colour reports being more understandable (Benbasat and Dexter, 1985: 1358). The decision quality and time performance improvement effected by colour appeared higher for graphical than for tabular reports. However, this research was conducted at a time when colour was the exception and not the rule. Whether or not to use colour is not even a question these days, but rather the focus is on which technology to employ. The use of colour can be very effective if used appropriately, and can enhance understanding or confuse decision-makers if used badly.

Graphic presentations enhance the ability of decision-makers to evaluate or process spatial information, whereas tables containing numbers enhance the evaluability of symbolic information (Vessey, 1994: 109). Tabular representations are superior for retrieving specific data values. Humans can process more information when it is presented graphically than when it is presented in text form (Tegarden, 1999: 9). Interactions between features are more easily perceived in graphic displays than in verbal descriptions and the relative strength of such interactions is likely to be stronger for graphic than for text information (Holbrook and Moore 1981: 103). Without the context and detail provided in a visualisation of data, managers may be less likely to explain their decisions to others without the data to back it up (Lurie and Mason, 2007: 168).

There is also the argument that strategy selection is a deliberate compromise between the benefits of minimising errors and the expected costs of cognitive effort for a particular task (Payne, 1976). In addition to this, the format in which information is presented does not always support the processing demands of the decision task (Jarvenpaa, 1989: 287). Task demands are “plans, algorithms, or systematic procedures used to integrate the information needed to make a decision” and can be exogenous or endogenous to the decision-maker (Jarvenpaa, 1989: 287). Where the format and processing demands differ, decision-makers acquire information in the way encouraged by the display format, but they may evaluate the information according to an evaluation strategy that they have used in the past, or schemata (Jarvenpaa, 1989: 288). By mixing strategies, effort is reduced and accuracy can be improved. Knowing the goals of the task, or what it requires, can provide a schema by which to evaluate the information (Jarvenpaa, 1989: 288).

Another aspect of structure to consider is whether the data shows a trend or not. When there is no trend in a series of data, there is a slight advantage for the use of tabular presentation (Harvey and Bolger, 1996: 120). However, when data does show a trend, graphical presentation of that data is superior (Harvey and Bolger, 1996: 120). Given that much information in organisational contexts involves integrating information that has been collected over time or space and usually aims to show a trend or change of some sort (eg. time or location), graphical presentation of this type of data is superior to tabular representation in the way it is perceived by decision-makers. If perception in a graphical format is superior for cognitive processing, then this assistance in information acquisition could be a method of limiting information overload.

When using judgement to make forecasts, variables showing a linear trend perform better when presented graphically. However, such forecasting is generally suboptimal because it is prone to biases and inconsistency (Harvey and Bolger, 1996: 122). It is more accurate to forecast untrended series from tables and trended series from graphs (Harvey and Bolger, 1996: 129). This is because trended and untrended series are subject to different cognitive biases and the strength of these biases depends on the format in which the data is presented (Harvey and Bolger, 1996: 130). The various biases will affect the decision outcomes in different ways and to different degrees.

Decision-making comprises the three sub-tasks of information acquisition, evaluation and learning (Einhorn and Hogarth, 1981: 9). Cognitive fit exists when spatial information acquisition tasks are supported by spatial problem representations and likewise for symbolic information. When cognitive fit exists, decision-makers don't change their strategy in response to changing demands on time or accuracy, but they continue to use processes that match the problem representation (Vessey, 1994: 107). In complex symbolic evaluation, data is processed perceptually to reduce cognitive effort. Therefore, more complex situations may show a change of strategy in order to reduce effort levels (Vessey, 1994: 106). Similar results were shown for information processing under time pressure, where the strategy was changed to ease processing. Data displayed in graphs are assessed using perceptual processes (Einhorn and Hogarth, 1981). Integrating data from different time periods uses cognitive resources and is both time consuming and more likely to result in errors (Einhorn and Hogarth, 1981). Graphic representations are the best type of visualisation to handle an increased decision load (Einhorn and Hogarth, 1981).

Visualisations are a good method to use in integrating data from different time periods in order to reduce cognitive effort, though there are still inherent biases and errors that will result. Graphs deal less effectively than schemata with the integration of data (Einhorn and Hogarth, 1981). This could mean that if a situation involving integration of similar data arises, it is better dealt with by using the template provided by the previous problem than integrating it in a new way in a graph. However, as technology and the business environment are changing rapidly, the problems that are faced by decision-makers are often new or unique and are not simply solved by applying schemata. This is where the values of graphs lie, supporting perceptual problem solving processes by providing integrating capabilities, but at the same time, preserving the underlying data. Tables provide data values but no integration and do not handle increases in information load as well as graphs do (Einhorn and Hogarth, 1981). In studies by Einhorn and Hogarth (1981) it was found that the accuracy of prediction using graphs is higher than with tables. More time is needed for prediction using tables because there is a higher information load. This shows the value in using visualisations, particularly graphics, in the integration of data for reducing the cognitive load of decision-makers.

Decision processes are strongly dependent on the format of the graphical presentation. The way the graphical information is arranged on a display affects the order in which decision makers acquire information (Jarvenpaa, 1989: 286). Tabular reports show that congruence affects decision time, but not decision quality. This links to other evidence that shows that

graphs may result in quicker processing of information, but not necessarily higher decision quality (Speier, Valacich and Vessey, 1999: 338).

Participants in the study by Jarvenpaa (1989) adapted to the task environment by varying the amount of time for the task while keeping the decision accuracy of the task as high as possible. Incongruent situations occurred when participants were presented with task demands and graphical formats that encouraged different types of information processing. The graphical format appears to matter more than the demands of the task in the process by which decision-makers acquire information (Jarvenpaa, 1989: 288). However, in information evaluation, the actual task and its interaction with the format appeared to be relatively more important than the format of the graphs, cognitive fit playing a greater role (Jarvenpaa, 1989: 299). Participants tended to use schema-driven processing combined with data-driven processing (Jarvenpaa, 1989: 299). This combination of processing techniques caused interaction between the graphical format and the task demands during evaluation (Jarvenpaa, 1989: 299). In graphs, grouped bar charts emphasise attribute differences in a more distinctive way than the same information presented in a tabular format, especially when there is a large number of attributes per alternative (Jarvenpaa, 1989: 299). This shows how graphs can have a greater impact on highlighting certain information to the decision-maker, according to the way in which it is presented. The graphical format and the match between the task demands and the graphical format can influence the efficiency of the decision-making strategy that is selected (Jarvenpaa, 1989: 300). The performance of decision outcomes can be judged on accuracy, decision time or both (Jarvenpaa, 1989: 300).

According to Eckerson and Hammond (2011), there are two categories of data visualisation technology. Visual reporting uses charts and graphics to show business performance. It is usually characterised by metrics and time-series information. An example of a visual report would be a dashboard or a scorecard, giving managers and other decision-makers a visual image of performance. This is contrasted to visual analysis, which enables users to visually explore data to discover new insights. Visual analysis tools empower business analysts to explore trends and variances in data sets and then to publish views for others to learn from (Eckerson and Hammond, 2011: 10). By introducing interactive dashboards, these two different types of data visualisation technology are being combined, integrating aspects from both to provide an optimum visualisation tool to decision-makers.

Tufte (1983: 96) suggests that graphic displays should only be used for large sets of data, because in smaller groups of numbers, tables usually outperform graphics. Visual displays that represent variables separately do not usually have an advantage over tables. The advantage of graphics comes from integrating multiple variables into a single graphic representation (Meyer, 1991: 222).

Visual dashboards seek to improve the awareness of team activity using a spatial representation of the shared information that represents team members' current activities (Biehl, Smith, Robertson et al: 1313). It is an approach to communication that can be effectively used in organisations of varying size and nature. Two practical examples of visual dashboard techniques that are used in organisations are the balanced scorecard and the

oobeya room, decision aids being used in organisations as visual simplifications of information.

### 3.4.3 The balanced scorecard and the oobeya room

There are different ways of displaying information visually in organisations. The balanced scorecard was conceptualised by Kaplan and Norton in the early 1990's and has been used in organisations for a number of years, gaining popularity over time (Cobbold and Lawrie, 2002: 1). The Oobeya room is a relatively new development in visual management and is to knowledge worker managers what Kanban is to managers in a production environment. These methods of visualisation each have merits and will be looked at in further detail.

#### Balanced Scorecard

The balanced scorecard is an example of cognitive simplification that is used in organisations as a method of preventing information overload. Along with other advantages, the primary advantage of a balanced scorecard is in that it provides a summary or overview of different areas of an organisation, for managers to get a good idea of activity. By providing short summaries of key indicators from different areas in an organisation in an integrative visual format, the cognitive load of managers is reduced.

The balanced scorecard contains a varied set of performance measures, covering financial performance, customer relations, internal business processes, and the organisation's learning and growth activities (Lipe and Salterio, 2000: 284 and Epstein and Manzoni: 3). It integrates a set of both 'leading' and 'lagging' performance measures that are designed to capture the organisation's strategy (Lipe and Salterio, 2000: 285). When making a decision, humans use simplifying decision strategies that are affected by the characteristics of a task. One such strategy that managers can resort to is looking at only common performance measures in evaluating multiple business units in an organisation, for example, financial measures. Traditional financial accounting measures such as the ROI and the payback period offer a narrow and incomplete picture of business performance (Martinsons, Davison and Tse, 1999: 73). A reliance on such data hinders the growth of a business and restricts its intrinsic value (Martinsons, Davison and Tse, 1999: 73).

The balanced scorecard shows measures that drive performance, minimising information overload by limiting the number of measures used (Kaplan and Norton, 1992: 72). Such measures do not only include the traditional financial accounting measures, as alone, these can give misleading signals for continuous improvement and innovation, but also include activities that today's competitive environment demands (Kaplan and Norton, 1992: 79). While these measures worked well during the industrial era, they are not the only things to be considered in the knowledge economy of today. A single measure can provide a clear performance target or focus a manager's attention on critical areas of an organisation. However, a dashboard demonstrates various indicators showing performance in a number of areas. Reliance on one instrument can be dangerous, as other important aspects of an organisation may be ignored or undermined. It is for this reason that the balanced scorecard incorporates four perspectives, answering the questions: How do customers see us? What

must we excel at? Can we continue to improve and create value? How do we look to shareholders? (Kaplan and Norton, 1992: 72).

In France, companies have been using a related tool called the 'Tableau de Bord', which is a dashboard that emerged in France in the early 1900's (Epstein and Manzoni: 3). The principle was then applied at the top management level to give senior managers a set of indicators that allowed them to monitor the progress of the business, compare it to the goals that had been set, and take corrective actions (Epstein and Manzoni: 3). The initial objective of giving managers an overview to support decision-making had two important implications: The Tableau de Bord is not a single document applying equally to the whole firm; also, it should not be limited to financial indicators. The balanced scorecard should be customised to each sub-unit in an organisation, while also aligning the sub-units to the overall vision and strategy of an organisation. Balanced scorecards and Tableaux de Bord group a small set of selected indicators in a single, succinct document, thereby helping managers to avoid being faced with too much information and reducing the chances of overload (Epstein and Manzoni: 9).

The balanced scorecard meets several managerial needs, bringing together in a single report many elements of a company and guarding against sub-optimisation (Kaplan and Norton, 1992: 73). Goals for time, quality, performance and service should be articulated and translated into specific measures. Customer performance derives from processes, decisions and actions occurring throughout an organisation and managers need to focus on those critical internal operations that enable them to satisfy customer needs (Kaplan and Norton, 1992: 74). The balanced scorecard considers internal and external measures that link top management's judgement about key internal processes and competencies to the actions taken by individuals that affect overall corporate objectives (Kaplan and Norton, 1992: 76). The information on a scorecard needs to be timely, coming from a responsive information system. The balanced scorecard is also a good way to create a shared vision and goals for an organisation, as top management must be involved because they have the clearest idea of the goals, vision and priorities of an organisation (Kaplan and Norton, 1992: 79). By combining different perspectives, the balanced scorecard helps managers to understand many inter-relationships in an organisation, which can lead to improved decision-making and problem solving. It helps to keep companies looking forward.

In a knowledge economy, organisations compete with information. This means that their ability to exploit intangible assets needs to be improved. The balanced scorecard has been used in strategy formulation, as it has the ability to link long-term strategy with short-term actions, providing detail about translating vision and strategy into action (Kaplan and Norton, 1996: 3). The balanced scorecard can link financial budgets with strategic goals and is a method of communication to everyone in an organisation, also providing opportunities for feedback and learning (Kaplan and Norton, 1996: 5).

The balanced scorecard takes into consideration customer-based as well as financial based processes. This can help the managers to monitor and improve business performance on a real-time basis, reducing the likelihood of information overload (Martinsons, Davison and Tse, 1999: 74). In addition to being used on an organisational scale, they can also be used in

individual departments or functional areas of an organisation, measuring, evaluating and guiding the decision-making processes (Martinsons, Davison and Tse, 1999: 75). It can even be used on performance and decision-making at specific project levels (Martinsons, Davison and Tse, 1999: 75). Balanced scorecards can inform managers as to what is happening and why, enabling them to base their decisions and actions on solid information rather than simply on intuition. In addition to these benefits, the cost of implementing the balanced scorecard in an organisation should not be great. This enables smaller organisations to benefit from such a method of management, as well as larger organisations. This can be empowering for smaller groups of decision-makers, helping groups to maintain an awareness of performance levels in the company without especially high levels of financial outlay. Businesses that are just starting or still developing, or those that do not have the financial capacity for high levels of technology can still use visual management techniques for effective management and communication in decision-making processes.

In relation to information overload, the balanced scorecard is a great simplification, only showing key areas of interest to management. Though this has disadvantages too, it aids decision-makers in reducing information overload, particularly at a management level. This makes potentially large amounts of data simple and easy to process, saving time and cognitive energy. They also show different areas of an organisation, drawing the attention of managers to areas they might not otherwise concentrate their attention on. However, the balanced scorecard still does not show all the areas of an organisation, only those deemed to be vital by other decision-makers. This subjective selection of what is important and what will be included on the scorecard affects the way that decision problems are framed and leaves decision-makers subject to various cognitive biases. This type of visualisation plays a large role in management by exception, with only the most 'important' areas being brought the attention of the managers for action, and others, possibly also significant issues, going under the radar of their focus. The scorecard should somehow be linked to the information system of the company, enabling management to delve deeper into issues that are brought to their attention, as well as other related issues. The creation of the scorecard could possibly also create extra work for some decision-makers, having to integrate or gather data that is not already in existence. If this is the case, the purpose of the scorecard in trying to reduce information overload is lost.

### Oobeya room

“Oobeya” (or obeya) is the Japanese word for project control room and the concept, like lean management in general, is growing in popularity in the Western world (Gurumurthy and Kodali, 2008: 105 and Tanaka, 2005: 1). The room is used mostly in project management and involves up to date visualisations of the various phases and progress being made in projects or in organisational departments. There may be various dashboards around the room, all showing up to date information to keep decision-makers informed.

Lean management systems focus on using organisational resources in an efficient way through continuous improvement and the elimination of waste (Andersson and Bellgran, 2009: 1). Waste can refer to the loss of “time, ideas, skills, improvements, and learning

opportunities by not engaging (with) or listening to the employees” (Andersson and Bellgran, 2009: 1). The implementation of such lean philosophies can lead to improvements in all business processes and create a ‘lean enterprise’. The Oobeya room is used most in organisations that do project-based work and is one aspect of the lean philosophy that can be implemented in an organisation.

The project control room itself is an advance in project work, but is only part of a new approach to product design (Tanaka, 2005: 2). Bringing visualisation to product development, or other knowledge work, is a new concept. The visual tools used in the Oobeya, along with the structure and discipline required to use them effectively have enabled companies to reduce the cycle time of projects (Tanaka, 2005: 2). Oobeya is team-oriented and takes into account the varying needs and strengths of the people on the project (Tanaka, 2005: 4). There are display boards in the project room that form a highly structured but simple system that helps the whole team to visualise the entire project (Tanaka, 2005: 4).

The process of creating the room begins with creating project objectives that are in line with the organisation’s strategy and its assessment of the market. These are then aligned with the more short term corporate objectives using the main board (Tanaka, 2005: 4). Project objectives, expected outputs, metrics, action plans, and reporting mechanisms become aligned with the vision of the organisation (Tanaka, 2005: 4). Each area of the project is included in the development process. Because action in the Oobeya is structured, it allows for meetings to be short and productive (Tanaka, 2005: 4). Time is saved and problems can be addressed as they arise and are resolved quickly. Managers in such a setup are more confident that work will be completed on time and that concurrency between different project teams will be maintained (Tanaka, 2005: 7). Close attention is paid to communication, which is key to managing knowledge effectively. The room aims to create and foster cooperation, intellectual stimulation and an open and honest atmosphere in general (Tanaka, 2005: 7). Because project team members can be drawn from all areas of an organisation, there needs to be a common understanding of issues and of goals if the result of the project is to be a success.

In firms that have a typically hierarchical management structure, it is often the case that project objectives may be unclear or not well communicated or insufficiently broken down into specific tasks for all employees in an organisation (Tanaka, 2005: 7). Goals and strategies may not be shared widely enough, resulting in a lack of coordination amongst different teams or individuals. Due to an absence of trust, problems may not be raised and project time could be longer and more information-intensive. The advantages of an alternative management structure and the use of an Oobeya room in such an organisation would be the reduction or elimination of such problems. In addition to this, the oobeya can also be a source of learning for employees, not only from visual information, but also from other employees. In observing and listening to senior workers in the same space, individuals can absorb knowledge and skills that they may not otherwise have been able to learn (Inatsugu, 2001: 5). Such exposure and the facilitation of interaction in the Oobeya helps learning to take place between individuals (Inatsugu, 2001: 5).

The decision-making process fits well into the concept of visual management used in lean product development (Paschkewitz, 2011: 3). An Oobeya is used for brief stand-up team meetings that can be held daily or weekly, depending on the scope and the progress of the project (Paschkewitz, 2011: 3). The visual management approach provides all team members and managers with up to date information on the status of the project. It removes the need for numerous time-consuming meetings and presentations that can take away from time and money that is spent on the project (Paschkewitz, 2011: 3). This approach also requires managers to be directly involved in the project. Interactions with team members can improve communication and help to promote a shared vision and ownership amongst the team (Paschkewitz, 2011: 3).

Management and visual communication is situated in a spatial environment, which, if designed well, is conducive to communication as the spatial design interacts with the visual elements (Andersson and Bellgran, 2009: 2). This can be used to “reduce waste in the form of unused creativity, long product development cycles, low motivation, complicated communication, low dedication or weak representation of the company identity” (Andersson and Bellgran, 2009: 2). There are different advantages in the use of the oobeya, which depend on how the visual communication is used. One advantage is the reduction in time for the project cycle (Andersson and Bellgran, 2009: 3). To visualise information in a room like an oobeya reduces project time that may have been spent on presenting and discussing the project and its progress (Andersson and Bellgran, 2009: 3). It creates shorter paths for information flow, supports fast and accurate decisions and helps with identifying problems as they arise (Andersson and Bellgran, 2009: 5). Such an environment can also encourage a positive view of the company and the project among employees, increase the status for the project or the department and reinforce motivation and a sense of feeling valuable to the project or organisation (Andersson and Bellgran, 2009: 6). The fact that others can see the work of individuals and their contribution to the project or the progress they are making increases accountability too. In the same way that the oobeya provides a space for the generation of positive attitudes and innovation, it could also be a place where negative attitudes are fostered. Should a project not be going well, such a space could become conducive to the generation of unconstructiveness amongst employees, as they see the (lack of) progress and share negative comments or criticism about the condition of the project.

