Decisions with Medium to Long-Term Consequences: Decision Processes and Structures.

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Decisions with Medium to Long-Term Consequences: Decision Processes and Structures.

Marianne Jakobsson
To my family, Krister,
Alma and Tida
Abstract

All of us make more or less important decisions during our entire lives, in private and professional arenas. Some decisions have consequences for an individual or organization in the short term, others have long lasting consequences. This thesis concerns studies of decision processes and structures involved in decision-making with medium to long-term consequences for an organization or individual. Study I and II focus decision-making theory and judgments in procurement. Study III concerns real-life, individual career decision-making. Study I used a laboratory context for an investigation of willingness to pay (WP) for the creation of a procurement offer. Study II investigated organizational decision processes and structures of procurement of large projects in a nuclear power plant organization. Study III investigated the decision process used to make a choice between two professional training programs leading to psychotherapist certification. Study I found, that participants used a multiplicative combination of probability and profit when judging WP for the creation of a bid. Scales of subjective probability had smaller ranges than objective probability. In this context, participants were more sensitive to variation in monetary value than to probability. In Study, II it was possible to describe the procurement process in a framework of information search and decision theory. A Multi Attribute Utility Theory-inspired model was used by the staff, in the evaluations of procurement alternatives. Both compensatory (e.g. negative aspects can be compensated by positive aspects) and non-compensatory (particular “pass” levels of attributes have to be exceeded for acceptance of a choice alternative) decision rules were used. In study III it was found that a development and extension of Differentiation and Consolidation theory described individual reasons pro and con alternatives before and after the choice of a professional training program.

Keywords: Decision-making, decision-structure, decision-process, decision-theory, nuclear safety
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List of Studies

The present doctoral thesis is based on the following studies:


Abbreviations

Differentiation and Consolidation theory – Diff Con
Expected Value – EV
EU – Expected Utility
SEU - Subjective Expected Utility
Multi Attribute Utility Theory – MAUT
Information Integration - II
Information Integration Theory – IIT
Willingness to pay - WP
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1.0 Introduction

Decision-making is an activity that follows us through our lives. Some decisions have short impact on our daily life while other decisions have long-lasting consequences for our self and/or others. Decision-making takes place in private life as well as in professional arenas. The studies in this thesis concern decision processes and structures involved in decision-making with medium to long-term consequences for the organization or individual. Thus, I do not consider minor, short-term decisions like what candy, or toothpaste to buy. Research of procurement has become a research area of great interest in Sweden since procurement is important in society, and not least, in public procurement. The area of procurement involves judgments and decisions both for buying and offering organizations. However, the field does not have a long research history. Also, it seems that it was investigated mostly in an exploratory manner. Therefore, parts of this thesis will focus on decision-making theory and judgment in procurement. It will present both a laboratory experiment, and applied research. In Study I, it was tested, to what extent economic theory in the form of Expected Value (EV) applies to hypothetical judgments of procurement problems. In Study II, procurement decisions in a company setting were studied with the aid of its written routines and descriptions from interviews about how the staff used the routines.

Another important area of decision-making, this time with the individual in focus, is real-life individual career decision-making. In Study III, the decisions investigated were made by clinical psychology students choosing between psychotherapeutic training programs. The choice has very high relevance for the psychologists’ later work life and it was a decision that created a great deal of involvement from the psychology students. Differentiation and Consolidation theory (Diff Con) was empirically tested by letting the participants give their own reasons pro and con the decision alternatives with judgments of the
strength of each reason leading to a new theoretical development of the theory. Thus, the thesis includes three papers about judgment and decision processes and structures involved in important decisions with medium to long-term consequences for either an organization or an individual.
2.0 Purpose of and Brief Introduction to Research Problems Studied.

To repeat, the aim of this thesis was to study decisions with medium to long-term consequences. Problem (1) To what extent does classical economic theory apply to procurement judgments? Problem (2) How can procurement routines in a nuclear power plant be described by a process oriented approach to decision-making and classical decision theory? Problem (3) How can a real life career decision be described by a process oriented decision theory?
3.0 Theories and research approaches

Decision-making theory covers a large variety of perspectives on how decisions should be made (normative decision theory), how decisions are made in practice or in reality (descriptive decision theory) and ways to optimize decisions (prescriptive decision theory). Normative decision theory represents the ideal way to make decisions based on a theory of rational processing of all possible information. Descriptive decision theory represents “the realistic part” of decision theory and describes how people make decisions in different situations and circumstances. The normative and the descriptive decision theories are closely connected since there is a common research aim to compare the normative decision-making with the way decisions are made. A structural research approach, where only the parameters of the decision problems leading to the outcome of a decision are studied and not the cognitive process in itself, can be used to study decision-making (Abelson & Levi, 1985). In this thesis the discrepancy between a normative structural decision model, Expected Value (EV) and the description of participants’ choices under risk will be illustrated in Study I (See Table 1). Judgment and decision making under risk refers to a situation were probabilities, and for example, monetary outcomes are known (Edwards, 1962). Another approach of studying decision-making is descriptive. A process approach means that also the mental process of the “psychological path” leading to a decision is studied. This approach will be illustrated in Study III in this thesis by an empirical test of a process oriented decision theoretical framework (See Table 1). Study II in this thesis studies routines for and actual judgment behavior and decision processes in a nuclear industry for the staff to find the best and winning contractor (See Table 1).
3.1 Structural Approaches

The classification “structural approach” applies to a theory that relates central information available about alternatives of a decision to the outcome of the decision. The mental processes in reaching the decision or the process after the decision has been created are not relevant in this approach (Abelson & Levi, 1985). As mentioned before, Study I of this thesis is an example of a study using a structural approach (See Table 1).