In relation to information overload, the oobeya provides an open source of information to employees, making it accessible and laying it out in such a way that is conducive to understanding. Such a room is designed to be understood by people from different teams, suggesting that information would need to be presented in a manner simple enough to be understood by employees who may not have a deep knowledge in a specific area. Particularly for managers, information overload can be reduced. Managers or supervisors are forced to be involved in the project. By continually being updated on the project status, information is gained incrementally and not as a single chunk at the end of the project which then needs to be understood and interpreted. The transparency and good communication that this presentation of information provides can reduce information overload. The oobeya is an example of organised knowledge management, which helps to reduce organisational

information overload. In turn, individual overload can be reduced too, through the good knowledge structure in the project room.

There are also limitations of using such a space for information presentation. An oobeya will not work in every organisation and its success is likely to be influenced by the management structure in place. If not well-managed, the oobeya could in fact overload individuals with information, with decision-makers trying to learn too much about a project outside of their scope of concentration. In terms of visualisations being a reduction of information, the oobeya is different. Because it is more on an organisational level, any biases or framing effects may have more far-reaching effects. Though the decision-makers have access to 'all' the information from across different groups, the information that is selectively displayed by each group is subjective and therefore biases are inherent. However, the biases and framing effects from this method of display may be less than other types of visualisations, as this method aims for transparency and displaying all information about a certain situation, with as little 'selection' as possible.

The idea of a dashboard is to give decision-makers, particularly those in positions of management, a good overview of a situation or a data set in one image. Dashboards provide summaries of important aspects of a situation that can speed up decision-making and assist in the reduction of cognitive load through the simplified version of the data that they provide. The way that the situation is framed or represented and the aspects of the data set that are chosen to be displayed on the dashboard affect the decision-maker and the decision outcome. The choices that shape the framing of the decision affect the way the decision-maker thinks about a situation and will therefore affect the choices that are made. The display of the dashboard, what and how it represents, therefore has a significant impact of the decision outcome. Biases, such as framing, overconfidence, anchoring and others are therefore prevalent in decisions based on dashboards, as they are inseparable from human choice and error.

### 3.5 Conclusion

When discussing visual representations in an organisational context, it is key to remember that visualisations are planned and structured reductions of data and information. Though there are both benefits and limitations to this form of display, it is important to remember what visualisations actually are, the process that is involved in producing them. That is, the aspect of choice that is involved; the considered and subjective selection of certain data to be displayed in a chosen format which by its nature excludes some aspects of the data and highlights others.

Bearing the above in mind, there are definite advantages of using visualisations to aid decision-makers and reduce the impact of information overload. Visualisations help to integrate data that has been gathered over time, from different sources or in different formats. This makes comparison easier and less taxing on cognitive efforts. When using graphics, cognitive processing is transferred to the perceptual system, reducing the cognitive load and effort required by the decision-maker. The fact that visualisations have the ability to highlight

certain aspects of data is both an attribute and a shortcoming. The highlighting of information can bring to the attention of the decision-maker pertinent aspects of data, raising awareness about certain issues (for example, in management by exception) and simplifying cognitive processing by making it obvious to the decision-maker what is important in a data set, thereby reducing effort that would otherwise be required in search. On the other hand, who is to decide what is important, what is worthy of the decision-makers' attention, and what should be ignored. Issues that may be less important for a period of time may suddenly become important or problems could arise, leading to questioning over why it was not highlighted at an earlier stage. In this way, these choices that are reductions may be systematically wrong or systematically right for a long time but then suddenly no more.

By the nature of what visual representations are, they reduce and simplify large sets of data. When the visualisation is interactive, this data may still be accessible, but the decision-maker is exposed initially to the simplification. This lessens the volume of data that the decision-maker needs to process, as the visualisation is a reduction. Because visualisations are data that has been changed into symbols, shapes and percentages, they transcend language or cultural barriers that may exist between decision-makers from different backgrounds. Though some further explanation may be needed, the visualisations itself may be able to be understood by a variety of people, who are able to share a common understanding about a scenario because it has been explained visually. This makes them useful in organisations where decision-makers from different areas of expertise, different cultures or different educational backgrounds work together, that is, most organisations around the world. Lastly, visual representations, by their nature save time and cognitive effort. They are simplifications, enabling easier processing by the decision-maker, and in so doing, they reduce information overload on the individual.

When considering whether or not to use visualisations in the decision-making process, it is important to weigh up the attributes of such a method with its limitations. Due the fact that visualisations involve a reduction in information, there is choice involved and therefore biases that come with subjectivity. Biases are an inherent limitation of visualisations, and the conscious reduction of data leaves framing an issue too. Information that is highlighted is subjectively chosen. This also leaves the data open to manipulation by those decision-makers selecting the information to be represented. Some data is excluded and it is important to bear this in mind when looking at visualisations. Cognitive fit, to some extent, is also important when designing the visualisation the representation should be a good match for the type of data it is showing. Further, the actual visualisation should be appropriately displayed, with not too much or too little or irrelevant information for its audience, and using colours and graphics suitably.

In assessing the use of a visual representation in a situation, the decision-maker needs to realistically assess the limitations and the values of the visual and measure these against the problem situation and the goals or the desired outcome. The decision-maker needs to decide what the priorities of the situation are and what they are willing to sacrifice for the benefits from the visualisation technique, or whether limitations are not worth the use of the technique. Vital though, is a realistic assessment of the situation, every time the technique is

being considered to be employed. However, there is not always the time or the cognitive effort required by the decision-maker to assess the situation, and decision-makers may tend to go the easiest or the quickest or most convenient route, without considering fully the implications or potential limitations of the actions they are choosing. This could be why visualisations may not always be beneficial, as some situations may not be well-suited to their use, or the limitations of the technique may prove to be too much of a hindrance in a particular circumstance. For situations for which they are well-suited though, visual representations of information can reduce information overload for decision-makers in organisations.

## Chapter 4

### FAST AND FRUGAL HEURISTICS

#### 4.1 Introduction

##### 4.1.1 Nature of the topic under discussion

The topic of this chapter concerns cognitive heuristics used in decision-making. The focus is on the use of heuristics in an organisational context and at a management level. This topic is relatively dynamic, involving an ongoing discussion between researchers that are testing and re-testing the concept and application of heuristics. Though there are numerous studies on the many associated biases, research tends to be focussed around a small number of the available defined heuristics that are used in decision-making, concentrated on the application of these heuristics to areas other than an organisational environment. The aim of this chapter is to show the relationship between the use of fast and frugal heuristics and a reduction in information overload through a decrease in cognitive processing in an organisational context. Though there is general agreement that heuristics are unplanned and intuitive thought processes, it is possible to learn from the results of fast and frugal decision-making in order to intentionally structure the process to use them as a means of decision support in certain appropriate contexts with appropriate information. The biases that are associated with the use of heuristics could be seen as limitations, but the effect can be reduced with awareness.

##### 4.1.2 Parameters of the topic

This chapter draws attention to the use of fast and frugal heuristics as an approach that could be used in organisations to minimise the negative effects of information overload. Specifically, the take-the-best and the recognition heuristic are focussed on, being the two most widely-researched fast and frugal heuristics. These heuristics as a method of finding solutions to problems in an organisational environment are discussed. This is discussed in relation to other methods of problem solving in organisations, most notably those based on computers. Although there are many cognitive heuristics that exist, specific reference is only made to fast and frugal heuristics, and even then, not all heuristics that could be considered as fast and frugal are included, but only those that have received the most attention in the literature, particularly the recognition and the take-the-best heuristics. This chapter limits the use of the term heuristics to cognitive heuristics only, and does not pertain to computational heuristics (Walczak, 2001). It does not include research on the biases that accompany heuristics, though there is mention of the overconfidence bias, as it is particularly prevalent in the organisational context of decision-making, and has been discussed in the literature relating to strategic or organisational decision-making. Which heuristics may be more applicable than fast and frugal heuristics, or alternative views on strategy selection in organisational decision-making has not been included in the discussion of this chapter. When reference is made to structuring the environment in such a way that is conducive to the use of certain heuristics, methods for doing so are not explained in detail. How to narrow down information to present the decision-maker with only a few options is also not discussed.

#### 4.1.3 Basis for the selection of the literature

Literature was selected according to its applicability and reference to the fast and frugal paradigm in particular, as well as to the use of cognitive heuristics in an organisational context or in business. Research conducted by Gigerenzer, who developed the concept of fast and frugal heuristics in decision-making with various collaborators, was included as a central argument, as well as research that critiqued the work of Gigerenzer and his colleagues or gave opposing views. A selection of literature pertaining specifically to the take-the-best and recognition heuristics, as well as the contexts in which heuristics are used and the reasons they are used has been chosen. Due to the large amount of literature available, that which was most relevant and/or most cited was selected until there was sufficient evidence to make a particular view clear. Other research that has been based on the use of the heuristics in this category and tested under different conditions has also been discussed.

#### 4.1.4 Problem and scope and variables included

The problem faced by decision-makers is in choosing a decision strategy with which to make their decisions in a given environment. Cognitive heuristics, specifically those that can be termed fast and frugal, can be used consciously or subconsciously with very little, but specific information to make relatively accurate decisions quickly. The variables include, firstly, individual factors such as personality, intelligence and the educational background and experience of the decision-maker, as well as secondly, the decision environment. The environment includes the decision-maker's social environment, time pressures, amount of information available, and other decision strategies available to the decision-maker. A third variable is the type of decision problem faced by the decision-maker. Not all types of problems are amenable to the application of heuristics. The research on heuristics has largely used particular types of problems and environments and this chapter attempts to investigate the implications that these have for organisational decision-making, specifically that done at a management level, and to apply the research to such a context.

#### 4.1.5 Organisation of the review

The review begins with an explanation of what heuristics, and more specifically, fast and frugal heuristics, are. Detail of the specific fast and frugal heuristics discussed are included. How such heuristics may apply in an organisational context is then explored, followed by a discussion of the core issues in the subject, including an argument of the appropriate use of regression models when compared to heuristics. Finally, the chapter concludes with a summary of the pros and cons of fast and frugal heuristics and the main disagreements among researchers in this area.

### 4.2 Fast and frugal heuristics

#### 4.2.1 What are fast and frugal heuristics?

The Probabilistic Mental Model (PMM) theory is a framework for modelling inferences from memory (Gigerenzer and Goldstein, 1996: 4). It states that the confidence that decision-makers have in their immediate and spontaneous knowledge is determined by the structure of

the task and the corresponding known environment in the memory of the decision-maker (Gigerenzer, Hoffrage, Kleinbolting, 1991: 35). The theory proposes that classical rationality is replaced with simple, plausible psychological mechanisms of inference, evolved mechanisms that allow the mind to implement decision-making under limited time and knowledge (Gigerenzer and Goldstein, 1996: 5). Fast and frugal heuristics are based on the PMM theoretical framework. They belong to a broader type of heuristic, known as lexicographic heuristics (Goldstein and Gigerenzer, 1996: 24). Take-the-best is the most well-known strategy that uses a lexicographic procedure where cues are ordered according to their validity. Psychological principles that are not lexicographic are also included in take-the-best. A lexicographic strategy simply implies that the alternative with the most important attribute is selected.

Heuristics are mental shortcuts or rules of thumb that are used by decision-makers for efficient cognitive processing, either consciously or subconsciously (Gigerenzer and Gaissmaier, 2011: 454). Fast and frugal heuristics are a type of cognitive heuristic that focus specifically on using as little given information or few cues as possible to simplify and speed up the decision-making process. Hence, this class of heuristics is frugal in that they require little information and fast as a result of this, allowing a lot to be accomplished using little knowledge and time. These heuristics are a one reason decision strategy (Goldstein and Gigerenzer, 1996: 1).

The word heuristic is of Greek origin and means “serving to find out or discover” (Gigerenzer, 2004: 62). Heuristics became more prominent after computer programming began, when it became clear that many important problems were not able to be solved computationally or did not have an optimal solution that could be worked out by following a specific structured method (Gigerenzer, 2004: 62). This caused uncertainty in how to go about solving certain problems, and this uncertainty applies whether problems are well-structured or not. While heuristics are currently generally understood as being rules, a rule is not necessarily a heuristic. A rule is only a heuristic when it exploits evolved capacities, when it exploits the structure of environments and when it is distinct from optimisation models, each of which will be discussed below (Gigerenzer, 2004: 63).

### Evolved capacities

A decision rule may be simply structured in an accessible way, but to implement the rule one needs to know how to interpret and apply it. Before decision-makers can act on these simple rules, decades of learning and education need to take place (Forster, 1999: 547). Fast and frugal heuristics emerge from a complex process of evolution that is not fast or frugal (Forster, 1999: 550). Humans have been provided with various capabilities, the extended practice of which evolves them into capacities (Gigerenzer 2008: 25). The cognitive capacities that heuristics exploit have thus evolved with learning over time. Without these evolved capacities, heuristics could not do their job; without heuristics, the capacities alone could not do the job either (Gigerenzer, 2008: 25). What makes heuristics simple is that they exploit these learned cognitive processes. This simplicity allows decision-makers to make

fast, frugal, transparent and robust judgements (Gigerenzer, 2004: 64). In order to work successfully, heuristics require little information and are able to be generalised to apply to new situations (Gigerenzer, 2004: 64). This does not mean that heuristics can be universally generalised though; they may be able to be applied to other situations as a rule of thumb, but they are domain specific, and a heuristic that can be successfully employed in one situation, may be unsuitable for another (Gigerenzer, 2001: 6).

Heuristics are what decision-makers use by default, but contradicting information or knowledge about the criterion can deter the decision-maker from using it (Gigerenzer, 2008: 24). Generally, studies have shown that people evaluate situations intuitively to assess which heuristic to use (Gigerenzer, 2008: 25). Due to the fact that decision-makers cannot know everything at once, they need to search for information as it is required. This costs them time and sometimes, money (Gigerenzer, 2001: 3).

In trying to save decision-making time, the theory of dual-process views of thinking that sees one type of processing that is parallel, relatively automatic, associative, and fast, known as system 1, and another that is serial, effortful, and rule-based, known as system 2, proposes that system one may respond to situations with relatively high accuracy (Payne and Bettman, 2004: 113). Heuristics are sometimes included in system 1 that is responsible for associations and making errors. This is contrasted with system 2 that exemplifies the laws of logic and probability (Kahneman, 2011: 21). While system 1 is the default processing mode, this way of thinking may or may not be corrected by system 2. In our modern technological society, with frequent and often large changes in the decision environment, decision-making may require more system 2 thinking, with an understanding that system 1 influences system 2 (Payne and Bettman, 2004: 113).

The heuristics that are a 'system' one way of thinking can be grouped into 'building blocks', according to the capacities that they exploit. When these basic heuristics are not applicable to a situation, they can be adapted or combined to build other heuristics (Gigerenzer, 2008: 25). By viewing the mind as an adaptive toolbox, it can be seen as consisting of different modules. The fact that the heuristics are organised into modules based on cognitive capacities helps the decision-maker in selecting a heuristic, as not all heuristics will be able to be applied in all situations (Gigerenzer, 2008: 25). Instead of one view towards problem-solving, there are different heuristics, organised into the modules or blocks by the various capacities that they exploit (Gigerenzer, 2008: 23). With recognition of these capacities, certain heuristics can be tested to see whether or not they could work in a given environment. If the heuristic can be applied, an evaluation process may still prevent its application (Gigerenzer, 2008: 24). This evaluation process assesses the heuristic's ecological rationality for a given situation (Gigerenzer, 2008: 24).

### Ecological rationality

Ecological rationality refers to rationality in relation to the context. Individuals and organisations often rely on simple heuristics that can be used to adapt to different situations (Gigerenzer and Gaissmaier, 2011: 456). Heuristics are not based on logical rationality, but

on ecological rationality (Gigerenzer, 2001: 64). This implies that the rationality of a heuristic is found only in relation to its environment. While the fact that a heuristic exploits already existing cognitive capacities makes it simple, its adaptation to the structure of the environment makes it clever (Gigerenzer, 2004: 64).

Heuristics are only rational or not relative to a certain environment. However, this is where their potential lies, as they can perform very well when used in a suitable environment (Gigerenzer, 2001: 5). To use heuristics well, it is important that the decision-maker is flexible and able to rethink the rules as the occasion demands (Sunstein, 2005: 2). The environment in which decision-makers find themselves and the influence of that environment on the choices made and the strategies used to make those decisions can often be underestimated. The degree to which the past can be applied to current situations depends on the extent to which the environment and the decision context are similar to the current one. To understand fast and frugal heuristics means understanding why they are ecologically adaptive (Forster, 1999: 562).

Out of the adaptive toolbox, the decision-maker is required to select a heuristic that is most applicable to the decision situation at hand. The trick to using heuristics is that even in situations where they may not appear to be rational, given the environment, using a heuristic might make most sense, making them ecologically rational. The ecological rationality of heuristics means that the more unpredictable a situation is, the more information needs to be ignored (Gigerenzer, 2008: 26). Most decisions that humans make lie on a continuum somewhere between being completely random, where previous information would be entirely ignored, to being completely deterministic, where systematic knowledge could be adhered to in order to be able to make a decision. The closer people are to the random end of the continuum, or the more unpredictable the situation, the more information needs to be ignored, as opposed to being taken into consideration.

The structure of the environment affects the choice of strategy used (Bröder in Hilbig, 2008: 1642). The use of heuristics is adaptable to the actual environments in which decision-makers find themselves, meaning that they can 'fit to reality' (Forster, 1999: 544). This decision-making strategy is contrasted to optimisation models that can be used in more general situations, as they follow a more classic logical rationality.

The notion of ecological rationality is convenient for fast and frugal heuristics, allowing them to be used in a more flexible way than optimisation models. Optimal strategies are often not known, and if they are, they may require unrealistic knowledge and there is little time (Gigerenzer, 2001: 2). It is assumed that human behaviour has evolved to be close to optimal in specific environments (Gigerenzer, 2001: 3). If heuristics have developed automatic and intuitive responses to problems in human environments, it could be argued that this is the optimal decision-making method for the human mind. Non-rational theories such as heuristics can exploit the structure of environments, so that some of the 'work' is done by the environment.

The environment in which decision-makers operate is not a fixed one. It is constantly created and framed by the decisions taken in it, by individuals and by other decision-makers in a particular environment. Because of its constantly changing nature, there is space to learn from the past and adapt the environment for future decisions to enable the more appropriate use of fast and frugal heuristics as a decision-making tool in organisations. The environment is structured continually by the decisions that are made, as individuals, as organisations, as countries. This shapes the environments of others, creating their frames and affecting the heuristics that they use to make decisions. How this environment is controlled or structured in such a way that certain heuristics are more likely to be used, or that decision-makers will see their realities or decision problems framed in a particular light depends on the actions of others.

The decision-making environment can be structured by controlling the information that is presented to decision-makers and the way in which it is framed. Though framing depends on the individual too, the organisational culture and the values of the organisation also play a role in determining the degree to which the use of heuristic decision-making is encouraged or not. Decision-makers need to know what the priorities of the organisation are and what the overall strategy is. This helps to create the culture and determines the kind of pressure felt by the decision-maker. It also gives an indication of the likely consequences of making errors, or the attitudes of management regarding learning and risk taking. Controlling the flow of information involves both how information is presented to senior management, as well as how much information and from what sources is presented to other organisational decision-makers.

In environments where ignorance is systematic, ignorance-based decision-making works well. For example, in competitive environments where the sequence in which the names of recognised objects are come across correspond with their performance, power, or size (Gigerenzer, 2001: 5). For the recognition heuristic to be effective, the organisation needs to ensure equal ignorance. For the take-the-best, certain factors need to be more prominent to ensure that certain cues preferred over others. A simple way of controlling these factors is to talk about them, to make clear the goals of the organisation, their priorities, make known names or ideas that are positive. In so doing, when the time comes for decision-makers to make a decision quickly using heuristics, there will be certain choices that are recognised or preferred. Another strategy to encourage heuristic decision-making would be to put decision-makers under time pressure for decisions. Where there is little time for decision-making, the use of heuristics is more likely, so pushing decision-makers for time can also be a strategy, or a way of structuring the decision environment.

Ecological rationality also considers the question of when not to use heuristics, when to avoid them so as not to make erroneous decisions. In environments where the cue preference is uniform, heuristics such as take-the-best would not do well. Similarly, where ignorance is not uniform, the use of the recognition heuristic should not be encouraged. In contexts where there is time for learning, especially where this is uneven, heuristics would not be an optimal strategy to employ. Seeing as fast and frugal heuristics take a less-is-more approach,

environments where decision-makers have a high degree of knowledge about various choice options, or time to learn about them, the use of heuristics will not be as successful as if not. Similarly, if decision-makers know absolutely nothing about either choice option and are indifferent between choices or cues, the use of heuristics will not show a great benefit. Decision-makers cannot know too much or too little if heuristics are to be successfully employed as a decision strategy.

The key to using fast and frugal heuristics as a decision tool in organisations is to try to structure the environment to match the cognitive structure of the decision-maker, enabling the appropriate use of the desired heuristic. The recognition heuristic performs well in environments where the biggest objects are talked about and will be recognised (Todd and Gigerenzer, 2007: 2). So, for example, if the recognition heuristic is desired, the environment should be structured such that the decision-maker is only presented with two choices. Provided the environment is competitive or decision-makers are systematically ignorant, this will encourage use of the recognition heuristic. Take-the-best will not do well compared to optimising techniques in contexts where distribution of cue importance is uniform (Todd and Gigerenzer, 2007: 3). If the take-the-best heuristic was desirable, the decision should be framed in such a way that cue that are unevenly distributed are selected for presentation to the decision-maker, so that the decision-maker would have distinct preferences and be more likely to use this heuristic than an optimisation technique. In such cases, take-the-best would perform better, especially in generalising to new decisions (Todd and Gigerenzer, 2007: 3).

Structuring the environment to encourage the use of particular heuristics first requires a good understanding of the heuristics and the way in which they work. In general, everyday decisions taken by most people, this would be difficult to do. However, an organisational environment is controlled to a certain extent, and this could be manipulated by management to frame the decision environment in such a way that encourages or discourages the use of heuristic decision-making. The key is to match the mental and environmental structures, and if the mental structure, or knowledge of the way a certain heuristic works, is known, then the environmental structure could be manipulated to match it. Having said this, it is important to note too that this is easier said than done. The environments in organisations do not just consist of a couple of people, but are large environments that are shaped by the decisions of people both within them and externally. This makes the environment more difficult to control, though it can definitely be structured to a certain degree.

In environments with “high variability, low predictability, and little opportunity for learning”, heuristics can be used to make good decisions (Todd and Gigerenzer, 2007: 3). Many organisations in the world today may fall into such an environmental category, where actions are fast-paced and there is little time for learning. Decisions need to be taken quickly in conditions that are uncertain. Human brains have evolved to become good at recognising patterns, which could arise from environmental processes that include physical, biological, social and cultural sources (Todd and Gigerenzer, 2007: 3). Decision-makers tend to search for resources that occur in patches or clusters and do best using rules that increase or decrease the tendency to stay in an area where each resource item is found, depending on whether clusters have widely varying or roughly equal numbers of resources (Todd and Gigerenzer,

2007: 4). When decision-makers then come across such resources, in an organisation for example, then they are likely to use heuristic rules that keep them there.

Probably most important for humans are structures found in and those that come from social environments (Todd and Gigerenzer, 2007: 4). Decision-makers base decisions on other people based on the pattern of people they have previously encountered (Todd and Gigerenzer, 2007: 4). The structure of the environment is also specifically created by cultures or institutions to influence the behaviour of others. This environment can be complimentary to decision-making or they may not fit well with people's decision mechanisms, instead causing confusion and poor decision-making (Todd and Gigerenzer, 2007: 4). Where choice attributes are distributed in a J-shape, where the gap between the preferences of the decision-maker is sudden and significant, as is seen in many areas where people make active choices, then this can be exploited by heuristics for choice or estimation (Todd and Gigerenzer, 2007: 4).

Due to the uncertainty in the environments in which decision-makers operate, robustness is needed in the decision strategies used. One of the best ways to be robust is simplicity, so the external uncertainty in the environment can impose a limitation of simplicity on the mental mechanisms that are used to make decisions (Todd and Gigerenzer, 2007: 199). The more time that is spent on decision-making, the less time there is for other activities, reducing the likelihood of organisations outdoing their competitors. Streamlining decision-making processes is therefore a good competitive advantage, and a worthy investment for organisational management. The environment thus further constrains decision-makers to be frugal and speedy in decision-making (Todd and Gigerenzer, 2007: 199). Further research is still needed into why a heuristic matches some environments and not others. The importance lies in matching mental and environmental structures to effectively use heuristics in decision-making.

### Optimisation models

More formal models of decision-making such as linear regression and Bayesian models aim at optimising decisions made (Gigerenzer & Goldstein, 1996: 5). An example of such a model is Weighted Additive Strategy (WADD)<sup>1</sup>, which uses all the relevant decision information, looking at weights and multiplying it by the value. Even though some of the calculations that may take place during such a process could happen unconsciously, optimisation models do not describe the actual decision-making process (Gigerenzer, 2004: 64). Such models are usually more focussed on the outcome of the decision than on the process itself. Heuristics provide an alternative. They are rules that aim to describe the actual cognitive process of decision-making as opposed to only the outcome. The heuristic itself can define what the end is (Gigerenzer, 2004: 65). Heuristics are used under the assumption of bounded rationality. Bounded rationality is the idea that the rationality of decision-makers is limited by cognitive constraints and the finite amount of time in which a decision is to be made. Rationality is limited by the amount of available information, and due to this lack of

---

<sup>1</sup> The WADD concept is known under different names (for example as SMART (Goodwin & Wright), MAU (French et al))

ability and resources, they are often unable to come to an optimal solution and instead, satisfice, settling for a satisfactory solution. Simon described it as the fact that “human rational behaviour is shaped by a scissors whose blades are the structure of task environments and the computational capabilities of the actor” (Simon, 1990: 7).

When information is scarce then heuristics will generally be advantageous compared to multiple regression and other statistical models that require large samples (Gigerenzer, 2004: 77). Heuristics do not try to find the best solution, or to optimise, but rather, they satisfice, settling for the first satisfactory solution that is found (based on an evaluation and categorisation of the environment) (Gigerenzer, 2008: 20). Models of heuristic cognition focus on situations in which people need to act fast, where there is uncertainty about probabilities or decision outcomes and where goals may be unclear (Gigerenzer, 2008: 22). Under such circumstances, logical and complete deliberate reasoning may not be the best tool to determine an optimal solution and heuristics may be used to make a decision.

Fast and frugal heuristics were formed on the basis of the structural relationship between the cues and judgement. They are simple models that do not search through all available information or integrate all the relevant information, but simply rely on one specific kind of cue to make a decision (Dhami and Harries, 2001: 6). By their definition, fast and frugal heuristics imply that decision-makers do not integrate all relevant information. They ignore part of the available or given information. Instead, they rely on substituting information for relevant cues, upon which decisions are based (Dhami and Harries, 2001: 6). In addition to the use of cues, many of these models are non-compensatory. This means that decision-makers use only one cue to discriminate between options. Non-compensatory models are less cognitively costly than compensatory ones, but also less accurate (Broder and Newell, 2008: 211). In the use of heuristics, cognitive information search may be random or ordered. It is limited by simple rules, for example, stopping once the first cue that discriminates between two alternatives (where choice is involved) is found. In ignoring part of the information given, more accurate judgements can arise than in the weighting and adding of all information (Gigerenzer and Gaissmaier, 2011: 451). This suggests that, in some situations, heuristics can be effectively used in reducing the cognitive load of a decision-maker to reach as accurate a decision as if all the information were to be taken into account in a statistical model.

Formal optimisation models of decision-making, such as linear regression or Bayesian models, help to identify the type of problem where more information and processing is beneficial and those where ignoring information will lead to success (Gigerenzer, 2008: 21). Decision-makers do not use heuristics only because of cognitive limitations. By studying only the mind, researchers can mistake the use of adaptive heuristics for a cognitive deficit (Gigerenzer, 2008: 22). The reasons for using heuristics lie in the nature of the problem that needs to be solved. Two of the reasons the mind uses heuristics are tractability and robustness (Gigerenzer, 2008: 22). Tractability refers to the fact that some problems are not able to be optimally solved by either the mind or a computer, or even if there is an optimal solution. Sometimes where there cannot be an optimal solution, it is easier and more accurate to use heuristics. Decision-makers have a need to know about the future and not only to rely on

hindsight to analyse the past, for example when planning strategy. The more difficult a criterion is to predict, the more irrelevant information there is to be ignored in past information (Gigerenzer, 2008: 22). The problem lies in determining which information to ignore. Heuristics that order cues by importance are a method of selecting which information to ignore.

The robustness of heuristics refers to the ability to make predictions about the future or unknown events (Gigerenzer, 2004: 64). This is contrasted to fitting, which refers to the ability to fit the past or already known data with current data. In judgments under uncertainty, one has to ignore some information in order to make good predictions.

A complex strategy 'overfits' relative to a simpler one if it is more accurate in fitting known data but less accurate in predicting new data (Gigerenzer, 2008: 22). Information about a decision has parts that are relevant and parts that can be ignored, known as noise. In decision-making, noise can often serve to complicate a decision and distract the decision-maker from what is really relevant. A heuristic that can reduce the chance of fitting noise is robust (Gigerenzer, 2008: 22). When information is ignored or forgotten, robustness can be improved (Gigerenzer, 2008: 22). The use of heuristics takes advantage of the capacities of decision-makers to find solutions for a problem that differs from a statistical method. Recognition is an example of a cognitive capacity that is exploited by the use of the recognition heuristic.

Heuristics should be robust and not overfit (Gigerenzer, 2001(a): 136). However, the strategy with the best fit is often the one that overfits the most (Gigerenzer, 2001(a): 136). This suggests that such a heuristic strategy is good for decision-making at the time, but not for the prediction of new data. However, this is to be expected, given the ecological rationality of a heuristic, it is unlikely that a strength of its use will be making predictions about the future. In research, there has been a tendency to blame the discrepancy between judgement and what a theory predicts on the human mind, as opposed to the model (Gigerenzer, 1991: 21). These differences are systematic and have become known as biases. Models of heuristics show bias whereas models with adjustable parameters show variance (Gigerenzer, 2001(a): 135). Cognitive biases have become associated with the use of heuristics, but due to their systematic nature, biases are able to be predicted and measures can be taken to lessen their effects (Tversky and Kahneman, 1979: 284). Despite this, they do still remain a limitation when making use of heuristic decision-making.

Though fast and frugal heuristics are based on the principle of ecological rationality, they can also be used in a way that is planned and more deliberate. When the strength of a heuristic is identified and matched to being compatible with a situation, the use of the heuristic can be planned. In this context, something would need to be known about the situation in which the heuristic will be applied. Therefore, in situations where nothing is known, there can be no planned use of heuristics. Another factor that makes fast and frugal heuristics not always possible to plan is the fact that they are intuitive. They are largely subconscious and automatic and in everyday use, decision-makers rarely use them consciously. However, there is also room for learning from heuristics and structuring the environment of the decision-

maker to enhance their use in appropriate environments. In this way, fast and frugal heuristics can be used as decision support systems, as planned techniques that can be used in helping to reduce information overload for decision-makers in an organisational environment.

It is difficult to understand exactly how heuristics work, as they cannot be tested by a machine and people's minds cannot be read (Forster, 1999: 548). There are many subjective and context specific factors that affect decision-making, making it hard to test thought processes in some kind of objective manner. They vary greatly, depending what cues are given attention by whom and when, and how alternatives are prioritised by decision-makers. Heuristics can be implemented because of the underlying cognitive capabilities that have evolved over many years of learning (Forster, 1999: 550). A heuristic can be successfully used because of the trade-off that results when they are used; that of generality versus specificity (Forster, 1999: 558). The criteria that measure the performance of a heuristic in the real world require more domain-specific solutions than where general logic would be able to be applied (Gigerenzer and Todd, 2000: 18). This is where the strength of using heuristics lies, in the ability to be applied to different situations in different ways, using different strategies, as the decision requires and the environment allows.

#### 4.2.2 The most common fast and frugal heuristics

The set of heuristics available to decision-makers is known as the 'adaptive toolbox'. Like a toolbox of a handyman contains many tools that can be used in different situations, the adaptive toolbox contains a set of heuristics, each being able to be used in different situations and allowing the decision-maker to adapt their strategy according to the context. The use of different strategies depend both on individual factors, such as experience, and on the characteristics of the environment, for example, the ambiguity of information (Andersson, Ekman and Edman, 2003).

When focussing on fast and frugal heuristics in particular, there are two that are most common in the adaptive toolbox. 'Take-the-best' and 'recognition' heuristics are both fast and frugal and are recognised as being used by decision-makers to simplify and speed up information processing and decision-making (Goldstein and Gigerenzer, 1996). The 'take-the-last' and 'minimalist' heuristics are also fast and frugal, but not as widely recognised and researched. These heuristics are based on the more fundamental recognition heuristic. When assessing probabilities of events or making predictions, people rely on heuristic principles that reduce such complex tasks (Gigerenzer, 1991: 2). These help to make judgement tasks simpler.

The recognition principle is ignorance-based, taking a less-is-more approach to decision-making. The less that is known about a decision option, the more the decision-maker has to gain from using the heuristic. It is useful when a criterion is strongly recognised. When paired comparisons of criterion are being made, the recognition principle instructs the decision-maker to select the one that is recognised (Hilbig, 2008: 1641). The recognition principle is a one-reason, non-compensatory strategy, where search is stopped if one object is recognised (Hilbig, 2008: 1642). It can be defined in the following way: "If one of two

objects is recognised and the other is not, then infer that the recognised object has the higher value with respect to the criterion” (Gigerenzer, 2004: 68).

Only a decision-maker who has heard of some but not all of the objects can successfully use the recognition principle. Because the decision is based on recognition alone, this decision strategy will not be successful if none or all of the options are recognised. It relies on partial ignorance of the decision-maker. The recognition principle is the foundation of the take-the-best heuristic, of which the take-the-last and minimalist heuristics are derivations. With the take-the-best heuristic, if recognition alone cannot decide an issue, then features are considered individually, in order, from the feature that is most diagnostic of the attribute to that which is least diagnostic (Chater, Oaksford, Nakisa and Redington, 2003: 64). As soon as a feature is found on which the alternatives differ, that feature is used to make the decision, meaning that only a single feature is used to make the decision.

The recognition principle is the simplest and the fastest way of taking advantage of the decision-maker’s ignorance or limited knowledge (Andersson, Ekman and Edman, 2003: 5). However, one downside of this principle is that it is not universally applicable (Goldstein & Gigerenzer, 2002: 76). The functioning of this principle is based on the assumption that decision-makers either recognise an object or they don’t. There is no need for further knowledge of the object, a situation so simplistic that it may not often be found in an organisational environment.

The take-the-best heuristic involves searching through cues in the order of their validity. The value of the cue that is most valid is looked at first. If one object has a positive cue value and the other does not, then search is stopped. If not, then this cue is excluded and search begins again. If no more cues are found, then the decision-maker should engage in guessing (Gigerenzer, 2004: 74). The decision-maker should assume that the object with the positive cue value has a higher value on the criterion. This is to say that if a cue is present for one object, then that object should be deemed more valuable than another object for which that cue is not present.

Brighton showed that the take-the-best heuristic is often more accurate and frugal than are complex nonlinear algorithms, for example neural networks, exemplar models, and classification and regression trees (Brighton, 1996 in Gigerenzer, 2008: 26). Take-the-best is frugal because it makes use of only one feature upon which to base its decision. It is fast because it does not search through and integrate information about other alternatives, only the most important. In this way, it is non-compensatory. The heuristic consists of the search rule, the stopping rule and the decision rule (Newell, Weston and Shanks, 2003: 83). The decision-maker searches cues in order of validity, beginning with the most valid. Search ceases when the first discriminating cue is found and then a decision is taken when the decision-maker chooses the outcome pointed to by this cue.

Algorithms that don’t exploit the recognition heuristic where recognition is strongly correlated with the target variable make a considerable number of wrong inferences (Goldstein and Gigerenzer, 1996: 19). This demonstrates the importance of matching the

heuristic to the appropriate type of information to get the greatest benefit from its use. Take-the-best can perform as well as or better than the decision algorithms that take all information into account (Goldstein and Gigerenzer, 1996: 9).

Other strategies that may be considered fast and frugal include guessing and do-what-the-majority-do heuristic, amongst others. The do-what-the-majority-do heuristic states that a decision-maker should follow the same behaviour as the majority of his peers. It is frugal in the sense that the decision-maker does not even consider the consequences of the decision, but simply ‘jumps on board’. This heuristic works in environments where both the observer and the demonstrators of the behaviour are in a similar environment that is stable and noisy, in the sense that the outcome of actions is unclear (Gigerenzer, 2004: 73).

Fast and frugal heuristics have a wide series of circumstances in which they can be applied, depending on their ecological rationality, and organisational decision-making is one of these areas. Heuristics have been used to simplify decision-making in organisation, providing solutions that may use less time and information than other models of decision-making.