3.2 Normative Theories

In Expected Value Theory (EV) a decision problem can be treated as a gambling situation with each decision as a potential bet with the possibility of gains and losses (Beach & Connolly, 2005). Primary principles of the theory are multiplication of the value \( v \) of a specific outcome by the probability \( p \) of the outcome and summing the products of outcomes \( p_i v_i \), \( i=1,2,3…n \). EV applies to objective probabilities and e.g. monetary values and is used when participants calculate known profits and probabilities to compute the best possible (in this case) expected monetary value (See Table 2). Early theories (Bernoulli, 1738/1954) and later (von Neumann & Morgenstern, 1947) postulated that utility was not a linear function of monetary value. At present, the EV theory is used only in comparisons with real human behavior as a rational norm (Edwards, 1954; Jøsang & Presti, 2004; Weber, 2010). This is also the approach chosen in Study I of the present dissertation (See Table 1).

Expected Utility (EU) Theory. The theory was invented as a result of the criticism of EV and adds other dimensions to the situation (Bernoulli, 1738/1954; Von Neumann & Morgenstern, 1947). Von Neumann and Morgenstern independently developed the primary axioms for Expected Utility theory. A core theme in the reasoning is that a game or a decision situation is not evaluated from the perspective of money gains to win or lose but in the perspective of which conse-
quence the result has in the level of wealth of a person and with at diminishing marginal utility with increasing monetary value. In Table 2, EU, that would mean that the subject knows and correctly uses the given probabilities but makes subjective judgments of the value of profits (Edwards, 1954).

Empirical, behavioral findings did not fit the EU theory very well (e.g., Allais, 1953; Mosteller & Nogee, 1951; Strotz, 1953). The theory had not used the individual’s own subjective representations of given probabilities but instead assumed that the decision maker fully could understand a given probability as such and that she or he was also was able to compute EU in the judgmental part of the decision process (See Table 1).

Subjective Expected Utility (SEU). A further development of EU-theory was SEU (Edwards, 1954). SEU merged from EU with its framework of von Neumann and Morgenstern axioms of utility maximization and a set of experiments by Ramsey (1931) on subjective probabilities. Ramsey (1931) raised the problems with objective probabilities and found evidence for systematically deviating subjective probabilities. It was hard to ignore the gap between the physical environment in which the judgments and the decisions were presented and the decision makers’ individual, subjective perceptions of the environment. These findings apply to infinite numbers of situations where a human being makes judgments and choices. When this distinction was pointed out, it was clear that predictions could not be made directly from an objectively described environment using, for example, probabilities. The perceptions and cognitive processing of information and the limitations of human perception and cognitive capacity to “map and calculate” the environment needs an understanding of human perceptual and cognitive processing (Simon, 1957).
Table 1. The thesis categorizations of the studies, normative and descriptive theory and structural and process research approaches.

<table>
<thead>
<tr>
<th>Structure</th>
<th>Normative</th>
<th>Descriptive</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Study I,</td>
<td>Study I &amp;II</td>
</tr>
<tr>
<td></td>
<td>EV, EU, SEU</td>
<td>SEU, MAUT, IIT</td>
</tr>
<tr>
<td></td>
<td>MAUT, Decision Aids¹</td>
<td>PT</td>
</tr>
<tr>
<td>Process</td>
<td>Decision Aids¹</td>
<td>Study, II &amp; III, PT, Diff Con</td>
</tr>
</tbody>
</table>

¹ Decision Aids are not treated in this thesis.

Work by de Finetti (1937/1964) also contributed to the introduction of subjective probabilities into decision theory. Savage (1954) completed a theoretical synthesis with the SEU framework, applying mainly to decisions involving uncertainty, i.e. decisions where the decision maker has to make estimations of the probabilities of events. It integrated subjective probabilities and subjective utility to characterize choice behavior of humans within the primary assumption of utility maximization. In SEU, the Expected Utility (U) replaces the value (V) in the formula for EV. The probability in the formula of EV is replaced by the individuals’ subjective assumptions concerning the probability of an outcome (See Table 2). When the probability of the outcome is known, (See Table 2) it has historically been named as decisions involving risk (Edwards, 1962). Study I of this thesis is an example of judgment and decision under risk. In Study II of this thesis there are examples of the staff having to estimate probabilities (and consequences) in a self-created MAUT-decision instrument. This is an example of decision under uncertainty and will be described later in the text.
Table 2. Three Variations of the Expected Value Model (modified from Edwards, 1955).

<table>
<thead>
<tr>
<th>Profit</th>
<th>Probability</th>
</tr>
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<tbody>
<tr>
<td>objective</td>
<td>objective</td>
</tr>
<tr>
<td>subjective</td>
<td>subjective</td>
</tr>
</tbody>
</table>

The SEU-model has met criticism, for example, for neglecting the cognitive aspects of decision making under risk (Kogan & Wallach, 1968).

*Multi Attribute Utility Theory (MAUT)* covers the rational evaluation and choice between alternatives in a multi-attribute decision task and is often used as a tool for improvements of human decision-making (decision aids). A decision problems attribute can be divided into sub attributes, processed in the same way as SEU (von Winterfeldt & Edwards, 1986). One example that often involves multi-attribute decision-making is the buying of a car. Purchase price span is often one characteristic that creates a frame for the decision, but inside that frame a lot of other attributes might be of concern, such as, running costs, color, performance, size, safety, comfort, design and others. The MAUT has been applied in various fields.