#### 4.3 How heuristics are applied in an organisational context

Heuristics are efficient because they enable people to quickly arrive at what are, frequently, accurate conclusions. This results despite constraints in the information processing capacities, limited knowledge and ambiguous environments faced by decision-makers (Andersson, Ekman and Edman, 2003: 4). The accuracy and success of heuristics should be evaluated with respect to their fit with the structure of the task environment rather than by how rational they may appear to be (Andersson, Ekman and Edman, 2003: 4).

##### Individual differences in personality

An individual is more likely to use system 1 than system 2 when the cognitive load is high and time is short (Payne and Bettman, 2004: 113). Such a case would be in organisations, where decision-makers may experience time pressure and a high information load. A heuristic decision strategy would likely decrease the chances of information overload in this context. Theoretically, when looking at these conditions, organisational decision-making would be ideal for the use of heuristics. However, there are external factors that influence decision-making in organisations. The social context of decision-making that often occurs in groups in organisations necessitates that there is some kind of shared meaning or understanding before a decision is made. This often requires that the thought process and logic behind a perspective is explained and that decisions are rationalised before being made.

These external factors can increase the cost, in time, money or effort, in accessing and acquiring information. The cost of acquiring information, like cognitive or emotional cost, may lead to greater simplification mechanisms that minimise information processing (Payne and Bettman, 2004: 113). It may also affect the order in which it is processed or whether it is processed at all (Payne and Bettman, 2004: 113). According to Simon (1956: 137), decision-makers only need a “simple perceptual and choice mechanism” to make decisions, and not elaborate procedures. The mind and the environment need to be matched to make effective

decisions, suggesting that real-world decisions are made using fast and frugal heuristics that satisfice. Such cognitive rules of thumb need to be codified, so as to help people to apply them to situations to which they are well suited and in order to help people to know which situations not to use them in, to avoid potential errors (Rachlin, 2003: 409). Real-world decisions take into account environmental constraints, as well as the constraints imposed by the thinking process itself. The brain cannot perform a large number of calculations in a short time in addition to the information acquired by the decision-maker (Rachlin, 2003: 410). It has been assumed that people first determine the level of satisfaction expected from a decision and then select a heuristic to deal with it based on past experience with a similar type of problem (Rachlin, 2003: 410). Heuristics and rules are the relations made cognitively between decision-makers' behaviour and their environment (Rachlin, 2003: 10).

Heuristics, though economical and usually effective, can also lead to systematic and predictable errors (Kleinmuntz, 1990: 298; Tversky and Kahneman, 1979). These errors are known as cognitive biases, and are associated with the use of heuristics. Heuristic processing styles can become so habitual or automatic that they will be applied even in situations where it would be preferable to use more formal or optimal procedures and where the use of heuristics could lead to serious biases (Bruggen, Smidts and Wierenga, 1998: 647). One such bias that is especially common in the management of organisations is known as overconfidence.

Overconfidence is when a decision-maker's confidence in his or her judgements is greater than their accuracy. In an experiment testing the knowledge of subjects in a certain area, the more knowledgeable subjects were, the less likely they were to use the decision rule given, which resulted in inferior performance. As Lin and Bier (2008) found, overconfidence among experts is not an uncommon bias. In organisations, overconfidence could be a common bias, where, due to experience and expertise in an area, management and other top decision-makers display more confidence in their decisions than their accuracy reflects. Particularly under conditions of uncertainty, this could be common bias. Warning subjects of the counter-productive results of abandoning the use of a decision rule caused the subjects to overcome the usually harmful effects of outcome feedback in a task involving probabilities (Arkes, Dawes and Christensen, 1986: 107). Those with expertise were less likely to use a decision rule than those with less expertise. This could suggest the presence of the overconfidence bias amongst these experts. Incentives for good performance actually resulted in poorer performance, as decision-makers were more likely to abandon the decision rule (Arkes, Dawes and Christensen, 1986: 107). This has potentially important applications for organisational decision-making.

### System 1 and system 2

Fast and frugal heuristics fall under what Kahneman and Tversky call system 1 thinking (Kahneman, 2011: 21). This type of type of thinking, though advantageous in many situations, and a great assistance in daily decision-making, can also prove to be a hindrance to decision-making. System 1 is very automatic, and not easy to be 'educated' or trained (Payne and Bettman, 2004: 125). In organisations, this means that it is difficult to use this type of

heuristic decision-making selectively, or apply it only to certain decision problems. It is when decisions need to be made quickly and require this type of thinking that one does not have the time to stop and think about consequent biases or cognitive errors that may result. System 1 also uses less energy and effort than system 2, which is a more deliberate, rationalised, slower type of thinking (Payne and Bettman, 2004: 125). In circumstances requiring system 2 thinking, system 1 is likely to be used as the default when the decision-maker is tired (Payne and Bettman, 2004: 128). Under conditions of information overload, the likelihood of the decision-maker being cognitively tired and lazy, and thereby resorting to system 1, is higher. When decisions are needed under time pressure such as in many organisational contexts, it may be the case that system 2 cannot keep up with system 1, and decisions are not able to be considered and rationalised at the time, but rather the decision-maker may act on system 1 and try to rationalise the behaviour afterwards. This links to the idea of Kahneman's that the remembering self oppresses the experiencing self, with the memory of the way a situation ended, playing a more significant role in future decision-making than the actual experience of the decision-maker during a situation (Kahneman and Riis, 2005). This could be dangerous in an organisational context. For example, where a previous situation, similar or not, ended well, decision-makers could be subject to the overconfidence bias. The way in which decisions are framed is key in determining the extent to which decision-makers may be susceptible to biases, for example, loss aversion. System 1 reacts to what confronts it in different contexts, making it especially susceptible to influence from the surroundings of the decision-maker and to biases (Kahneman, 2011: 22). This enables it to be influenced in an organisational context.

Though system 1 is more susceptible to biases in decision-making, it is less likely to make the same predictable errors (biases) when dealing with things (as opposed to symbols) or raw data (as opposed to percentages) (Holt, 2011). This has important implications for organisational decision-making, particularly with regard to the use of visualisations in organisations. Visualisations tend to turn situations and objects into symbols and raw data into percentages that are then able to be represented in a comparable way. In so doing, visualisations are actually increasing the susceptibility of decision-makers to biases in their decision-making, making them more prone to errors than they might otherwise be if left to process data. On the other hand, processing the raw data without visualisations is often not possible given the time requirements and the volume to be processed, and these pressures would result in the decision-maker resorting to system 1 decision-making in any case.

#### Likelihood of heuristic use

In situations where there is a lot at stake (such as a financial reward in the above study), for example the resources of a large organisation or a decision outcome that will implicate a number of people, then decision rules are abandoned. Decision-makers under such circumstances may prefer either to look at figures that data provides or to go with their gut or what other people say is rational, as opposed to what they know is a rule that produces more successful results. If such a decision rule cannot easily be justified according to classical rationality (or appears counter-rational in a particular circumstance) when there is a potentially large reward or loss, then it is not used, despite the knowledge of the potential that

an inferior decision will be made. When testing for the overconfidence bias, when confusion between single events and those that occur more frequently is clarified, the bias disappears (Gigerenzer, 1991: 6). This suggests that a clear understanding of the task situation will help to prevent against this bias.

In a study done by Andersson, Ekman and Edman (2003), heuristics were found to be used successfully in forecasting. As organisational decision-making may often involve decision-making about the future or events that have not yet happened, such decision-making may be useful in this context. The recognition heuristic was the strategy used in forecasting worldwide soccer events. The participants with limited knowledge were able to produce slightly better results than were the experts. It has been suggested that this is due to the fact that experts may suffer from the overconfidence bias (Andersson, Ekman and Edman, 2003: 4). No other strategy that was explicitly used achieved higher results.

Astebro and Elhedhli (2006: 396) found that experts appear to use heuristics differently to lay people and may have a higher forecasting accuracy, as they have a tendency to utilise information better and not be influenced by irrelevant information. While this may be so, the likelihood of biases such as the overconfidence bias to be found in such decision-makers is higher than among lay people. Though both groups of people suffer from judgemental biases, lay people may be more easily distracted by irrelevant information, and they may be less discerning in their use of available data (Ben-Shakhar, 1998 in Astebro and Elhedhli, 2006: 396).

Emotions can also act as guides for exploring and stopping search, affecting how likely heuristics are to be used, and how and when they are used (Gigerenzer, 2001: 7). Other personality traits that affect and are affected by emotion also have an impact on decision-making. People who satisfice are generally more optimistic and have higher self-esteem and life satisfaction. As heuristics are satisficing strategies to decision-making, this suggests that the personality traits above are likely to be found in the type of people that use heuristics. Alternatively, those who seek to maximise, or optimise, their decisions are more susceptible to depression, perfectionism, regret, and self-blame (Schwartz et al, 2002 in Gigerenzer, 2004: 80).

There are two responses to emotion-laden tasks. Problem-focussed coping tries to maximise accuracy and emotion-focussed coping can show avoidant behaviours, such as passing off decision-making to others or deciding on the status quo so as to more easily justify decisions to others (Payne and Bettman, 2004: 124). In an organisational context, there is likely to be some kind of trade-off made, as decision-makers will desire the accuracy from an emotion-focussed coping strategy, while at the same time, the emotion-focussed strategy will play a role too, given the social nature of decision-making here. One effect of the emotion-focussed strategy is where individuals may cope with decisions by avoiding trade-offs and adopting non-compensatory strategies such lexicographic heuristics (Payne and Bettman, 2004: 124). Where there are a large number of alternatives, heuristics are able to be used for the elimination of options. Because of the ecological rationality of heuristics and the changing nature of environments, it is not possible to predict a generalised context for the successful

use of a heuristic. However, the systematic study of fast and frugal heuristics does allow for recommendations to be made (Gigerenzer, 2004: 83).

The individual differences in decision-makers have an impact on whether they are likely to use heuristics as a decision-making strategy in the first place, and further, how they use them (Bröder and Newell, 2008: 208). When experiments were conducted on the processing capacity of decision-makers, it was not found to be linked consistently to preferences for particular strategies (Bröder and Newell, 2008: 208). No evidence thus far has found a correlation between the personality of a decision-maker and their preference for certain strategies (Bröder and Newell, 2008: 208). Those decision-makers that show signs of neuroticism are more likely to use a heuristic such as the recognition heuristic, as they are less trusting of their own knowledge about an option (Hilbig, 2008: 1642). Instead of trusting their own logic and rationality then, they may decide to rather make use of a cognitive rule and employ heuristics. They may also not be able to access the knowledge they have, thus leaving them with little choice but to apply the recognition heuristic (Hilbig, 2008: 1642). The less susceptible decision-makers are to neuroticism, the less likely they are to adhere to the recognition heuristic. In an organisational context, the majority of managers may be more likely to exhibit confidence in their decision-making than neuroticism, as experience and education will provide assurance in their decision-making. This would suggest that such managers at top levels in organisations would be less likely to use the recognition heuristic than other decision-makers who are perhaps not in positions of management.

Managers who work in large organisations have been described as being risk averse and more predictable and professional in the way they make decisions (Busenitz and Barney, 1997: 10). Heuristics can be used to refer to simplifying strategies that individuals use to make decisions, especially under conditions that are uncertain and complex (Busenitz and Barney, 1997: 12). Most decision-makers apply heuristics to their decision-making most of the time, although the degree to which individuals are subject to using them varies (Busenitz and Barney, 1997: 13).

The Busenitz and Barney study on the use of heuristics in strategic decisions made by entrepreneurs and managers in an organisational context found that heuristics could be used to explain variations in the strategic decisions of these different types of decision-makers (1997: 13). Managers usually have less uncertainty than do entrepreneurs in the conditions under which they have to make decisions. Entrepreneurs are more likely to use heuristics (and be subject to biases) than other more cautious decision-makers (Busenitz and Barney, 1997: 14). It can be argued that heuristics are applied unconsciously. Those decision-makers who are not comfortable with using them will be naturally attracted to larger organisations where they are not used as frequently in decision-making as by entrepreneurs. Such differences could explain why some entrepreneurs can make bad managers. The types of decision made in each context may be similar, but the conditions around the decision (such as levels of uncertainty, available data from the past, time pressure, other actors involved etc) are very different. This attracts different types of personalities and decision-making styles to each type of decision-making position and perpetuates the types of decisions, tools and strategies used in decision-making in these different contexts.

Apart from attracting different styles of decision-makers, the use of heuristics may be more accepted and even encouraged in larger organisations, where the entrepreneur who began them are still in charge of or influential in the management structure, than in large multi-national corporations or in smaller organisations. Larger multinationals are more likely to be more hierarchical, following a formulaic method to management that can be applied to all offices. Entrepreneurs are more likely to use heuristics in decision-making and the extent to which the presence of such decision-making remains within an organisation is dependent on the management structure that is put in place, but is more likely to remain than in an organisation that becomes multi-national. Similarly, the age and growth profile of an organisation may impact the extent to which fast and frugal heuristics are applied or encouraged in decision-making. For example, in large companies that keep management centralised, where the founder is either still closely involved with or was very influential in in the management of these organisations, and the company has become expanded greatly, the use of fast and frugal heuristics is more likely to be used or encouraged than in a large company that is much older and has steadily expanded over decades, with different managers having been in charge, but not significantly shaping the structure of the organisation. This is a generalisation for two types of larger organisations, and there are those that have set out to grow with a very specific and rigorous management structure from the beginning. However, for those that begin with entrepreneurs open to the idea of using fast and frugal heuristics in decision-making, the question of the extent to which that remains in the organisation, as long as or longer than the original entrepreneurs, is an area for future research.

### Heuristics in management

Psychological heuristics are models for making decisions that rely heavily on core human capacities, that do not necessarily use all available information (information that is used is processed by simple computations) and are easy to understand, apply, and explain (Katsikopoulos, 2010: 3). The way in which Katsikopoulos (2010: 3) defines heuristics above shares some, but not all of, the properties of Gigerenzer's fast and frugal heuristics (Goldstein & Gigerenzer, 2002: 75). Lexicographic heuristics function by retrieving attribute values one at a time from the decision-maker's memory, relying on peoples' capacity for recall. These heuristics can also be applied to categorisation, a type of judgement problem. It has been argued that simple heuristics such as fast and frugal decision trees (that have a lexicographic nature) can make decision processes more transparent and easier to understand and communicate to others (Katsikopoulos, 2010: 5). In an organisational or group environment, this might be an advantage in helping to create a shared understanding. Forecasting involves inferring the value of an object. Where inferences need to be made about the future, then heuristics have a superior performance to optimisation models (Katsikopoulos, 2010: 16). In conditions of uncertainty where judgements about the future need to be made, the use of heuristics can be a reliable tool for decision-makers. In business, or an organisational environment, this would be common in making decisions regarding pricing, output volumes and strategic planning for the future of the organisation.

In an organisational environment, decisions may frequently involve a choice between two or more options, but the likelihood of the decision-maker recognising and knowing something

about each option is relatively high, making heuristics such as take-the-best that apply the recognition principle the unlikely deliberate choice of decision-makers in such a context. However, it can be applied in other areas of business and even used as a distinct strategy. An experiment was conducted testing the recognition of brand names (Gigerenzer, 2001(a)). Some organisations, such as Benetton, have used such a strategy in the successful marketing of their brand, pushing the name of the brand to be recognised, as opposed to the product itself (Gigerenzer, 2001(a): 125).

The fact that a less-is-more approach is required with the recognition principle could have positive implications for management in organisations. Used as a decision-making tool for senior managers needing to make decisions in an organisation about areas of their business that they do not have a detailed knowledge of, this heuristic could assist in the choices that they make. Group members seem to intuitively trust the recognition heuristic, which can improve decision accuracy (Gigerenzer, 2004: 72).

In groups, decision-makers may use the majority rule and other heuristics to make decisions about people as potential employees (Todd and Gigerenzer, 2007: 4). Heuristics used by decision-makers in a group environment can be an efficient decision-making tool, while also resulting in biases such as groupthink. Recognition knowledge can be gained through social exchange and the recognition patterns can then be given prominence in group decision-making (Reimer & Katsikopoulos, 2004 in Todd and Gigerenzer, 2007: 4).

There are a number of positive implications of the less-is-more approach for management. Of course, this comes with limitations too, and it is up to the decision-makers or the organisation involved to weigh these up against one another. The less-is-more approach makes the technique more adaptable, as it does not require situations with full or complete knowledge in order to be successfully used. For management, this means that they may be able to take decisions about the future when certain elements are uncertain. This also means that internally, if there are issues or departments about which management does not have full knowledge, they are still able to take decisions based on the limited amount that they do know or that is presented to them. This can save time, but may result in a poorer quality decision; sometimes more context is needed for a good decision to be taken. It could also be argued, however, that knowing more, that knowing the context and all the additional information that is not given could bias a decision-maker. Managers with no detailed knowledge are better able to take a quick, heuristic-based, decision founded on what they see without being biased by contextual issues, or additional knowledge about what was not given.

The less-is-more approach also makes efficient use of time for decision-makers. Time is a scarce resource in organisations, particularly for management. Time that is not spent on making decisions can be more effectively spent on other work that is needed for it to do well. Thus, the use of heuristics to speed up organisational decision-making can be seen as a competitive advantage too.

Critics of the less-is-more approach in organisational decision-making might argue that management would be making decisions that are ignorant and unjustifiable. In this way,

management by exception is not positive, as attention is only drawn to what is presented to the decision-makers at management level and other issues are not dealt with. By providing only enough information for fast and frugal heuristics to be used successfully, the question of what has been excluded arises. The choice of what this included information is subjective and the bare minimum may not suffice, with informed decisions based on as much information as possible being a better option. There needs to be an awareness of what is not being considered and though the less-is more approach can be useful for managers in facilitating quick and 'easy' decisions, this comes at a price which each decision-maker needs to decide whether or not to pay.

The fact that certain heuristics can only be successfully used in certain domains has some implications for management when advocating the use of fast and frugal heuristics in organisations. The domain specificity limits the use of heuristics and means that they cannot be applied universally, as a general rule. They may not even be able to be applied across all offices in an organisation, if the offices are spread out globally; this depends partly on how uniform the organisational culture is. The use of heuristics is more likely to be encouraged in flatter management structures that are open to learning and risk-taking and each decision-maker taking some responsibility for their choices, but this environment is not as easily controlled. Thus, the planned and structured use of heuristics may do better in such an organisational environment; one that is more controlled.

Gigerenzer would argue that domain specificity enables fast and frugal heuristics to be flexible, able to be applied to all kinds of situations and used with different styles of management. The adaptability of heuristics means that it can be used in both a structured environment, in a planned manner, or just encouraged to be used more freely, on an ad hoc basis by decision-makers. Management would benefit from the use of heuristic decision-making in the time that it saves, both for managers and for the rest of the organisation, freeing up the time of decision-makers to increase productivity in other areas, allowing growth. Management should trust the judgement of the human capital in which they have invested to use heuristics appropriately in decision-making.

On the other hand, critics of this approach would argue that in order to use heuristics in an organisation as a specific decision-making strategy, a carefully controlled environment is required in order to structure it in a way that is to be compatible with the heuristics being used. Such an environment is not feasible in reality, as there are too many outside influences and factors beyond the control of management that could result in suboptimal use of heuristics and consequently poor decisions being made. It is easier, more reliable and the results are more easily able to be generalised when data is input into optimisation models, with less of a risk being taken and therefore easier to account for the decisions. Thus, organisations for which numbers, facts and statistics about productivity are important are more likely to use optimisation methods, while those that are not as bound by figures may find space for the use of fast and frugal heuristics. Due to the general agreement that they are intuitive and unplanned, heuristics are more likely to be used in an organisation that allows for some freedom among decision-makers, but that will also influence the environment in subtle ways to encourage or discourage the use of particular heuristics.

### Social nature of context

Not only does the nature of the decision problem and the way in which it is presented influence decision-making in organisations, but the type of organisation and the organisational culture are other factors that need to be taken into account when looking at decision-making processes. In addition to this, the demographic characteristics of CEOs (for example, their work experience or their education) influences the methods they use in strategic decision-making (Papadakis, Lioukas and Chambers, 1998: 117). The type of ownership or control of an organisation also has a significant impact on several aspects of strategic decision-making processes (Papadakis, Lioukas and Chambers, 1998: 119).

Not only can the decision strategies that are used be designed, but one can also design organisational environments. In organisations, managers can design environments that are more or less likely to lead decision-makers to use certain heuristics. For example, this could be done through the way that the organisation is structured and the organisational culture that is created. This could have an effect on group decision-making too, with the likelihood of heuristics being used lower in groups, as thoughts are rationalised and explained before decisions are made. Heuristics are tools that have been customised to solve diverse problems, finding solutions that are different from the strategies that logic may provide.

The concept of structural isomorphs suggests that if two problems have different contents, but the same structure, then judgments should be the same (Gigerenzer, 1991: 20). However, though the structure of the problems may be the same, the context in which they occur may be very different, resulting in the unsuitability of the use of the same judgement. Because judgement under uncertainty, and indeed much of organisational decision-making, occurs in a social environment, there are other factors that influence the decisions that are made. The presence of other people can make a decision seem more or less rational. For example, decisions that are looked at in isolation may be seen as irrational, but when taking into consideration the social context of the decision, this behaviour looks different and is understood as being more rational (Gigerenzer, 1991: 21). Human judgment and decision-making is domain specific and not guided by general logic that is applicable in all situations. In an organisational context, people share knowledge and decisions taken. In the process of sharing information, a process that is allowed by certain types of knowledge structures being in place, the internal cognitive representations held by a decision-maker can be shaped. In such a way, sharing imposes constraints on information processing and judgment (Freyd, 1983 in Gigerenzer, 1991: 21). There is, however, a lack of connection between research on group decision-making and social cognition that focuses on individuals (Gigerenzer, 1991: 21). This has resulted in a lack of research that applies individual cognitive processes for decision-making to group situations, for example those found in organisations.

Predictions about the behaviour of decision-makers can be made based on knowledge of the decision-maker's environment (Simon, 1979: 496). In many organisations, decision-makers are more likely to satisfice than to optimise. Managers create organisational slack, a 'cushion' of actual or potential resources, so that it is not performing at its maximum potential, serving as a buffer between decisions made and the environment outside of the organisation.

There has been evidence of fast and frugal heuristics used in organisational and other decision-making effectively, but the degree to which this method should be used as opposed to optimisation models, and how effective such heuristics may be, is disputed.

#### 4.4 Core issues

In the literature on heuristics and their use, there has been discussion over some contentious issues. The core issue in this field appears to be the value of using heuristics in everyday life. There is an argument that the test conditions under which heuristics have been explored are not able to be generalised to reality and that optimisation models are in fact a more accurate and reliable strategy for decision-making under uncertainty. Some of these arguments are further explored to uncover the controversies.

##### Decision-making in reality: Optimisation vs heuristics

Research conducted by Newell, Weston and Shanks (2003) looks not at how plausible the take-the-best heuristic is, but rather, how well it fits in describing everyday activity and decision-making the way it actually happens. The way that decisions are managed needs to take into consideration the importance of the trade-off that happens between accuracy and frugality when decisions are made using heuristics (Newell, Weston and Shanks, 2003: 82). With less information being used, some degree of accuracy is foregone, as not every detail is included in the process of decision-making.

It has been found that heuristics perform well in problems of inference such as judgment, forecasting and categorisation (Katsikopoulos, 2010: 2). When applied in business, heuristics have performed competitively, to such an extent that it may even be desirable to instruct decision-makers in a professional environment to make use of heuristics under the appropriate conditions (Astebro and Elhedhli, 2006: 395). Studies by Gigerenzer and Todd (1999: 22) have shown that in comparison to standard strategies used in decision-making, heuristics can be fast, more frugal and more accurate. However, if the environment is very linear and predictable, optimisation models may perform better (Katsikopoulos, 2010: 18). The key is to identify the situations in which each model will perform best. This suggests that in the right environment in an organisation, the use of heuristic strategies may simplify and speed up decision-making, while still allowing good decisions to be taken.

Decision-makers use simple rules and focus on a subset of cues, as opposed to everything that might be available to them (Astebro and Elhedhli, 2006: 400). Because it does not consider a selected set of cues, it has been argued that the take-the-best (and the recognition) heuristic is not as effective at prediction as those that do consider such a set of cues (Astebro and Elhedhli, 2006: 405). Tversky and Kahneman make a similar argument, that although most people use heuristics to simplify decision-making, they actually cause decision-makers to make sub-optimal decisions (Tversky and Kahneman, 1979 in Astebro and Elhedhli, 2006: 395). While this is true, it is recognised that decisions made using heuristics may be sub-optimal, as they are tools for satisficing and not for optimising. Gigerenzer and Goldstein (1996: 30) argue that heuristics might provide fast and reasonably accurate decision-making. Despite the contrast in these two opinions on heuristics, they are not mutually exclusive.

Heuristics are not claimed to be optimising solutions, but they have been proved that, when used in suitable environments, they can provide both fast and accurate decision-making, using relatively little information.

An optimisation model that can be used to make a decision involves the computation of the minimum or maximum of a mathematical function that incorporates all available information about the decision problem (Katsikopoulos, 2010: 6). Such functions include Bayesian and linear decision-making models. Tallying is a decision strategy that lies between heuristics and optimisation. There have been three main findings of computer simulation studies that compare the accuracy of lexicographic heuristics and tallying with that of optimisation tools. Firstly, the accuracy of lexicographic heuristics, linear models and simple Bayesian models is not that different. Second, the accuracy of heuristics is surprisingly competitive with the optimisation models, particularly for prediction, proving that they could be a viable alternative if used appropriately. Finally, all models can achieve relatively superior and inferior performance (Katsikopoulos, 2010: 10). This shows that only under certain circumstances will heuristics perform well, or better than optimisation models. It is not a rule that they will do so under all conditions all of the time. When the size of the data selection was relatively small, the fast and frugal decision tree tended to do best, whereas when the set was larger, the optimisation methods tended to do best. Take-the-best (and in some cases tallying) also had higher predictive accuracy than simple Bayesian models when there was not much information available (Katsikopoulos, 2010: 10). Scarce information tends to favour the use of heuristics, resulting in greater accuracy in prediction than optimisation models. However, the opposite tends to be true under conditions of high levels of information (Katsikopoulos, 2010: 16).

In studies relating to judgement, Dhimi and Harries (2001: 5) showed that on average, the fast and frugal model and the regression model fitted the data equally well. Results that were published later by Gigerenzer et al. compared the fit of both models on a new set of data and this time found that the fast and frugal model provided a better fit to the data than the regression model (Gigerenzer et al, 1998 in Dhimi and Harries, 2001: 11). There have been methodological concerns with the studies of fast and frugal models (Dhimi and Harries, 2001: 12). The more complex a decision is, the higher the likelihood is that a decision-maker will search for more information (Dhimi and Harries, 2001: 21). This flexibility suggests that fast and frugal models are more psychologically plausible than the regression model (Dhimi and Harries, 2001: 21). When decision-makers are under time pressure, stress or increased information load, judgement may shift between compensatory and non-compensatory decision-making (Maule & Svenson, 1993 in Dhimi and Harries, 2001: 21). However, when under time pressure, decision-makers do not use all of the relevant information. This suggests that under conditions of time pressure, decision-makers may be more likely to use heuristics than under other circumstances where time is not a concern. Due to the time constraints of many decision-makers in an organisational context today, heuristics may be used frequently, whether consciously or not.

Though time constraints affect the use of heuristics, there are no concrete rules about when heuristics are used. Gigerenzer's adaptive toolbox implies that the environment determines

which heuristics are used. However, the fact that there is no evidence of any circumstances in which a particular heuristic, such as take-the-best, is universally employed seems to be problematic for the fast-and-frugal approach (Newell, Weston and Shanks, 2003: 84). Decision-makers struggle to place their faith in a rule unless they have evidence that prior situations show some uniformity in the environment (Forster, 1999: 555). If one cannot predict which heuristics will be used in which environments, then determining the heuristic that will be selected for a particular environment is done retrospectively and the fast-and-frugal approach looks in danger of becoming ‘unfalsifiable’, removing the possibility for it to be contradicted (Newell, Weston and Shanks, 2003: 84).

### Heuristics and context

The recognition heuristic claims that inferences are made based on whether an option is recognised or not, and that all other available cues are ignored (Pachur, Bröder and Marewski, 2008: 183). However, the presence of additional cue knowledge can have an effect on decision-making (Pachur, Bröder and Marewski, 2008: 183). Not everyone is as strong as experts in being able to focus on the ‘right’ cues and ignore the ‘wrong’ ones. With efforts focussed on trying to decide which cues to ignore and which not to, it is important not to increase cognitive processing so much so that the benefit of reduced load from using the heuristic is lost. The recognition principle is more likely to be a tool for exploiting recognition naturally when inferences have to be made from memory rather than from an external source. There are strong differences in the way that different people use recognition. For an inference, the heuristic may be affected by whether additional cue knowledge has been learned outside or within the experimental setting (Pachur, Bröder and Marewski, 2008: 183). Even when the recognition cue is not recognised as being the most valid and may even be contradicted by additional and relevant cue knowledge, there appears to be a strong reliance on recognition (Pachur, Bröder and Marewski, 2008: 183).

Large amounts of contradictory evidence are necessary to override the impact of the recognition heuristic, suggesting that it is a relatively robust heuristic. It has been suggested that the effect of additional knowledge is stronger in tests involving induced recognition and additional cue knowledge that have been taught in the experiment than in tests involving natural recognition and knowledge that already existed in the decision-makers’ cognition (Bröder and Eichler, 2006). Recognition is an effect that dominates over other cues. Only one of the two ways in which such a dominant effect would come about is consistent with Goldstein and Gigerenzer’s (2002) description of the recognition heuristic (Pachur, Bröder and Marewski, 2008: 205). Either additional cue knowledge could fail to compensate for recognised information if no other cues are retrieved, or, recognition could be the only determinant of the judgment because it is so heavily weighted (Pachur, Bröder and Marewski, 2008: 205). This may be because people can assess an object’s value on the recognition cue with more confidence than its value on other cues (Pachur, Bröder and Marewski, 2008: 205).

It is widely believed that compensatory strategies are cognitively more costly than non-compensatory strategies (Bröder and Newell, 2008: 211). They are also believed to be more accurate. However, the higher accuracy has been questioned by proponents of the concept of

the adaptive toolbox, who have showed that non-compensatory rules can be just as accurate as compensatory ones (Goldstein and Gigerenzer, 1996: 30). The use of heuristics in the adaptive toolbox assumes that compensatory strategies are cognitively costly (Bröder and Newell, 2008: 211). As Bröder and Newell (2008) have shown, this is not necessarily the case. Compensatory strategies were used under conditions with a high cognitive load and were subject to “thought-less” routines. Information search is costly where costs are either determined by external factors such as time pressure or intrinsic factors such as memory retrieval (Bröder and Newell, 2008: 211). Enhanced cognitive capacity increased the proportion of decision-makers using simple heuristics where they were ecologically rational (Bröder and Newell, 2008: 211). The cognitive capacity refers to both intelligence and free working memory capacity and has an impact on how adaptive the use of strategies was. The decision of how to decide, or which decision strategy to select, is the most demanding task in a new decision situation (Bröder and Newell, 2008: 212). Decision-makers need to assess the type of information that is available, as well as the decision environment to adopt the approach best suited to the decision that is required. In an organisational context, this could suggest that for decision-makers in new situations, in order to save on cognitive processing, decision-makers may be more inclined to use heuristic decision-strategies that require less thought if under pressure.

In the test environment, there was a very subtle advantage in the payoff for take-the-best. The results showed 60% of participants used take-the-best under conditions with low cognitive load and only 26% used it in the condition with a heavy cognitive load (Bröder and Newell, 2008: 210). This is contrary to the expectation of the contingency model. In the tests conducted by Bröder and Newell (2008), the costs of strategy execution do not differ much between take-the-best and compensatory strategies. Participants were able to use compensatory strategies even under conditions of heavy cognitive load. The cognitive load impaired decision-makers’ ability to determine the payoff structure of the environment and then to choose the appropriate heuristic (Bröder and Newell, 2008: 210). This shows how a higher cognitive load can slow down the decision-making process. However, heuristics are intuitive and though the environment can be structured to encourage their use in certain situations, the choice of which heuristics to use after looking at the environment is not a conscious process most of the time and happens automatically.

In measuring levels of intelligence, tests showed that decision-makers that use take-the-best were slightly more intelligent than decision-makers using compensatory strategies (Bröder and Newell, 2008: 209). This was opposite to contingency logic, which predicts that simpler strategies are associated with less intellectual capacity (Bröder and Newell, 2008: 209). However, a post-hoc analysis of the experimental game’s payoff structure showed that there had been a relatively subtle advantage in the expected payoff of take-the-best over the compensatory strategy used (Bröder and Newell, 2008: 209). This leaves the level of intelligence involved in strategy selection inconclusive.

Individuals tend not to make very good decisions in situations where little information feedback is provided or where there are a large number of cues to consider (Astebro and Elhedhli, 2006: 395). This would suggest that under conditions of information overload, or in

situations where a number of alternatives are presented, decision-makers struggle to make good decisions. This is, to some extent, contrary to Bröder and Newell's (2008) findings that participants were able to use compensatory strategies under high cognitive load. While this may be so, compensatory strategies are usually more time consuming and more costly on cognitive load, resulting in the possibility that a good decision may be reached, but after extensively more consideration and time than a non-compensatory decision strategy. In a study on analysts that judged the potential market success of inventions, it was found that the analysts who used heuristics for their judgments, correctly forecast the likelihood of an invention reaching the market as often as or more than "linear additive statistical models" (Astebro and Elhedhli, 2006: 395). Heuristics are able to simplify decision-making because they lessen the complexity of a decision by reducing the effort required for cognitive processing. With fewer cues, decision-makers are able to process all the given information, so heuristics are often used when there are many alternatives involved in a decision (Payne et al, 1993 in Astebro and Elhedhli, 2006: 396). This way, excess or unnecessary information is often eliminated by default when the heuristic is employed. Assuming that the objectives of the decision-maker include accuracy and a reduction in cognitive processing, heuristics may still be an efficient way of making decisions (Payne et al, 1993 in Astebro and Elhedhli, 2006: 396).

A warning of the possibility of not using a decision rule, as well as the lack of a financial incentive, led subjects in a study by Arkes, Dawes and Christensen (1986: 93) to judge more consistently. When standard decision-making procedures were abandoned, it was found that decision cues were used inconsistently (Dawes and Corrigan, 1974 in Arkes, Dawes and Christensen, 1986: 94). The experiment showed that those decision-makers who were not given an incentive for good judgement were less likely to shift their choice of decision strategy and therefore performed better (Arkes, Dawes and Christensen, 1986: 93). Thus, decision-makers who may find themselves using heuristic decision-making on a daily basis, for decisions without significant incentives may perform better, as they are less likely to shift their decision strategy.

If information is available that doesn't place too heavy a burden on the working memory of a decision-maker, then the costs of cognitive processing for different decision strategies are not a serious factor, the format of information sources have little effect, and cognitive cost differences between strategies like take-the-best and optimisation strategies are insignificant (Bröder and Newell, 2008: 211). When the working memory is not burdened, the integration of information is also not very costly, as the conclusion of a study testing the performance of decision-makers under a high cognitive load demonstrated (Bröder and Schiffer, 2003 in Bröder and Newell, 2008: 211). In the high cognitive load conditions in this study, 60% of participants probably used a compensatory rule (Bröder and Newell, 2008: 211). Retrieval of information from one's memory results in cognitive costs and promotes early stopping rules. However, these cognitive costs can be reduced by the use of integrated, pictorial stimuli. This suggests that if information is easily accessible, the cognitive load is reduced. The use of pictures can aid this reduction, assisting the process of decision-making (Bröder and Newell, 2008). Decisions made in reality, as opposed to under test conditions, probably involve a

mixture of information sources and thus, a mixture of different cognitive costs (Bröder and Newell, 2008: 211).

Rather than selecting strategies, decision-makers might adjust their thresholds, from either lenient criteria that allow fast and frugal searches or strict criteria that require more information (Bröder and Newell, 2008: 212).

### Controversy around heuristics and the adaptive toolbox

When it comes to reducing information overload, the use of fast and frugal heuristics has some limitations. When using heuristics in the reduction of information overload, they are being used as a decision support system (DSS), a technique to aid decision-making. They can only be used in such a way when something is known about the decision context or the situation in which they are to be used. Under conditions of complete uncertainty, they cannot be used, as they are based on the principle of ecological rationality, and so need to be planned according the 'ecology', or decision environment.

Further, they are used in different ways by different people and there is no way of standardising a procedure for their use in organisations. The use of heuristics is highly subjective, which may be problematic in larger organisations or organisations where individual thinking is not encouraged. Due heuristics' subjective nature, their use is difficult to monitor or standardise. Cognitive biases are inherent in the use of heuristics and decision outcomes will not always be accurate, possibly complicating matters in the future. Their subjective nature means that their use will differ from person to person; what may be considered as important information or aspects of a decision problem by one person may not be by another. This difference will always exist, even between employees of an organisation who have all gone through the same training and know their organisation's strategy and priorities. Fast and frugal heuristics do not take into consideration all available information, do not reach optimum solutions and cannot necessarily be rationalised and justified. For these reasons, organisations may be hesitant to encourage their use by decision-makers, even if it is planned for use as a DSS. They are limited in reducing information overload in their need for knowledge about a situation and in the freedom of the decision-maker to use them.