As an empirical illustration, Hämäläinen, Lindstedt and Sinko (2000) showed that a MAUT-analysis is useful in nuclear emergency management. The use of a neutral facilitator, in this case one of the researchers, and a value-focused approach was seen as useful when right after the accident selecting a strategy for protecting of the population
after a simulated nuclear accident. The neutral facilitator was seen to be beneficial to keep the discussion focused and take the right steps in the right order to reach a well-founded decision in the limited time. Also, a lot of staff was not familiar with the foundations of decision theory, which is where a neutral facilitator could be of help. The neutral facilitator could help the nuclear experts to avoid pitfalls such as groupthink and biases coming from expertise in nuclear. The MAUT-risk analysis ensured that the decision makers considered all aspects of a decision problem and that their values and preferences were made explicit. The prioritizations and the structuring during the decision analysis is, according to the authors, often the phase where there are the most gains in using decision-analysis approach. Also, the situation of decision-making in a group setting of experts from different areas coming together to form decisions was regarded to benefit from using a MAUT-risk analysis approach. The structured approach would give the participants a common framework enhancing communication between the parties. The attributes should be determined in advance since the process of finding them is time consuming. (Hämäläinen, Lindstedt & Sinko, 2000). Kainuma and Tawara (2005) proposed MAUT for assessing supply chains (in general) extended by integrating environmental factors. They considered this approach to be one of “the lean and green supply chain” methods. The method enabled the evaluation of a supply chain performance from both a managerial viewpoint and an environmental viewpoint. MAUT was used as a tool when an expert panel identified 24 factors representative of Nursing Practice Models (Brennan & Anthony, 2000). The 24 factors were identified in order to produce quantitative measurement techniques to provide a useful evaluation of nursing practice. The aim of the quantitative measurement techniques was to complement the existing measurement of Nursing Practice Models, which were costly, and non-reproducible, global judgments made by experts. As decision research as a field has evolved and widened, research inspired by the theories above have blossomed. They are all classified as structural theories by Abelson & Levi (1985).

Prospect Theory (PT) is a decision theory with elements of cognitive processes. It postulates an early phase were the decision problem is edited and a later phase of evaluation. The first phase enables a first fast analysis of possible prospects (alternatives). In the evaluation
phase, the prospects are compared, and the prospect with the highest 
value is chosen. The parameter $w$ is the function of weight and $v$ is the 
value function. PT relates variables to probability and value (utility). 
A decision situation is judged relative to the decision maker’s personal 
value reference point. The reference point can be affected by, e.g., 
framing factors that can result in different decisions for the same deci-
sion problem (Kahneman & Tversky, 1979). Thus, the value function 
depends on the change in assets. It is connected to the reference point 
in such a way that people adapt to changes in for example wealth and 
form new points of reference. A wealth level will therefore, for one 
person be seen as richness and another as poverty. The value function 
also depends on the level of wealth as in EU and SEU. The value 
function is quite stable in relation to the reference point, which means 
that people with quite different amounts of actual wealth consider a 
gain on the value axis about equally attractive. The same applies to 
losses. For most choice problems it seems that the reference point is 
the status quo of current assets. However, there are circumstances 
where gains or losses are considered in the light of an expectation or 
aspiration level. Kahneman and Tversky (1979) give the example of 
an unexpected taxation on the pay cheque, which is considered as a 
loss and not as a reduced gain. Thus, the point of reference is im-
portant for how a decision maker judges gains and losses as expressed 
in e.g. monetary value.
As seen in Figure 1, the value function is steeper for losses than gains, which means a general loss aversion, the same monetary loss means more negative utility than a corresponding gain positive utility.

![Value Function](image)

Figure 1. Example of value function according to PT.

Then there is the weight function (w) for probabilities. One of the central characteristics of the estimated weight function is that, for small probabilities, (objective probabilities close to zero) it is over weighted, \( w(p) > p \) and, for large probabilities, (objective probabilities close to one) it is under weighted \( w(p) < p \). A primary assumption is that \( w(0) = 0 \) and \( w(1) = 1 \). Very close to 0.00, the probability is evaluated as 0, and the over weight changes to under evaluation. The same occurs for probability judgments close to 1.00 where these values are approx-
imated by 1. These approximations can be created either in the editing or evaluation phases. The introduction of the cumulative prospect theory (CPT) (Tversky & Kahneman, 1992) developed further the original PT, but this theoretical development is of minor importance in this dissertation.

3.3 Descriptive Theories

In modern decision research, (from the 1960s and on) there has been a great concern with and a lot of results reporting that decision makers are not perfectly rational or calculating correctly when they make their decisions. Instead, deviations from rationality have often been found in studies testing normative decision-making by, for example, Prospect Theory (Kahneman & Tversky, 1979; Slovic, Fischhoff & Lichtenstein, 1977). This development resulted in structural decision models used in studies of how people actually make decisions and interpretations of discrepancies between predictions based on normative theories and real decision/judgmental behaviors (Gilovich, Griffin & Kahneman, 2008).

One theory that has, among others, focused on decision-making from a descriptive point of view is Information Integration Theory (IIT). IIT was developed and generalized in the 60’is. It is an inductive theory (Anderson, 1981), compared, for example, to the deductive, axiomatic approach of EU. IIT, (Anderson & Shanteau, 1970) meets many of the criticisms made of SEU, such as; the criticism of neglecting cognitive aspects of decision making and risk taking (Kogan & Wallach, 1967). Already in 1961, the problem of measuring and disentangling the subjective value and subjective probability functions when experimenting on SEU was discussed (Edwards, 1961).

The primary concept of IIT is integration: (1) How do people integrate or synthesize information about multiple stimuli (in this case monetary values and probabilities) to produce their responses (See Figure 2). (2) How can a given response be decomposed into its components, valuation; the processing that translates physical stimuli, (e.g., the cognitive representation of 90 % probability) to corresponding psychological value, cognitive algebra. There seems to be a com-
mon tendency for people to average, subtract or multiply when inte-
grating information. *Functional measurement* is the conceptual foun-
dation and practical techniques for deriving psychological mental val-
ues from the information presented to a person, often and in the pre-
sent dissertation, numerical stimulus.

\[
\begin{align*}
S_1 & \rightarrow s_1 \\
S_2 & \rightarrow s_2 \rightarrow r \rightarrow R \\
S_3 & \rightarrow s_3
\end{align*}
\]

Valuation function  Integration function  Response function

Figure 2. S (physical stimuli) influences the participant and they are
processed by the valuation function into s (psychological values),
which are integrated to r (implicit response), which is externalized to
the explicit response R.

IIT has used the method of functional measurement in order to ana-
lyze information integration (II). During the development of the the-
ory, a number of generalized models for IIT were found. They are add-
ing-type models, multiplying models and averaging models. To test
the strategy with which participants integrate information the stimuli
should be manipulated in a factorial design, which is the design, used
in Study I of this thesis. If an additive model is used for Information
Integration, the response data will exhibit parallelism when judgments
in each row are plotted separately against the column values in the x-
axis. If a multiplying model is used, the response data will exhibit a
fan-pattern. Crossovers in plots with response data, for example, part-
ly parallel plot-curves but with crossovers in the plotted data suggest
In an experiment (Anderson & Shanteau, 1970), stimuli with objective probabilities in the form of the roll of a dice with a chance of winning of 1/6, 2/6, 3/6, 4/6 and 5/6 and the monetary value of 5, 10, 25 and 50 cents were used. This corresponds to Study I of this thesis, in which there were hypothetical alternatives with objective probabilities and monetary values. Study I of this thesis differs from Anderson and Shanteau (1970) study in that it had hypothetical scenario vignettes consisting procurement decisions instead of a hypothetical gambling problem. In Study I, probability was presented as percentages of the chance to obtain procurement offering instead of the chance by a dice. The monetary values of hypothetical gain used in Study I were large, from 100 000 to 2 000 000 SEK, whereas the hypothetical monetary values to win were quite small in the study by Anderson and Shanteau (1970). The results of Anderson's and Shanteau study (1970) showed a linear fan pattern that supported a multiplicative model and the objective and subjective probabilities were nonlinearly related. The theoretical foundation of these findings was inductive and, therefore, the subjective values and probabilities found were called SEV at the time (subjective expected probabilities and values) instead of SEU, since the foundations of EU was not a starting point for IIT approach at that time. The results were verified by Shanteau (1974).

IIT gives a theoretical foundation also for treating multi attribute models (Anderson, 1981, 1982, 2007, 2013; Anderson & Zalinski, 1988; Zalinski & Anderson, 1989), but this capacity will not be used in this thesis. Study I used functional measurement in its study of how objective probabilities and monetary outcome values are used in judgments of procurement offers.

### 3.3 Process Theories

Already in 1951, Lewin stated assumptions concerning the connection between pre-decision and post-decision representations of decision alternatives. Festinger developed the assumptions further into his Theory of Dissonance. The central concern, in the Theory of Dissonance, (Festinger, 1957, 1964) is to point out the process following a decision. Post decision conflicts (dissonance) lead to cognitive processing in order to minimize the tension (negative feeling caused by
dissonance) by a spreading of alternatives to favor the attractiveness of the chosen alternative and to disfavor the attractiveness of the non-chosen alternative (Festinger, 1957; 1964). When the spreading of the alternatives occurs the negative feeling of the decision will be reduced. The Theory of Cognitive Dissonance was developed into conflict, choice and commitment theory by Janis and Mann (1977). The central issue for the development was to show that the restructuring of the decision problem and biases in the information search start already in the pre-decision phase. The post-decision conflict will remain only if the restructuring in the pre-decision phase was not completely successful. Sanfey, Rilling, Aronson, Nystrom and Cohen (2003) found that distress or conflict early in the decision-making process may be comforted by increased activity in particular brain regions. The brain regions can both ease a shift toward decision-consistent attitudes, and regulate the activity in other brain regions responsible for experiences of arousal, affective distress or discomfort (Sanfey et al. 2003). Focusing on brain activity during pre- and post-decision stimulus ratings, it was found that brain activity in particular areas of the brain during initial ratings, predicted subsequent selection of items. Change in activity, in the same brain area, during ratings following decision-making was highly correlated with attitude change (Sharot, De Martino, Dolan, 2009). Berkman and Liberman (2011) studied attitude change and difficult, self related decisions. Participants “rationalized” by scoring “they never wanted” the rejected alternative. Using Functional Magnetic Resonance Imaging, fMRI (a technique that can give a picture of the working brain), it was possible to track how the decision-related attitude change happened. It was found that the decision-related attitude change was an immediate byproduct of conflict-resolution processes during the decision-making. This was consistent with the suggestion of dissonance reduction as a consequence of brain down-regulation of distress or arousal responses, through selection of more decision-consistent interpretations of stimuli. Decision-making may involve a fast spreading of processes aimed at solving discomfort or distress generated early in the decision-making process. The parameters of negative and positive feelings concerning the decision over the entire decision process (pre- and post-decision) were investigated in Study III in this thesis.
Study III, investigated both the pre-decision and the post-decision phases and the restructuring in both phases. Dominance structuring theory aims to describe how decisions are formed (Montgomery, 1983). All decision processes are assumed to aim at the goal of finding one dominant alternative and, therefore, the rule of dominance was in authority of all other decision rules. When an alternative had reached dominance, the theory proposes that no more structuring will occur. The pre-decision phase is in focus in this theory, and split into the following phases: (1) pre-editing (2) finding a promising alternative (3) testing of dominance (4) structuring of dominance (Montgomery, 1983). Dominance was not studied specifically in this thesis. Payne, Bettman, Coupey and Johnson (1992) and others have later found empirical evidence of value restructuring mostly in the pre-decision process.