Fast and frugal heuristics are generally agreed to be intuitive and automatic; they cannot be controlled, monitored or implemented in a standardised way. Heuristics are highly subjective decision tools and no two decision-makers will reach an outcome in the same way. This subjectivity and the degree of choice involved mean both that the use of them will not always lead to very accurate decisions and that there are biases inherent in the use of heuristics. With this in mind, it could be questioned at what point it becomes reckless to use heuristic decision-making when is lots of money or other resources at stake, or many people affected by the decision. In some cases, this may be so, but if optimisation techniques were to be used as an alternative, there would be so much information to process that decision-makers would likely become overloaded and end up satisficing and being affected by other decision biases, in addition to the possible negative effects of information overload.

Kahneman's most recent book, *Thinking, Fast and Slow* (2011), comprises his life's research, including that done with co-author Tversky. It explains thinking in terms of system 1 and system 2, two metaphors for describing the different ways in which decisions are made. The book, though making rational and logical arguments is based largely on simple examples and questionnaires, and not on real behaviour. Though there is no denying that such systems of thought as described in the book actually exist, their use by decision-makers in every day behaviour may not be as prescribed and predictable. The Linda problem involves decision-makers being told something about a woman named Linda and then asked to guess which of two statements about her was more probable (Kahneman, 2011: 156). Most people actually guessed the statement with the lower probability, simply because the other one sounded more likely given the description of Linda (Kahneman, 2011: 158). Experiments that are taken in context, such as the Linda problem, may not be so controversial had the wider context, the expectations that facilitate conversation in reality, been taken into account.

There are some problems with fast and frugal heuristics as a decision rule. Rules imply that they heuristics are something that can be implemented or imposed, whereas, though they are rules for the way in which a decision is made, externally, they are noticed more as patterns that emerge in decision-making as a result of a subconscious and automatic thought process. This thought process uses certain rules, but the heuristics themselves are not necessarily applied to situations in a manner associated with rules. Though there is room for learning from them and structuring the environment to be conducive to their use, they are not generally applied as rules to decision-making, as they are difficult to consciously control. This makes it difficult to control their use in organisations and the biases they produce, and difficult to 'educate' them, or the decision-makers using them, to be used only at certain times. As mentioned, they are generally not applied to decisions in a conscious manner, however, their application can be determined by the decision context. The type and size of the organisation, the way information is presented and the mental state and pressures on the individual decision-maker all have an effect on the extent to which heuristics are likely to be used in decision-making. The management structure and attitude towards learning and risk-taking, the degree to which the organisation is open to making mistakes and learning from them also either encourages or inhibits the decision-makers from using heuristics.

Fast and frugal heuristics are not a rule that can be relied on to get a certain outcome. They are not a technique to guarantee certain results, something that is often desirable in organisations where there are major financial or other implications of the decision. Heuristics cannot be systematically applied, which is of particular relevance to multi-national organisations that apply a certain method of decision-making or style of management to all offices globally. Because this is a more subjective approach to decision-making, organisations are unlikely to encourage them, unless they have great faith in the abilities of the people they hire. Their use is more likely to be encouraged in organisations where employees are seen as an investment to be stimulated and retained. As a decision rule, fast and frugal heuristics may be seen as unreliable and as taking too big a risk, rendering organisations hesitant to encourage their use, as results not are always predictable. Despite

this, there are some situations in which their use is more accurate than optimisation or tallying models of decision-making (Todd and Gigerenzer, 2007: 169).

A limitation of the heuristic rule is that that it always favours the known over the unknown, the bigger and better over the smaller and weaker. Whether it is the recognition heuristic or take-the-best, the underdog doesn't 'win'. Opportunities are only given to known quantities. This results in the big getting bigger and the small getting smaller. Generally speaking, this is not always positive. However, it can be exploited by organisations if it is recognised and the environment is structured in such a way as to encourage certain likelihoods in heuristic decision-making. By popularising the organisational agenda, certain factors will be better or more known in the minds of the decision-makers, influencing their choices related to this. This works in a positive feedback loop, with the effect of subtle influences and changes of structure having larger and more far-reaching consequences, and making what is already known, more known.

There is no evidence of how decision-makers actually use these rules and how they perform in natural settings, not under test or study conditions (Astebro and Elhedhli, 2006: 397). In terms of the types of problems that heuristics have been tested on under experimental conditions, if sufficiently complex problems aren't dealt with during testing, the result may be simple methods of solving them. Heuristics that are tested on simple problem don't take into account the complexities that are faced in the real world, calling into question the validity and applicability of heuristics in their everyday use.

The decision-making research conducted by Payne and colleagues viewed fast and frugal algorithms as being at one end of a continuum (Chater et al, 2003: 65). Where Gigerenzer focussed on questions of judgement, Payne, et al looked at how people make choices between options. It was found that there is no strong reason to view take-the-best as having more cognitive plausibility than other algorithms. Gigerenzer and Goldstein (1996) do not explicitly discuss whether they see take-the-best as a cognitive algorithm that is universal or one that is selected dynamically by decision-makers from a range of possible decision-making methods. One criticism of the take-the-best heuristic is that people are not always satisfied taking a decision based on one piece of discriminating information. Many decision-makers may prefer to look for other information that may serve to increase their confidence in a decision (Harvey & Bolger, 2001 and Svenson, 1992; 1996 in Newell, Weston and Shanks, 2003: 84). This could be a significant reason why take-the-best has not been adopted universally.

Increasing the complexity of a task may lead to a higher likelihood of the use of heuristics, as the cognitive processing becomes more onerous for the decision-maker. In the experimental environment used by Newell, Weston and Shanks (2003), the take-the-best strategy did not do especially well, but the fast-and-frugal approach in general did do well. The majority of participants searched for cues by ordering their validity. Many decision-makers made the choice to obtain more information than was necessary, violating the stopping rule (Newell, Weston and Shanks, 2003: 88). These participants all violated the decision rule too. Another

experiment found that search was ended after discovering a discriminating cue or terminated after finding the most valid cue, both responses predicted by the take-the-best heuristic. This suggests that the decision strategy chosen will be dependent on the situation in which a decision presents itself.

Deviations from take-the-best suggest that either the heuristic is only adopted by a minority of decision-makers, and thus that its existence in cognition is doubtful, or that researchers are still looking in the wrong place for the conditions that promote its use (Newell, Weston and Shanks, 2003: 92). This leads to the question of where the 'right' place may be and under what conditions, an opportunity for future research to explore. People are not always satisfied to make a decision on the basis of one piece of discriminating information, particularly in organisations where there may be high-risk high-reward situations.

While optimisation models have their advantages too, the focus has been on the circumstances in which fast and frugal heuristics may be used, and when they may be used with greater efficacy than optimisation models. Though there is disagreement about the conditions under which each should be used, there are some environments to which fast and frugal heuristics are more suited.

#### 4.5 Conclusion

The notion that fast and frugal heuristics are intuitive and unplanned is generally supported in the discussion amongst researchers. They are used on an almost subconscious level to make decisions quickly, saving both time and cognitive effort. In understanding the way that the various heuristics work, it is possible to appreciate both the values and the limitations of their use.

Heuristic exploited cognitive capacities that have evolved in humans over a long time. These basic capacities, such as recognition are exploited to enable quick decisions that require very little information. These heuristics can be used by decision-makers in many different situations; their success depends on the ecological rationality of the heuristic. This holds both value and acts as a constraint to the use of decision-making. The value is derived from the fact that heuristics can be used by decision-makers in a variety of contexts with various types of information and by people at various levels of expertise. Their flexibility adds value to heuristics as a decision-making tool. However, this is also a limitation, as they cannot be applied in all circumstances with all different types of information. Heuristics are only used successfully when they exploit the decision environment, enabling the environment to of part of the work involved in making the decision. The type of information needs to be appropriate for the heuristic, as does the context. This relates to the problem of attention, where the decision-maker who attends to a problem and when it is attended to are significant determinants in the decision outcome.

Whether these heuristics are actually used as they are described in reality is also a discrepancy in the research. Though they are logical and rational, the question arises of how much they are used in everyday thinking or whether they are too subconscious to be exploited and used. The degree to which they can be controlled or used as an explicit tool by decision-

makers is questionable. Some may argue that they are too subjective to be implemented as a strategy in an organisational environment. The lack of control that comes with the use of heuristics and the need for appropriate information in an appropriate environment, their lack of being able to be generalised, may be problematic for some organisations. Knowing when to use which heuristic is being able to apply the heuristic that is most rational in a given information context. It is this subjective decision that is difficult to be controlled, or for some kind of rule to be applied as to when to use which heuristic; this is dependent on the judgement of the individual decision-maker.

Despite these limitations, the flexibility of heuristics is an advantage too, allowing their use in a variety of environments. Their use saves decision-makers time and enables decisions to be made under conditions of uncertainty or where little information is known. Theoretically, it is possible to influence their use, or the likelihood of their use, to encourage or discourage certain heuristics in various environments. With an understanding of the heuristic; the way it functions, what information is best suited to its use and in what contexts it is most appropriate, it is possible to structure and plan the environment to a certain extent to encourage the use of certain heuristics. By identifying the strengths of a particular heuristic, they can be analysed and certain aspects may be learned from to enable their application in new environments.

When heuristics are used in organisations, they can be used in the way that decisions are framed for management and the decision environment in the organisation can be subtly influenced by management so that decision-makers in the organisation are primed to think in a certain way or to recognise certain cues. When being used in presenting choices to managers, other decision-makers are responsible for the filtering of information, making it more susceptible to biases, but also the fact that this preparation or pre-decision processing is done by other people reduces the processing required by management. When management is priming organisational decision-makers to think in a desirable way about certain issues, they are assisting the decision-makers when it comes to making a choice, as certain cues will be more easily recognised or known to be more desirable. In this way, both managers and other decision-makers in organisations can use the concept of fast and frugal decision-making in their work to ease decision-making for the other.

Most of the time, heuristics perform better than the predictions of statistical models when tested in the area business, among others (Goldstein and Gigerenzer, 2009: 766). When used appropriately, in a way that is ecologically rational, decision-makers can gain from the use of heuristics, both in the reduction of cognitive processing that is required by them and in productivity, saving themselves times and maintaining or improving the accuracy of their decisions.

## Chapter 5

### CONCLUSION

#### 5.1 Introduction

Decision strategies are sequences of mental operations used to transform an initial state of knowledge into an achieved goal state where the decision problem is solved (Payne and Bettman, 2004: 126). It is assumed that people have a selection of strategies that are acquired through experience and training as well as some that are hardwired, but decision-makers also have cognitive constraints and a limited knowledge for strategy implementation. This can result in predictable and, sometimes significant errors or biases (Payne and Bettman, 2004: 129).

Both visual representation and fast and frugal heuristics are decision strategies that deal with the problem of cognitive information management, and can be used as support for making a decision in an organisational context. Though there are limitations and biases that arise from these, there is value too. With the vast amount of information available to decision-makers, these strategies can also assist in reducing information overload. There are similarities between the two approaches in the structure of the way that information is handled. Each has the potential to reduce the cognitive load of the decision-maker and in turn reduce information overload. When used appropriately, these techniques can achieve the meta-goals for choice, maximising the accuracy of a decision, and minimising the cognitive effort required for the decision (Payne and Bettman, 2004: 122). Both of these cognitive information management techniques also result in the presence of biases and errors in decision-making. The possibility of using these two approaches in conjunction with one another is further explored as a DSS that could reduce information overload for individual decision-makers in organisations.

#### 5.2 Comparisons

##### 5.2.1 Information overload and visualisation

Data or information that is represented spatially, such as graphs, is processed more easily, with less cognitive effort, than data that is represented symbolically, for example, in a table (Vessey, 1994: 105). Because spatial information is easier to process, it reduces the cognitive load for the decision-maker. This can result in faster decisions with more information being processed. Spatial representation of information such as graphs can often integrate data from various sources or data that is collected over a period of time or space. Spatially represented data is easier to acquire information from than symbolic. Such an incorporation of data into one visual aid that is easier processed than pages of data and tables can allow for the decision-maker to absorb more of the information than if it were presented symbolically. Through the visual representation of data, information processing is made easier and the cognitive load is reduced. This suggests that under conditions of information overload, or where there may be greater volumes of information than the decision-maker has the time to

process, visual representation of information may reduce the likelihood of information overload through easing processing for the decision-maker.

The Oobeya room enables lots of information to be seen at once. This may include simplifications of the information or its graphical representation, or not. In applying the theory of information processing to such a display of information, it is not clear what the consequences may be. The fact that information is added and changed as the project progresses may mean that the processing of information is more easily presented in such a room. The fact that the information is presented and understood incrementally may result in easier processing for the decision-maker, as there is not a final handing over of documents to management with a load of information on project progress that then needs to be absorbed. Rather, the slower, more incremental method of learning may assist in the processing of information, reducing the cognitive load on the decision-maker. However, on the other hand, there is a lot of information presented all around one room. This could overwhelm a decision-maker or lead to confusion if there is only interest in one area of the information or in specific detail. Such a room may therefore cause information overload for some decision-makers, depending on the needs of the decision-maker and the type and presentation of information in the Oobeya room.

The balanced scorecard approach renders a more certain outcome with regards to information overload than does the Oobeya room. Presenting only a simplified representation of the information about different areas of an organisation, the balanced scorecard has a higher likelihood of easing cognitive processing and therefore reducing information overload. Because information on a balanced scorecard represents only the most important details of different areas in an organisation, a simplified version of progress, the scorecard shows a summary that contains less information than if presented in a report. This means that the processing for the decision-maker will be eased and that the chances of the decision-maker suffering from information overload will be reduced.

Information that is presented visually is necessarily biased by those compiling the visualisation. It is framed in a certain light to attract the attention of decision-makers to certain elements of the data. This may be adjusted, depending on who and when attention will be received from. The visualisation of information often involves a simplification of data, or a reduction in its volume. It also means that information is represented spatially, which is easier for processing. The reduced amount of information enables easier processing. Easier processing results in a lower cognitive load for the decision-maker. A lower cognitive load means a reduced chance of information overload affecting a decision-maker. Therefore, information that is presented visually may lead to an increased chance of information overload being reduced. When information is spatial in nature, it will reduce cognitive load when presented graphically. There are many other visual representations that can be appropriate for different types of information. Visualisations by definition are structured simplifications of data and do not include everything. This process thereby pre-defines the fact that cognitive load will be reduced when using visualisations.

### 5.2.2 Information overload and heuristics

With increasing amounts of information available, decision-makers should benefit from the availability of more and better data (Bruggen, Smidts and Wierenga, 1998: 645). However, in the processing of information, decision-makers show cognitive limitations (Bruggen, Smidts and Wierenga, 1998: 645). To reduce the mental effort involved in information processing, decision-makers may be prone to using heuristics, though this may lead to errors (Bruggen, Smidts and Wierenga, 1998: 645). Although certain heuristics may perform well in highly predictable environments, such as the anchoring and adjustment heuristic, these heuristics may perform poorly in less predictable environments, where much strategic decision-making happens under conditions of uncertainty (Bruggen, Smidts and Wierenga, 1998: 645). However, fast and frugal heuristics can perform well under uncertainty, as they require the limited information that comes with such circumstances.

Sparrow (1999: 145) found that “the greater the complexity, the more the untrained person searches for and relies on habitual and routine cues”. This suggests that with higher volumes or an increase in the complexity of information, the human mind is more likely to use heuristics and mental short cuts as a coping mechanism. The problem is that people in organisations are largely not untrained, but (highly) educated. This may mean that instead of relying on “habitual and routine cues”, they are more likely to cognitively engage in search or in problem solving in complex problems, using system 2 thought processes. This does not leave such decision-makers immune to cognitive biases; on the contrary, the overconfidence bias (among others) was found to be common among experts.

Heuristics generally produce satisfactory outcomes and are used either because decision-makers have no choice (limited cognitive or processing capabilities), to simplify because of cost and time or because they may have been satisfactory in the past and are readily available in memory (Payne and Bettman, 2004: 114). Heuristics involve methods for complex problem-solving with limited information. People increase their use of choice heuristics such as elimination by aspects and satisficing as the decision task becomes more complex (Payne and Bettman, 2004: 121). Other biases that are likely to arise in an organisational context include, but are not limited to priming, anchoring, groupthink, confirmation bias, overconfidence.

One of the major problems with employing fast and frugal heuristics in an organisational context is that the heuristics are based on the assumption that the decision-maker has at least partial ignorance of the problem, and not a lot of knowledge about the cues. In organisations, it is likely that this will not be the case. Managers, particularly those on a senior level, are likely to have knowledge of the problem greater than what is required for the optimal use of heuristics. However, this ironic implication does depend largely on the management structure of the organisation and the way in which it is run. Some managers may only have a general idea of what is going on in each business unit (for example with MBE), in which case their knowledge will be limited and heuristic decision-making might be very suitable for certain problems. On the other hand, managers who prefer to have an in-depth, detailed and up-to-

date understanding of the functionality of every area of business, or of their unit, are likely to know 'too much' for fast and frugal heuristics to produce a good outcome.

This leads to the question of whether the planned use of heuristics in organisations is viable or not. While heuristics are generally agreed to be intuitive and unplanned, there is room for learning from them and structuring the decision environment to make their use more or less likely. Managers can promote particular ideas or goals to an organisations, encourages choices based on these priorities to be made if using heuristics such as the recognition or the take-the-best heuristic. In this way, the environment of decision-makers is being subtly influenced to encourage certain, organisationally desirable choices to be made. The decision-makers at a lower level than senior management can also structure the presentation or framing of decisions to encourage the use of heuristics in decision-making. In this way, it is possible for an organisation to use heuristics as a decision-making strategy. The context of the organisation is social and the framing of decisions, the priming of decision-makers and the use of decision strategies are all shaped and influenced by other decision-makers in an organisation. This reduces the ease with which it is controlled, but it is possible to encourage or discourage heuristic decision-making in the way that the environment is structured.

The attention that is given to problems also determines how successful the use of heuristics may be. Who gives attention (how much knowledge they have of the problem situation, how much power they have to make changes), when it is given and the way that that decision-maker structures the problem and prioritises the alternatives will have an effect on the decision outcome. Decision-makers who do not have much time or knowledge of an area may be better candidates for using heuristic or system 1 decision-making. If possible, such individuals could be identified and decisions posed to them in such a way as to encourage the use of certain heuristics.

There are arguments that optimisation models are better than fast and frugal heuristics; they take into account all the information provided to produce a better quality and more accurate outcome, an optimal decision. While this may be so, heuristics do not claim to make the optimal decision. Decision-makers that use them are not setting out to optimise, but rather, to satisfice. Heuristics do not claim to produce optimal decision outcomes, but only to produce satisfactory outcomes, very accurate when used in the correct environment. In some decision environments, linear or regression models of decision strategies that optimise may outperform fast and frugal heuristics. However, this is not to say that the outcome produced by heuristics may not be good, just that those produced by optimisation models in those circumstances are better. The degree by which they may perform better or the decision quality of the fast and frugal outcomes is not taken into account or specified. This suggests that they may be a chance that heuristic decision strategies do perform well under some circumstances when compared to optimisation strategies.