Differentiation and Consolidation theory, (Svenson, 1992, 1996, 2003, 2006) describes decision-making as an ongoing process in which one alternative is gradually differentiated from competing alternatives. When a decision problem is encountered a preliminary decision alternative is selected (cf. dominance theory). To support the preliminary choice in subsequent decision processes there are different decision rules applied in an adaptive way to make a decision possible. Restructuring of facts and evaluations to support the preliminary choice may also occur. The preliminary choice will be the final decision if the first differentiation process is successful. If the process is not successful, another preliminary choice will be selected, and there will be a new differentiation loop. Facts and evaluations of facts, the attractiveness of the facts, are treated in the decision process in a way so that structuring and restructuring of both facts and evaluations of facts may occur in the process of reaching a decision that is coherent with the chosen alternative as the best and of the non-chosen alternative as a safely rejected alternative. This coherence is called a between alternative coherence with a decision (Holyoak & Simon, 1999; Simon, Pham, Le & Holyoak, 2001; Glöckner & Betsch, 2008). The present thesis tests parts of the Diff Con theory in a real-life career decision context and with some methodological and theoretical additions to the original theory and its methods.
Diff Con describes that value/attractiveness evaluations are restructured both before and after a decision in a manner that the chosen alternative is upgraded in attractiveness and/or the non-chosen alternative downgraded in order to complete a decision and later to further support a decision made. Within alternative coherence can also appear in the phases of pre-decision differentiation and post-decision consolidation. This means, that an alternative that is a preliminary choice, is gradually restructured during the decision process to create a stronger correlation between its decision supporting attributes at the end than at the start of the decision process. A non-chosen alternative is restructured to achieve greater within coherence as a rejected alternative (Bond, Carlson, Meloy, Russo & Tanner, 2007). The within alternative coherence both for the chosen alternative and the non-chosen alternative in the pre-decision and the post-decision phases was investigated in Study III of this thesis.

Seemingly natural ways of thinking about decisions are in terms of reasons pro and con the different alternatives (Shafir, Simonson & Tversky, 1993). This approach was used in Study III using reasons, unlike the traditional way of treating attributes when analyzing decisions. The smallest unit traditionally analyzed, the attractiveness of an aspect (of an attribute), was in this study replaced by the strength of a reason. Different reasons can be used for different alternatives rather than having all alternatives characterized by the same set of attributes as in most traditional decision studies.

The studies in this thesis concern decision processes and structures involved in decision-making with medium to long-term consequences for the organization or the individual. As mentioned earlier, part of the thesis will focus on some questions arising in the area of procurement and will report on a controlled empirical laboratory experiment as well as an applied study of information and decision processes in nuclear industry with focus on decision-making and judgment in procurement. With individual and real-life decision-making in focus, another part of this thesis will focus the choice processes between therapeutic professional training program for psychology students at the advanced university level; a choice that has high impact on their future working life. Here, Diff Con theory was tested empirically. Some extensions of the theory were tested by the use of reasons and letting the participants
give their own reasons pro and con the decisions alternatives and give strength ratings for all reasons at each session created new theoretical development. In all, the thesis includes three papers about judgment and decision processes and structures involved in important decisions for either an organization or an individual, with the aim to study the problems identified in the purpose section.
4.0 Method

4.1 Research problems

In line with the first research problem of the thesis, Study I was conducted, in a laboratory setting, with procurement offers described by vignette-scenarios. It investigated how the structure of procurement decisions in the perspective of the tenderer affected judgments of procurement offers. To specify, the study focused on the maximally accepted costs for creating an offer and given information about the size of the company, the probability of winning the offer, and the possible profit of a successful offer. The main problem formulations of the investigation were (i) Bidders deviate from classical economic theory as expressed by the Expected Value Theory. (ii) Judgments from larger companies accept greater maximum cost offerings compared to smaller companies. (iii) In addition, the study investigated how probabilities of winning the offer and potential profits will be integrated when maximum bidding cost judgments are given.

Study II described and analyzed parts of the decision processes in the organizational procurement routines carried out by the staff of a nuclear power facility. A process perspective on decision-making was applied here. The purpose was descriptive and prescriptive (what improvements were needed).

In Study III, concerned with career decisions, the predictions were (i) Differentiation and consolidation processes would change and/or distort the reasons pro and con the alternatives before and after the final decision, (ii) The changes/distortions would be in a direction so that the difference between the strength of the reasons for the chosen and against the non chosen alternative would be greater later in the pre-decision and the post-decision processes and thereby create between alternative coherence. (iii) Differentiation and consolidation processes would also gradually create within alternative coherence during the
decision process. That is, different measures speaking for or against an alternative will converge over time so that the correlations between different measures will increase, (iv) that overall positive feeling associated with the decision should increase and negative feeling would decrease with increasing differentiation.

4.2 Data collections

The studies were based on 3 different data collections obtained in different ways: Judgmental responses to Scenario vignettes in booklets (Study I), interviews, industry and regulatory documents (Study II) and questionnaires asking for judgments and decisions about the participants personal real-life choices (Study III).

4.3 Samples of Participants

Study I was conducted with a sample of students taking courses in psychology and coming from different undergraduate behavioral studies who volunteered to participate in an experiment in economic psychology. Most students had earlier work life experience making them especially interested to take part in the experiment. Study II was conducted with project engineers and procurement staff at a nuclear power facility suggested by the management and accepted by the investigation team. Study III asked all psychology students to participate in the study, at a specific phase in their education where they were about to make a decision leading to a real career-choice.

4.4 Measures

In Study I, variables for analyzing procurement decisions in the perspective of the tenderer were: (a) judgments of procurement offer as the maximally accepted costs for the creating of an offer. (b) willingness to pay (WP)) and the possible profit if the offer was successful. The independent parameters were probabilities at four different levels, profit at five different levels and company size (yearly turnover) at two different levels.
In Study II, a semi-structured checklist was used in the interviews. The interview first of all delimited the area to large projects of procurement managed in the industry and relevant for nuclear safety. Both procurement of material and service were included, and with special specifications concerning nuclear safety. The procurement projects considered should also cover contracted personnel.

The questions, based on previous theory and empirical and practical knowledge covered: (A) Requirement specifications/where in the process safety aspects were included/communication of the specifications. (B) Compensatory procurement (the offering part might offer on parts of the project or the entire project or both). (C) Numbers of offers/screening, early candidates. (D) Criteria/Judgment of different risks, economical, quality and safety. (E) Possible trade offs between cost, quality and safety of delivery and nuclear safety in relation to D. Type of measurements of the parameters (D), quantitative, qualitative or a mix. (F) Feedback/bonus on earlier suppliers. (G) Judgment of safety culture. (H) Collection and organization of information from earlier experience of suppliers. (I) A bad and a good procurement case. (J) Management system for own management, control and assessment and development of procurement. (K) Safety goals and guiding principles for safety management and development. (L) Strengths and weaknesses of the steering documents of procurement. (M) Early candidate changes. (N) Insights to teach other procurers.

In study III judgment parameters collected were: Positive feeling for decision, negative feeling for decision, overall attractiveness for each choice alternative, degree of certainty of each attractiveness rating. Furthermore, participants’ listed reasons pro each alternatives with corresponding strength ratings, participants’ reasons con each alternative with strength ratings.
4.5 Analysis of Material and Data

For the analysis of material in this thesis, a number of approaches were used and therefore the studies will be treated one at a time.

Study I

Mean difference in WP between the small and the large company was analyzed in a t-test. WP was analyzed as a function of probability and profit in a search for a multiplicative linear fan, or other, structure of subjective probability and profit (Anderson, 1981, 1982, 1996, 2008; Rundall, Weiss, 1998; Weiss, 2006). A value/attractiveness and a subjective probability scale were estimated. Lastly, WP in relation to EV (at the different levels of probability) was analyzed.

Study II

The investigators wrote down the interviews and used both the written instructions for the procurement process and a digitalized decision aid used in the plant to structure the analysis. Together with the interviews, the written instructions and the digitalized decision aid were used to form a flow chart where essential parts of the procurement process were described (See Study II, Figure 1). There where also a part which described a bad and a good procurement case study. The investigators followed up and concentrated the results from the flow chart and the cases by thematizing in the three different areas, 1) communication, 2) decision processes and 3) quality and safety. We developed a final section with observations and recommendations to add practical meaning to the material. The participants read the analyzed material for comments of the interpretations, synthesized by the interviewers. Corrections and complements were explicitly asked for.
Study III

The finally chosen alternative for each participant was identified and separate calculations for the chosen and the non-chosen alternative were made. Earlier studies have reported that a decision maker treats a chosen alternative in the same way irrespectively of which of two possible alternatives they prefer (Salo & Svenson, 2001; Svenson & Hill, 1997). The variables were analyzed in ANOVAS, repeated measures, over sessions for chosen alternative, and in the same way for the non-chosen alternative. A differentiation/consolidation measure also was computed and analyzed ((Reasons for chosen+reasons for non-chosen)-(reasons for non-chosen+reasons for chosen). Also Positive and negative feelings concerning the decision were analyzed in ANOVAS, repeated measures, over sessions. Bonferroni corrections were used.
5.0 Summary of Empirical Studies

5.1 Study I

Judgments of acceptable costs of hypothetical procurement offers as a function of success probability and profit: A vignette study.

5.1.1 Background

Study I was about procurement in the perspective of the tenderer and focused on the costs of creating a contract offer, the risks of not winning the contract and profits after a successful contract offer.

The last couple of years, research on procurement have been an important research area in the European Union. Among other reasons for this, is that procurement is of growing concern for society, because public procurement involved about 1800 Billion EURO per year corresponding to 16 % of the EU gross domestic product (GDP) (Commission of the European Communities, 2008)\(^1\). In the private sector, there are no figures about the total monetary resources exchanged via procurement. Also Sweden has had a focus on procurement and competition during the last years. In 2008, the government of Sweden gave the Swedish Competition Authority (a state agency) an assignment (Government Assignment, 2008) to take a broad review of competition in Sweden and strengthen competition and the efficiency of public procurement (The Swedish Competition Authority, 2009:4). According to theory, procurement and competition allow new companies to get into the market, and this would strengthen Swedish companies' possibilities to act on the international market. This situation was

\(^1\) GDP is the market value of the officially recognized, produced final products and services within a certain time set. The GDP per person (capita) is often used as a measurement of standard of living.
also seen as useful to consumers in keeping quality up and prizes down. The authorities found that Sweden had some shortcomings in the area of competition, e.g. too few actors in the procurement market. Effective public procurement leads to increasing competition and was judged to be especially essential for small and middle-sized companies (Government Assignment, 2008).

Against this background, some research projects were conducted in Sweden. One example in the area of public procurement and supported by the Swedish Competition Authority was an investigation with the aim to investigate why so few small companies took part in offering in the area of public procurement (Swedish Competition Authority, 2008). The study emphasized the importance of the, relatively speaking, higher cost for a small company to take part in offering in comparison with a larger company. The relative cost was assumed to cause the small company not to offer in many cases, which was revealed in the results (Commission of the European Communities, 2008; the Swedish Competition Authority, 2009:4 & 7). The area of procurement involves judgment and decision-making both for buying and offering organization. As mentioned before, in the present dissertation the initial study of judgment and decision-making focused on the offering cost from the supplying organization’s point of view in relation to company size, risk of not getting/the chance of having the assignment and profit.