Searching for information costs time. This equals productivity and therefore money in an organisational context. Fast and frugal heuristics lessen the time spent in searching for information. Therefore, the use of heuristics can save time. They can also save costs. This could come about when time has a monetary value on it, such as is often the case with

decision-making in organisations, or because the information required originates from a source external to the decision-maker or the organisation and involves costs, either in financial terms or in other resources necessary for its retrieval. The need to save time or money on information search may only be necessary or applicable to some situations though. When time is not under pressure and does not cost money, then using other methods of decision strategies may be preferable. This may also be so when the type of decision being made requires an outcome that is specifically very accurate or detailed. Under such circumstances, it may be more suitable to spend time considering all the available information in order to produce an optimal solution.

One such method could be employing the WADD technique. WADD is good when there are greater levels of conflict between alternatives, but not under conditions of time pressure, where lexicographic strategies perform better (Payne and Bettman, 2004: 117). The cognitive effort required with heuristics increases more slowly than the effort required to use WADD as the choice task is made more complex (Payne and Bettman, 2004: 120). The accuracy advantage of strategies like WADD is greatest in contexts with greater levels of conflict among the attribute values. WADD tends to be less sensitive to changes in task and context factors than heuristics. One exception to this general conclusion is the case of time pressure. Under great time pressure, heuristics result in the best outcome in terms of maintaining decision accuracy (Payne and Bettman, 2004: 120).

It is likely that individuals will adjust their standard for accuracy according to the different task demands (Payne and Bettman, 2004: 120). Heuristic strategies can be highly accurate with considerable savings in cognitive effort. No single heuristic can be accurate in all environments. The basic concept behind this is that preferences and beliefs are frequently constructed in the moment, as they are needed, rather than simply being retrieved from memory (Payne and Bettman, 2004: 129).

Individual cognition plays a role in the way that decisions are made. Subjective factors that are specific to individuals influence how one perceives and makes sense of the environmental and organisational worlds. These perceptions influence decision-makers' views of problems and hence the strategies that are then formulated in response to and the decisions that are taken around these strategies. When analysing the cognitive processes that are used in making a decision, Schwenk (1988) identified four topics relating to strategic cognition in particular. These types of decisions would be especially applicable to management, notably senior management, who are responsible for making decisions that influence the strategic direction of an organisation.

Heuristics and biases, cognitive frames, strategic assumptions, and analogy and metaphor are four distinct processes that are common to strategists from different backgrounds when considering strategic decisions. Due to the fact that people's minds have limited information-processing capacity to deal with the complexity of strategic problems, heuristics can be used to aid this process. This introduces biases into strategic assumptions. These biases form the basis for problem representations, which can then be applied to new problems through analogy and metaphor (Schwenk, 1988: 47). While proving useful in dealing with the

processing of information, particularly around complex problems, heuristics can lead to biases and to errors in the processing of data. Biases can restrict the range of alternatives conceptualised by decision-makers, for example the availability bias or the illusion of control. Individuals often draw from past similar experiences and, though having the potential to help to process current information by contextualising a decision for an individual, heuristics can result in biases too. When using analogies, the differences between the past and current situations must be taken note of. Particularly when making decisions in a group environment, analogies are more likely to shape problem formulation. Shared analogies can draw in agreement from others and can result in groupthink (Schwenk, 1988: 47).

Though heuristics can aid the processing of large amounts of information in complex problems to improve decisions, assumptions made need to be consistent with available information, as they form the base upon which a managers' frame of reference is built (Schwenk 1984: 124; 1988: 46). An awareness of biases that can result from the use of heuristics can help to prevent against their influence when assumptions are made in decision-making. In understanding a strategic problem, data can either be analysed and a new problem representation (schema) can be developed or analysis can be followed by the application of a previously developed schema. Strategists with different backgrounds attend to different features of problems to formulate them in different ways.

Because strategic decisions involve decision-making under uncertainty, ambiguous data may cause potential disagreement among managers over which factors are important. Evaluation is the final cognitive stage before the selection of a strategy for a decision (Einhorn and Hogarth, 1981). Cognitive simplification during the evaluation phase may increase the chances of successful implementation of the strategy, by increasing decision-makers' confidence in it, as well as their commitment to it. This impact of simplification assumes that there is a high degree of consensus among decision-makers. Where a divergence of assumptions exists, simplification processes are likely to be corrected, and heuristics are not likely to lead to biases and have a negative impact on the decision (Schwenk, 1984: 124).

Due to the human mind having a limited capacity to process information and deal with the complexity of strategic problems, biases are introduced into strategic assumptions. Biases have the effect of restricting the range of alternatives conceptualised by decision-makers (Schwenk, 1988: 44). The strategic assumptions that result then form the basis for schemata, which are representative of the problems. Analogy and metaphor may be the means through which these schemata are applied to new problems. Representations of problems and solutions to those problems may then be applied to new problems that show some similarity to the original situation. Heuristics can be used here too, in the application of schemata to new problems. Though they can be useful, they can also lead to errors and biases. The assumptions that are made need to be consistent with the available information, as they form the base upon which a managers' frame of reference is built (Schwenk, 1988: 45). This is where the danger lies in applying schemata to new problems, where available data may not match that of the original problem.

The validity of using heuristic decision-making in organisations in a planned or structured way is not clear. Theoretically, it has the potential to be used as a DSS to reduce information overload. However, it is also possible that the nature of the decisions faced by management and other decision-makers in organisations, and the complexity of the organisational environment render the approach impractical and implementation unattainable. It is possible that with overload and the scarcity of attention, that if decision-makers use heuristics, it will be in an unplanned and unguided way, beyond the control of management or even themselves.

### 5.2.3 Visualisation and heuristics

Visualisations may encourage the use of heuristics to lead decision-makers to better outcomes than without them. For example, in large organisations where management at a senior level does not have detailed knowledge of all areas in their organisation, they may simply be exposed to summaries, such as a balanced scorecard, or visualisations of different areas in order to get a broad overview. This may provide an opportunity for heuristic decision strategies to be used successfully, for better decisions to be made using less information. Decision-makers will be partly ignorant about the details of some of the decisions that they are making, which is a necessary condition for the use of fast and frugal heuristics. The limited knowledge that such decision-makers may possess may make the use of fast and frugal heuristics not only more accurate, but more cost effective too, as time is often money in businesses, and in making decisions faster, the organisation could save money and time. These are scarce resources and if they are able to be saved, the organisation could be more productive. In this way, cognitive overload is further reduced too.

However, in many organisations, this may not be the case. Decision-makers may not take major decisions based on relatively little information, preferring to be as knowledgeable as possible due to possible financial and other implications. The risk of making important decisions without full knowledge of a situation is probably too high for many decision-makers, especially given the number of stakeholders that could be affected. Forecasting or judgement about the future that is done in organisations often occurs in decision-making at a strategic or financial, and more senior, level. The 'higher up' a decision is made in an organisation, the higher the likelihood that it affects more people, although some cynics might disagree. With numerous stakeholders and a reputation to manage, senior decision-makers are unlikely to want to use fast and frugal methods that require them not to be fully informed. When decisions need to be rationalised to other people, then optimisation decision strategies are more likely to be used, as they can be justified, both within the group of decision-makers involved, and outside of that group to various stakeholders. Decision-makers in such positions are unlikely to want to be seen as not considering all available information to optimise decision-making, as if there are any negative consequences or issues down the line, these decision-makers will not have a leg to stand on in terms of rationalising their choice to others. Therefore, despite the fact that heuristics may be good decision-strategies for management in organisations, the chance of them being employed is unlikely given the social context of the decision situation. While visual representations of information may be used, the organisation is still likely to use optimisation methods on which to base decisions,

with visualisations simply being an aid to decision-making, or an accompaniment to reports or symbolically-represented information.

The take-the-best and other lexicographic heuristics all rely on the use of only the 'best' cues and, in so doing, save on the amount of information processing effort required; those cues that are not the best are ignored (Astebro and Elhedhli, 2006: 397). In a similar way, visualisations can sometimes represent trends or focus on only the more important information. This also saves on the amount of cognitive processing that is required by the decision-maker. In processing the information that is presented by visualisations, they could be used as an indication of important cues, aiding cue generation and ranking. In this way, visualisations can prompt decision-makers in their use of heuristics.

Retrieval of information from one's memory results in cognitive costs. However, these cognitive costs can be reduced by the use of integrated pictorial stimuli (Bröder and Newell, 2008: 211). This suggests that if information is easily accessible, the cognitive load is reduced. The use of pictures can aid this reduction, assisting the process of decision-making. This suggests that for optimum decision-making under time pressure, when the aim is to reduce decision load as much as possible, the combined use of heuristics and visual representations could be a good decision strategy. The visual representation of data could integrate and simplify it enough to be easily accessible. This simplification could highlight only the most important aspects of a problem situation, allowing the decision-maker to use a heuristic decision strategy in approaching the problem, as the visualisation might exclude the irrelevant information, or noise, from the decision-maker. If visualisations automatically exclude a portion of irrelevant information (or only pick up on trends or key pieces of information), then this provides a good platform for the use of heuristic decision strategies.

Fast and frugal heuristics can be combined with visualisations, for example, in fast and frugal decision trees. These trees can make decision processes more transparent and easier to communicate to others (Katsikopoulos, 2010: 5). This could imply that such a combination of visualisation and heuristics may be good for organisations, where strategic decision-making happens in groups. Such a visualisation would lay out the problem visually and present the cues to the decision-maker, as well as the possible outcomes, resulting in what should be quick decision-making. It is useful in that it provides a method of using fast and frugal heuristic decision strategies at a group level that enables decisions to be justified or rationalised more so than if by an individual decision-maker. Because the cues and their validities and outcomes are laid out visually, they can be discussed and understood by others. This also reduces the probability that biases will be found in the decision, as when there are more decision-makers rationalising a decision, the chance of biases is decreased (Schwenk, 1984: 124), with the possible exception of groupthink.

Both heuristics and visual representations of data are evaluated with respect to their fit with the structure of the task environment. The type of data available, the decision-makers viewing the representation and the context of the data are all important factors in considering both what type of visualisation to produce as well as whether a visual representation of data is the appropriate and preferred method of presentation. Similarly the use of fast and frugal

heuristics is based on their ecological rationality, also basing the suitability of their use on the decision environment.

Both of these heuristics also aim to reduce the cognitive load of the decision-maker, enabling information processing to be sped up. In visualisations, this is done by integrating data from across time and space and sources. The effective combining of data into one visualisation and the patterns and trends that are brought to the attention of the decision-maker reduce the cognitive load, doing the work that the decision-makers would have been required to do themselves if looking only at raw data. Fast and frugal heuristics reduce the cognitive load of the decision-maker by selecting only the most important information to pay attention to. Only this information is (or these cues are) processed as part of the decision then, and the rest is ignored.

In aiming to reduce the cognitive load, heuristics and visualisations are both able to reduce the probability that a decision-maker will suffer the negative effects of information overload. However, as mentioned, the success of both approaches does depend on the decision environment, meaning that although both methods can assist in the reduction of information overload, it does not mean that they necessarily do, as that is context dependent. Factors such as the size, age and type of the organisation and its culture and management style, the format that the information is presented in, the time and other organisational pressures on decision-makers, as well as personal pressures and stress levels in the life of individual all form part of the context that helps to determine how successful the different approaches are in reducing information overload, at organisational and individual levels.

Visualisations may be better utilised in larger, more structured or hierarchical organisations. This may be so due to the more systematic way that information can be displayed through visualisations, and their ability to standardise the way that certain information is presented. This manner of displaying information is able to be applied globally and the use of a certain format enables information to be understood by decision-makers from various backgrounds. Many established organisations may be more risk averse than newer organisations. Visualisations thus provide a more rationalised and logical approach to decision-making that can be easier explained to stakeholders and to other people.

Fast and frugal decision rules may be more likely to be found in organisations that have a flatter management style and a looser structure, in one where the culture is such that each employee is viewed as an asset to the company. Such an organisation is likely to place more trust in employees and to place a higher emphasis on the importance of teamwork. Levels of trust are likely to be higher, leading to a more encouraged use of freedom in individual work tasks. This may result in the use of fast and frugal heuristics. Newer companies or organisations that are dynamic and trying to actively grow and expand may be open to more risks and may also have a high volume of information needing to be processed. This could put decision-makers under pressure, resulting in an increased likelihood of system 1 thinking, or the use of fast and frugal heuristics.

Both decision aids discussed render the decision-maker subject to cognitive biases. In the visual representation of data, this results from the fact that certain elements of graphs are made more prominent or attention is drawn to certain aspects of the data according to the way in which it is presented. The visualisation will not be completely objective and does not take into account all aspects of the available data. In a similar way, fast and frugal heuristics do not consider all aspects of available data and can ignore much of it as a requirement. Looking at only certain cues or processing data according to a specific heuristic can lead to systematic and predictable cognitive biases (Kleinmuntz, 1990: 298; Tversky and Kahneman, 1979). In both of these circumstances, there are measures that can be taken to reduce the biases, but they are still evident and part of the decision-making process. Group decision-making, as would happen in many organisations, is one process during which it is possible that the likelihood of biases is decreased, as individual differences will result in views being challenged and questioned and, during the process, the likelihood of biases being reduced or eliminated. Groupthink is a potential problem though.

Both visual representations and fast and frugal heuristics can be used as decision aids. However, there are a number of differences between these two strategies. Visual representation is an external model, while fast and frugal heuristics is an internal psychological model. Visual representations are structured and planned reductions in information, whereas heuristics are intuitive and unplanned thought processes. Therefore visualisations do not take into account individual differences in decision-making as much as heuristics do. The outcome of using fast and frugal heuristics as a decision strategy is more dependent on the individual decision-maker than is visual representation. Visual representation covers a broader range of display types and is a more general decision aid, able to be used by more people in a wider variety of environments and levels of organisational decision-making. Visual representations of data are more amenable to group decision-making than are heuristics. The latter of these is a more individual and personal decision strategy and harder to justify in a group situation, whereas visual representation of data is easier to use in group situations, often tailored for those who may not have an in-depth knowledge about a certain field.

To the extent that relevant aspects of the environment are latched onto and irrelevant ones ignored, even very simple choice mechanisms are likely to yield satisfactory results (Payne and Bettman, 2004: 112). Conscious attention is the scarce resource for decision-makers and information processing is costly (Payne and Bettman, 2004: 112). “An increase in the cognitive (or emotional) cost of processing an item of information, like the cost of acquiring an item of information, will lead to greater use of simplification mechanisms that minimise information processing” (Payne and Bettman, 2004: 113). This shows how decision-makers would automatically divert attention towards techniques that will reduce cognitive load. Because processing is costly, people also tend to accept information in the form that it is given rather than trying to change it (which requires effort).

The two approaches connecting and successfully overlapping in reality is unlikely in reality. It is theoretically possible, but given that both approaches are so dependent on the decision environment and the use of appropriate information, the combination could be disastrous if

not used correctly. Given the stakeholders, the decision-makers in the organisation, the external and internal context and the dependency of the success of these approaches upon so many variables, the likelihood of combining the approaches successfully in reality may not be that high. What may work is to have a visualisation of a heuristic decision process, such as a fast and frugal decision tree. This combines information, but as little as possible and is made visual so that ideas can be easily shared in a group decision-making context (and therefore rationalised by the group), with the logic being understood by all. Biases are minimised and this looks like the most realistic opportunity for combining the two approaches to make fast and frugal visual decisions with minimal processing and maximum reduction of information overload.

### 5.3 Conclusion

When looking at visualisations and fast and frugal heuristics as decision support systems, it is important to be aware of the limitations of these techniques. Both planned reductions and intuitive decision-making leave decision-makers susceptible to framing and biases. In the determination of whether these two means of reducing information overload can successfully be connected, it is important to remember that in addition to the combined effect of their advantages, the negative effects of this could be doubled, with potentially disastrous results for decision-making. If being used together, there needs to be careful planning involved, with deliberate attention and space for discovering hidden patterns and new combinations, as well as situations that are not conducive to good decision-making. Decision-makers need to look at past situations to try and find patterns in the decision environment that could be replicated or avoided to encourage the desired actions.

There are values and limitations of visualisations and fast and frugal heuristics in their role in reducing information overload as DSSs in organisations. Attention is a scarce resource, and how when and who allocates attention is important for the decision outcome. There is often a tendency in organisations to deal with short term problems over long term planning. Both of these approaches can be used in forecasting decisions, assisting with long term strategic planning in addition to current short term decision-making. Visualisations tend to focus the attention of decision-makers in a more controlled and structured way than heuristics do. Cognitive biases are inherent in either approach. Good decision-making depends on a realistic assessment of the limitations of any cognitive process by the decision-maker, in addition to its values.

The study frames and combines existing issues differently to further an understanding of a different problem that is not usually discussed with regard to visualisation and fast and frugal heuristics. It discovered a similarity between visualisation and fast and frugal heuristics in the structure of the way information is handled. Both of the approaches discussed are means of reducing information to smaller chunks or sets that are manageable and that greatly enhance the efficiency of decision-making. This similarity also includes the pervasive reality of biases. Inherent in both of the approaches is the certainty that there are distortions in selection that lead to mistakes and biases in decision-making. These are especially prevalent in novel situations. Both methods of information handling are common in everyday decision-making,

but this study provides a new way of framing them, with relation to reducing information overload and in the possible combination the two methods. The combined use can amplify both the benefits and the dangers of each. Under the appropriate circumstances, visualisation and fast and frugal heuristics can be used as cognitive information management processes to reduce information overload, effectively improving the efficiency of organisational decision-making.

## BIBLIOGRAPHY

- Adler, P. S., Goldoftas, B., and Levine, D. I. (2012). Flexibility Versus Efficiency? A Case Study of Model Changeovers in the Toyota Production System. *Organization Science*, 10(1), 43-68.
- Andersson, P., Ekman, M., and Edman, J. (2003). Forecasting the Fast and Frugal Way : A Study of Performance and Information-processing Strategies of Experts and Non-experts When Predicting the World Cup 2002 in Soccer. *Business Administration working paper no. 2003: 9. SSE/EFI*.
- Arkes, H. R., Dawes, R. M., and Christensen, C. (1986). Factors Influencing the Use of a Decision Rule in a Probabilistic Task. *Organizational Behavior and Human Decision Processes*, 93-110.
- Astebro, T., and Elhedhli, S. (2006). The Effectiveness of Simple Decision Heuristics : Commercial Success for Forecasting Ventures. *Management Science*, 52(3), 395-409.
- Balls, A. 2012. 'The Flattening of Corporate Management' in *National Bureau for Economic Research* (online). 27 October 2012.
- Bawden, D., and Robinson, L. (2008). The Dark Side of Information: Overload, Anxiety and Other Paradoxes and Pathologies. *Journal of Information Science*, 35(2), 180-191.
- Bellgran, M., and Andersson, J. (2009). Spatial Design and Communication for Improved Production Performance. In Proceedings of the *Swedish Production Symposium*, November 2009.
- Benbasat, I., and Tan, J. K. (1990). Processing of Graphical Information: A Decomposition Taxonomy to Match Data Extraction Tasks and Graphical Representations. *Information Systems Research*, 1(4), 416-439.
- Bettman, J. R., and Kakkar, P. (1977). Effects of Information Presentation Format on Consumer Information Acquisition. *Journal of Consumer Research*, 3(4), 233.
- Biehal, G., and Chakravarti, D. (1982). Information-Presentation Format and Learning Goals as Determinants of Consumers' Choice Memory Retrieval and Choice Processes. *Journal of Consumer Research*, 8(4), 431-441.
- Biehl, J. T., Czerwinski, M., Smith, G., and Robertson, G. (2007). FASTDash: A Visual Dashboard for Fostering Awareness in Software Teams. *CHI 2007 Proceedings, April 28-May 3*, 1313-1322.
- Blair, A. (2012). Information Overload. *History of Ideas*, 64(1), 11-28.