5.1.2. Purpose

The major purpose of the present study was to experimentally test to what extent classical economic theory in the form of Expected Value (EV) applies to procurement judgments. More specifically, the Study aimed at investigating how the structure of procurement decisions in the perspective of the tenderer would affect judgments of procurement offers. The judgments were maximally accepted costs for creating an offer, which is WP.
5.1.3 Method

The research questions were investigated with an experimental within participant factorial design. The independent experimental variables were: (1) Size of company measured in turnover last year; SEK 20 or SEK 150 million. (2) Probability (p) of “winning” the contract; 5 different levels. (3) Profit increase if winning the contract; 5 different levels. The problems were presented in a scenario booklet. First, a written instruction was given to a participant and the scenario booklet then continued with a scenario where the participant was instructed to imagine her/himself in the role of a leader of a company that offers and carries out education project programs for state, county councils, municipalities and the private sector. An example of a scenario vignette was:

“- The educational company that you are responsible for now has 50 Million SEK in annual turnover with a profit margin of 10%.

-The probability of winning the offer competing with other bidders is 70%.

- If you receive this offer, your company will get an increase in turnover in the upcoming year of 10 Million SEK with a preserved profit margin of 10%.

Your task is to judge how much the company, as a maximum, could pay to create an offer. Make sure that you give the absolutely maximum value of the offering costs.

“What do you think offering cost maximally could be in this scenario?”

I judge that the maximum cost the company can pay is _________ SEK for preparation and submission of the offer.”

The participants were instructed to judge each scenario. In all, 70 psychology students at Stockholm University took part in the Study. The participants were allowed to spend the time they each needed to complete the 50 scenarios.
5.1.4 Major Findings

WP values were plotted against probability factor levels (1-4) with profit level as a parameter. Level 5 of the probability factor levels was not analyzed in this study since it was a probability factor of 100 % security to win the offer. WP were plotted with “probability to win the contract” as a parameter. For each profit and probability level, a fan structure of significant linear functions emerged. This provided support for a multiplicative combination of subjective probability and profit (Anderson, 1981; Weiss, 2006).² Average empirical values for judgments of WP were created for an offer at four different levels of probability and the five different objective levels of profit. Levels 1-4 of probability were 10 %, 35 %, 60 % and 90 %. Level 1-5 of the profit were 100 000 thousand SEK, 500 000, 800 000, 1 300 000 and 2 000 000 SEK. Scale values were created for probability and profit levels respectively by summing each row and each column and computing the means. The first value for probability and profit was normalized to 1.0.

The normalized marginal means give subjective values of the profit dimension (U) and for the probability dimension (Ψ) respectively (Anderson, 1970; Weiss, 2006). The subjective scale values were inserted in $y=Ψ*U$ to predict the empirical judgments, which showed excellent predictive power supporting the multiplicative model.

Judged and normalized described probabilities were normalized by proportional transformations, making the lowest value coincide at 1.0. The range of subjective scale values of probability was smaller than the objective range of probabilities. The corresponding “shrinking of range” was found for the profit scale but the range difference was not

² The explained variance of each line when profit was a parameter were: 100 000 SEK, 99 %, 500 000 SEK, 98 %, 800 000 SEK, 99 %, 1 300 000, 95 %, 2 000 000, 98 %. The explained variances for each line when probability was a parameter were: p= 0.10, 86 %, p= 0.35, 97%, p= 0.60, 98 % and p= 0.90, 96 %.
as large between objective and subjective scales as for the probabilities.

5.1.5 Conclusions
The results of the Study showed that the SEU-model described the data and that the bidders deviated from classical economic theory as expressed by EV. The small company and the large company did not deviate in WP, which is a prediction also made by EV. The participants were sensitive to the level of the given probabilities but more sensitive to the level of profit. Concerning both probability and profit, the participants were not as sensitive as EV would predict. Further, the participants overestimated lower probabilities and underestimated higher probabilities. Profit and probability levels showed a fan structure of significant linear functions providing support for a multiplicative combination of subjective probability and profit (Anderson, 1981; Weiss, 2006). Subjective scale values were used to predict empirical judgments quite successfully.

5.2 Study II
Procurement in the nuclear power industry, quality, safety and decision-making.

5.2.1 Background
Swedish nuclear plants were and are undertaking a great deal of modernization. The purpose of the modernization is to upgrade the plants in order to increase the power output. Along with the increased power production there is a purpose to increase safety. Alongside the changes and modernizations, the ability to procure, for example, equipment then becomes an essential aspect of the safety work and an aspect of succeeding with projects in order to upgrade power production and increase the turnover of the plants. The Swedish Nuclear Power Inspectorate identified a need of a deeper understanding of how procurement was done in practice and how the procurement management system support the decision process in selecting a supplier that meets the demands of the operation, quality and safety.
5.2.2. Purpose
The major purpose of the present Study was to map and make an analysis of the decision processes in the procurement routines in the nuclear industry in order to provide a basis for: (1) Further development of safety inspections about procurements for Swedish Radiation Safety Authority. (2) Improvements of procurement routines in general in a nuclear power plant. (3) Improvements of safety management in connection with procurement within a specific nuclear-power plant.

5.2.3 Method
The procurement processes in a nuclear power plant were analyzed from a decision theoretic perspective. Key staff at the plant was interviewed and written instructions as well as digitalized processes were used as data in the analysis.

5.2.4 Major Findings
The results illustrated the most essential moments during the procurement process with descriptions from interviews and documents. The procurement process was possible to describe in a framework of decision theory. The participants recognized their text well after the interviews were written out, categorized and thematized.