- Bröder, A., and Eichler, A. (2006). The use of recognition information and additional cues in inferences from memory. *Acta psychologica*, 121(3), 275-284.
- Bröder, A., and Newell, B. R. (2008). Challenging Some Common Beliefs: Empirical Work within the Adaptive Toolbox Metaphor. *Judgement and Decision Making*, 3(3), 205-214.
- Busenitz, L. W., and Barney, J. B. (1997). Differences between entrepreneurs and managers in large organizations: Biases and heuristics in strategic decision-making. *Journal of Business Venturing*, 12, 9-30.
- Card, S., Mackinlay, J., and Robertson, G. (1991). The Information Visualizer: An Information Workspace. In *Proceedings of the SIGCHI conference on Human factors in computing systems: Reaching through technology*, 181-186.
- Castells, M. (2000). *The Rise of the Network Society* (Second Edition). Oxford: Blackwell Publishers.
- Chan, S. Y. (2001). The Use of Graphs as Decision Aids in Relation to Information Overload and Managerial Decision Quality. *Journal of Information Science*, 27(6), 417-425.
- Chandler, P., and Sweller, J. (1991). Cognitive Load Theory and the Format of Instruction. *Cognition and Instruction*, 8(4), 293-332.
- Chater, N., Oaksford, M., Nakisa, R., and Redington, M. (2003). Fast, Frugal, and Rational : How Rational Norms Explain Behavior. *Organizational Behavior and Human Decision Processes*, 90, 63-86.
- Cleveland, W. S., and McGill, R. (2009). Graphical Perception and Graphical Methods for Analyzing Scientific Data. *Advancement Of Science*, 229(4716), 828-833.
- Cobbold, B. I. M., and Lawrie, G. J. G. (2002). 'The Development of the Balanced Scorecard as a Strategic Management Tool' in *Performance Measurement Association*.
- Dean, D., and Webb, C. (2011). Recovering From Information Overload. *McKinsey Quarterly*, January 2011.
- DeBusk, G. K., Brown, R. M., and Killough, L. N. (2003). Components and Relative Weights in Utilization of Dashboard Measurement Systems like the Balanced Scorecard. *The British Accounting Review*, 35(3), 215-231.
- Dhami, M. K., and Harries, C. (2001). Fast and Frugal versus Regression Models of Human Judgement. *Thinking and Reasoning*, 7(1), 5-27.

- Eckerson, W., and Hammond, M. (2011). Visual Reporting and Analysis: Seeing is Knowing. *TWDI Best Practices Report (First Quarter)*.
- Edmunds, A., and Morris, A. (2000). The Problem of Information Overload in Business Organisations: A Review of the Literature. *International Journal of Information Management*, 20(1), 17-28.
- Eick, S. G., and Wills, G. J. (1995). High Interaction Graphics, *European Journal of Operational Research*, 81(3), 445-459.
- Eppler, M. J., and Mengis, J. (2003). A Framework for Information Overload Research in Organizations. *Organization Science*, (September), 1-42.
- Eppler, M. J., and Mengis, J. (2004). The Concept of Information Overload : A Review of Literature from Organization Science, Accounting, Marketing, MIS, and Related Disciplines. *Organization Science*, 325-344.
- Epstein, M., and Manzoni, J. (n.d.). The Balanced Scorecard and Tableau de Bord: A Global Perspective on Translating Strategy into Action. *Academy of Management Journal*.
- Few, S. (2012). Information Dashboard Design. *Perceptual Edge*.
- Forster, M. R. (1999). How Do Simple Rules “Fit to Reality” in a Complex World? *Minds and Machines*, (1), 543-564.
- Fuchs, G. (2005). Beyond the Dashboard: Making Better Decisions. *Business Intelligence Journal*.
- Gigerenzer, G. (1991). How to Make Cognitive Illusions Disappear : Beyond “Heuristics and Biases” in Stroebe, W and Hewstone, M (Eds). *European Review of Social Psychology*, 2, 83-115. Chichester: Wiley.
- Gigerenzer, G. (2001). Decision Making: Nonrational Theories. *International Encyclopedia of the Social and Behavioral Sciences*, 5, 3304-3309. Oxford: Elsevier.
- Gigerenzer, G. (2001(a)). ‘The Adaptive Toolbox: Toward a Darwinian Rationality’ in French, JA, Kamil, AC and Leger, DW (Eds). *Evolutionary Psychology and Motivation in Nebraska Symposium on Motivation*. Volume 48. Lincoln: University of Nebraska Press.
- Gigerenzer, G. ‘Fast and Frugal Heuristics: The Tools of Bounded Rationality’ in Koehler, DJ and Harvey, N (Eds). (2004). *Blackwell Handbook of Judgement and Decision-making*. Blackwell Publishing: Oxford.
- Gigerenzer, G. (2008). Why Heuristics Work. *Association for Psychological Science*, 3(1).

- Goldstein, D. G., and Gigerenzer, G. (2009). Fast and Frugal Forecasting. *International Journal of Forecasting*, 25(4), 760-772.
- Gigerenzer, G., and Gaissmaier, W. (2011). Heuristic Decision Making. *Annual review of psychology*, 62, 451-82.
- Gigerenzer, G., Hoffrage, U., and Kleinbölting, H. (1991). Probabilistic Mental Models: A Brunswikian Theory of Confidence. *Psychological review*, 98(4), 506-28. Available at: <<http://www.ncbi.nlm.nih.gov/pubmed/1961771>> [5 March 2011]
- Glazer, R., Steckel, J. H., and Winer, R. S. (1992). Locally Rational Decision Making: The Distracting Effect of Information on Managerial Performance. *Management Science*, 38(2), 212-226.
- Goldstein, D. G., and Gigerenzer, G. (1996). Reasoning the Fast and Frugal Way: Models of Bounded Rationality. *Psychological Review*, 103(4), 650-669.
- Goldstein, D. G., and Gigerenzer, G. (2002). Models of Ecological Rationality: The Recognition Heuristic. *Psychological Review*, 109(1), 75-90.
- Green, M. (1998). Toward a Perceptual Science of Multidimensional Data Visualization: Bertin and Beyond. *ERGO/GERO Human Factors Science*, 1-30.
- Gurumurthy, A., and Kodali, R. (2008). A Multi-criteria Decision-making Model for the Justification of Lean Manufacturing Systems. *International Journal of Management Science*, 3(2), 100-118.
- Harvey, N., and Bolger, F. (1996). Graphs versus Tables: Effects of Data Presentation Format on Judgemental Forecasting. *International Journal of Forecasting*, 12, 119-137.
- Hemp, P. (2009). Death by Information Overload. *Harvard Business Review*, 87(9), 83-89.
- Hilbig, B. (2008). Individual Differences in Fast-and-frugal Decision Making: Neuroticism and the Recognition Heuristic. *Journal of Research in Personality*, 42(6), 1641-1645.
- Hogarth, R. M., and Einhorn, H. J. (1981). Behavioral Decision Theory: Processes of Judgment and Choice. *Journal of Accounting Research*, 19(1), 1-31.
- Holbrook, M. B., and Moore, W. L. (2012). Feature Interactions in Consumer Judgements of Verbal Versus Pictorial Presentations. *Journal of Consumer Research*, 8(1), 103-113.
- Holt, J. (2011). 'Two brains running' in *The New York Times: Sunday Book Review*, 25 November 2011.

- Hunt, R. G., Krzystofiak, F. J., Meindl, J. R., and Yousry, A. M. (1989). Cognitive Style and Decision Making. *Organizational Behavior and Human Decision Processes*, 44(3), 436-453.
- Hutchinson, J. W., Alba, J. W., and Eisenstein, E. M. (2010). Heuristics and Biases in Data-Based Decision Making: Effects of Experience, Training, and Graphical Data Displays. *Journal of Marketing Research*, XLVII (August), 627-642.
- Inatsugu, H. (2001). Personnel Systems in Japanese Local Governments. *The World Bank Institution*.
- Jarvenpaa, S. L. (1989). The Effect of Task Demands and Graphical Format on Information Processing Strategies. *Management Science*, 35(3), 285-303.
- Kahneman, D., and Tversky, A. (1979). Prospect Theory: An Analysis of Decision under Risk. *Econometrica*, 47(2), 263-292.
- Kahneman D., and Riis J. (2005). 'Living, and Thinking About It: Two Perspectives on Life' in Huppert, F. A., Baylis, N. and Keverne, B. (Eds.). *The science of well-being*, 285-304. Oxford: Oxford University Press.
- Kahneman, D. (2011). *Thinking, Fast and Slow*. London: Penguin Books.
- Kalyuga, S., and Renkl, A. (2009). Expertise Reversal Effect and Its Instructional Implications: Introduction to the Special Issue. *Instructional Science*, 38(3), 209-215.
- Kaplan, R., and Norton, D. (1992). The Balanced Scorecard- Measures That Drive Performance. *Harvard Business Review*.
- Katsikopoulos, K. V. (2010). Psychological Heuristics for Making Inferences: Definition, Performance, and the Emerging Theory and Practice. *Decision Analysis*, 08(1), 1-24.
- Kattman, B., Corbin, T. P., Walsh, L., and Moore, L. E. (2012). Visual Workplace Practices Positively Impact Business Processes. *Benchmarking: An International Journal*, 19(3).
- Kirschner, P. A., Clark, R. E., and Sweller, J. (2006). Why Minimal Guidance During Instruction Does Not Work: An Analysis of the Failure of Constructivist, Discovery, Problem-Based, Experiential, and Inquiry-Based Teaching. *Educational Psychologist*, 41(2), 75-86.
- Kleinmuntz, B. (1990). Why We Still Use Our Heads Instead of Formulas: Toward an Integrative Approach. *Psychological bulletin*, 107(3), 296-310. Available at: <<http://www.ncbi.nlm.nih.gov/pubmed/2190252>> [20 February 2012]

- Lin, S. and Bier, V. M. (2008). A Study of Expert Overconfidence. *Reliability Engineering & System Safety*, 93(5), 711-721.
- Lipe, M. G., and Salterio, S. E. (2000). The Balanced Scorecard: Judgmental Effects of Common and Unique Performance Measures. *The Accounting Review*, 75(3), 283-298.
- Lucas, H. C., and Nielsen, N. R. (1980). The Impact of the Mode of Information Presentation on Learning and Performance. *Management Science*, 26(10), 982-993.
- Lurie, N. H. (2004). Decision Making in Information-Rich Environments: The Role of Information Structure. *Journal of Consumer Research*, 30(4), 473-486.
- Lurie, N. H., and Mason, C. H. (2007). Visual Representation: Implications for Decision Making. *Journal of Marketing*, 71(January), 160-177.
- Malhotra, N. K. (1982). Information Load and Consumer Decision Making. *Journal of Consumer Research*, 8(4), 419-430.
- March, J. G. (1994). *A Primer on Decision Making: How Decisions Happen*. New York: The Free Press.
- Martinsons, M., Davison, R., and Tse, D. (1999). The Balanced Scorecard : A Foundation for the Strategic Management of Information Systems. *Decision Support Systems*, 25, 71-88.
- Messner, C., and Wänke, M. (2011). Unconscious Information Processing Reduces Information Overload and Increases Product Satisfaction. *Journal of Consumer Psychology*, 21(1), 9-13.
- Meyer, A. D. (1991). Visual Data in Organizational Research. *Organization Science*, 2(2), 218-236.
- Michalos, A. (1973). Strategies for Reducing Information Overload in Social Reports. *Strategies*, 1(1), 107-131.
- Newell, B. R., Weston, N. J., and Shanks, D. R. (2003). Empirical Tests of a Fast-and-frugal Heuristic: Not Everyone “Takes-the-best”. *Organizational Behavior and Human Decision Processes*, 91, 82-96.
- Newell, B. R. (2005). Re-visions of rationality? *Trends in cognitive sciences*, 9(1), 11-5.
- O’Reilly, C. A. (1980). Individuals and Information Overload in Organizations: Is More Necessarily Better? *Academy of Management Journal*, 23(4), 684-696.

- Over, D. 'Rationality and the Normative/Descriptive Distinction' in Koehler, DJ and Harvey, N (Eds). (2004). *Blackwell Handbook of Judgement and Decision-making*. Oxford: Blackwell Publishing.
- Papadakis, V., Lioukas, S., and Chambers, D. (1998). Strategic Decision-making Processes: The Role of Management and Context. *Strategic Management Journal*, 19(2), 115-147.
- Paschkewitz, J. J. (2011). Ensuring Reliability in Lean New Product Development. *ASME 2011 International Mechanical Engineering Congress and Exposition*, 1-9.
- Payne, J. (1976). Task Complexity and Contingent Processing in Decision Making: An Information Search and Protocol Analysis. *Organizational Behavior and Human Performance*, 16(2), 366-387.
- Payne, J.W. and Bettman, J. R. 'Walking with the Scarecrow: The Information-processing Approach to Decision Research' in Koehler, DJ and Harvey, N (Eds). (2004). *Blackwell Handbook of Judgement and Decision-making*. Oxford: Blackwell Publishing.
- Pinker, S. (1990), 'A Theory of Graph Comprehension' in Feedle, R (Ed.), *Artificial Intelligence and the future of testing*, 73-126.
- Powell, W. W., and Snellman, K. (2004). The Knowledge Economy. *Annual Review of Sociology*, 30(1), 199-220.
- Rachlin, H. (2003). Rational Thought and Rational Behavior: A Review of Bounded Rationality: The Adaptive Toolbox. *Journal of the Experimental Analysis of Behavior*, 79(3), 409-412.
- Russell, A. D., Chiu, C.Y., and Korde, T. (2009). Visual Representation of Construction Management Data. *Automation in Construction*, 18(8), 1045-1062.
- Ryszard, B. (2007). 'Management by Exception' in *Strategic Control* (online). Available at: <<http://www.strategic-control.24xls.com/en232>> [30 October 2012]
- Savolainen, R. (2007). Filtering and Withdrawing: Strategies for Coping with Information Overload in Everyday Contexts. *Journal of Information Science*, 33(5), 611-621.
- Schick, A. G. (1990). Information Overload: A Temporal Approach. *Accounting, Organizations and Society*, 15(3), 199-220.
- Schwenk, C. R. (1984). Cognitive Simplification Processes in Strategic Decision-making. *Strategic Management Journal*, 5(2), 111-128.
- Schwenk, C. R. (1988). The Cognitive Perspective on Strategic Decision Making. *Journal of Management Studies*, 25(1), 41-55.

- Segel, E., and Heer, J. (2010). Narrative Visualization: Telling Stories with Data. *IEEE transactions on visualization and computer graphics*, 16(6), 1139-48.
- Silveira, P., Rodríguez, C., Casati, F., Daniel, F., Andrea, V. D., and Worledge, C. (2010). On the Design of Compliance Governance Dashboards for Effective Compliance and Audit Management. *Management Science*, (April 2009).
- Simkin, D., and Hastie, R. (2007). An Information-Processing Analysis of Graph Perception. *Journal of the American Statistical Association*, 82(398), 454-465.
- Simon, H. (1979). Rational Decision Making in Business Organizations. *The American Economic Review*, 69(4), 493-513.
- Simon, A. (1990). Invariants of Human Behaviour. *Annual review of psychology*, 41, 1-19.
- Sparrow, P. (1999). Strategy and Cognition: Understanding the Role of Management Knowledge Structures, Organizational Memory and Information Overload. *Creativity and Innovation Management*, 8(2), 140-148.
- Speier, C., Valacich, J. S., and Vessey, I. (1999). The Influence of Task Interruption on Individual Decision Making: An Information Overload Perspective. *Decision Sciences*, 30(2).
- Sunstein, C. R. (2005). 'Fast, Frugal, and (Sometimes) Wrong' in Sinnott-Armstrong, W (Ed). (2005). Massachusetts: Bradford Books.
- Sweller, J. (1988). Cognitive Load During Problem Solving: Effects on Learning. *Cognitive Science*, 12(2), 257-285.
- Tanaka, T. (2007). Quickening the Pace of New Product Development. *QV System*, 1-9.
- Tegarden, D. P. (1999). Business Information Visualization. *Business Information Visualization*, 1(1).
- Tezel, A., Koskela, L., and Tzortzopoulos, P. (2009). The Functions of Visual Management. Proceedings of the International Research Symposium. Salford, UK.
- Todd, P. M., and Gigerenzer, G. (2007). 'Mechanisms of ecological rationality: heuristics and environments that make us smart' in Dunbar, RIM and Barrett, L (Eds). *The Oxford Handbook of Evolutionary Psychology*. Oxford: Oxford University Press.
- Tufte, ER. (1983). *The Visual Display of Quantitative Information* (second edition). Connecticut: Graphics Press.
- Tufte, E. R. (2006). *Beautiful Evidence*. Connecticut: Graphics Press LLC.

- Tufte, E. R. (2009). Power Point Is Evil. *Style (DeKalb, IL)*, (11), 1-5.
- Tversky, A. and Kahneman, D. (1986). Rational Choice and the Framing of Decisions. *The Journal of Business*, 59(4), S251-S278.
- Umanath, N., and Vessey, I. (1994). Multiattribute Data Presentation and Human Judgment: A Cognitive Fit Perspective. *Decision Sciences*, 25(5/6).
- van Bruggen, G.H., Smidts, A., and Wierenga, B. (1998). Improving Decision Making by Means of a Marketing Decision Support System. *Management Science*, 44(5), 645-658.
- Van Zandt, T. (2004). Information Overload in a Network of Targeted Communication. *Rand Journal of Economics*, 35(3), 542-560.
- Vessey, I. (1994). The Effect of Information Presentation on Decision Making: A Cost-benefit Analysis. *Information and Management*, 27(2), 103-119.
- Wainer, H., and Velleman, P. F. (2001). Statistical Graphics: Mapping the Pathways of Science. *Annual Review of Psychology*, 52, 305-335.
- Walczak, S. (2001). Neural Networks as a Tool for Developing and Validating Business Heuristics. *Expert Systems with Applications*, 21, 31-36.
- Whinston, A. B., and Zhang, P. (1995). Business Information Visualization for Decision-Making Support - A Research Strategy. *iSchool Faculty Scholarship, Paper 15*.
- Whyte, J., Ewenstein, B., Hales, M., and Tidd, J. (2008). Visualizing Knowledge in Project-Based Work. *Long Range Planning*, 41(1), 74-92.