The staff at the nuclear power plant used a MAUT-inspired model, with expert judgments of weights for different attributes, in the evaluation of alternatives and both compensatory (in which e.g. negative aspects can be compensated by positive aspects) and non-compensatory (in which particular “pass” levels of attributes have to be exceeded for acceptance of a choice alternative) decision rules were used in the procurement process. Nuclear safety was evaluated in a non-compensatory manner following regulatory criteria while costs were evaluated in trade-off compensatory rules. Thus, weakness in one consideration might be compensated by strength in another consideration. Nuclear safety above the regulator and law requirements were not integrated in a compensatory manner when procurement alternatives were evaluated. The MAUT-inspired model used at the nuclear plant differed from a conventional MAUT through that the judged attributes were formulated mostly as questions, and the “an-
“answers” were given in judged probabilities translated to categories of numbers (1-5) and judged consequences, translated to categories of numbers (0-5), if the attribute applies. The number assigned to the probability and the number assigned to the consequence was then multiplied giving a value con the candidate (a higher value speaks against choosing the candidate). An integrated judgment judged the offering in a value pro the candidate through integration of the (1) commercial judgment, (2) judgment of accountability/stability, (3) quality system, (4) judgment of technique. Weights were assigned to point 2-4 by assigning judgments from 0,5 (less important) till 3 (essential). This is multiplied by a value for each offer, for each section giving a value pro the candidate (a higher value speaks for choosing the candidate). The attributes were priced (except, of course, the attribute price) so the comparison between offers (only at attributes that are compensatory) is in the end from an economical viewpoint. The nuclear plant assessed an organization’s safety culture at an early stage of the purchasing process. A successful and a less successful procurement case were reported with the lessons learned from them.

5.2.5 Conclusions
The conclusions from the Study were that the procurement process was possible to describe in a frame of decision theory and that a MAUT-inspired model was used in the evaluation of alternatives on compensatory decision rules (non-compensatory decision rules were evaluated outside the model). Further we found that the existing written instructions for procurement where well elaborated and adequate. There was a lack of staff resources when procurement teams were formed, which meant that external personnel sometimes had to be engaged in such a team. Therefore, the emphasis on safety had to be communicated effectively to those joining the team from outside the plant. From a competitive point of view, the number of potential suppliers was often too small. There was a feedback system of experience from previous contracts. The information from the system was of little use since it was not documented so that it was possible to conduct a quick and efficient information search. This would be a weakness when safety and quality information was needed quickly in a procurement process.
5.3 Study III
Creating coherence in real-life decision processes: Reasons, differentiation and consolidation.

5.3.1 Background
As described earlier in this dissertation, Diff Con is a process theory that models mental processes both before and after a decision. In this contribution, parts of the theory relevant in this context were presented and used.

5.3.2 Purpose
The purpose of the present contribution was to contribute a development of Diff Con (Svenson, 1992, 1996, 2003, 2006; Svenson & Benthorn, 1992) and to test some predictions of the extended theory. More specifically, we tested predictions of the theory with psychology students on the advanced level while they choose between two different training programs for professional clinical psychologists. The programs were independent and based on different theoretical approaches (psychodynamic and cognitive behavioral) and determined the students’ future therapeutic careers to a large extent.

5.3.3 Method
Decision alternatives where two professional training programs each 1.5 years long and designed to prepare a participant for her or his future career as a psychotherapist. The programs were conducted independently of each other. The theoretical foundations were different; one program was founded on cognitive behavioral theory and the other on psychodynamic theory.

There were 4 sessions during which questionnaires were administered. Two sessions took place before and two after the decision. The first questions asked about positive and negative feelings in conjunction with the decision concerning therapy-training program. There were one scale for positive and another for negative feeling. The participants were instructed to write a number corresponding to their feelings towards the decision alternatives at the time. Following this, two ques-
tions asked for the overall attractiveness of each of the two programs. The next pair of items in the questionnaire asked for the degree of confidence / uncertainty associated with each of these attractiveness ratings. After this, the participants were asked to write down the reasons they could find speaking pro and con each alternative. The alternatives were presented on top of a page and in one column for each alternative. The participants wrote down the reasons for choosing that alternative. On the next page, the reasons for not choosing each of the alternatives were listed in the same way in a column for each alternative. The participants were also asked to indicate the strength of each reason next to it. In the first session, the columns were blank and in the next 3 sessions the earlier reasons given by each participant had been typed into the appropriate columns by the experimenter. In sessions, 2, 3 and 4 participants were asked to add new reasons and rate the strength of all reasons, old and new according to how strong they were at the time.

5.3.4 Major Findings
Before and after the decision, the attractiveness of the chosen alternative was upgraded, and the non-chosen alternative downgraded. The number of reasons pro and con alternatives and the strength ratings of the reasons gave a more complete picture than attractiveness. The numbers of reasons increased from the first to the last session. The reasons supporting the chosen alternative increased in strength. Positive feelings concerning the decision dominated and increased though not statistically significant. The negative feeling decreased significantly from the first to the last session. In informal comments participants reported that the Study had also served as a decision aid.

5.3.5 Conclusions
The conclusion from the Study was that a development and extension of Diff Con was possible. The theory was developed to include reasons pro and con alternatives and tested on students making decisions between two university psychotherapy training programs (cognitive-behavioral and psychodynamic therapy).
5.4.1 Results revisited

In Study I, no difference was found between procurement offers depending on a company’s turnover, which is predicted by EV but not experienced by the regulating authorities. But a multiplicative model with subjective probabilities and values gave an excellent description of procurement judgment in the laboratory.

In Study II of this thesis, the results illustrated the most essential moments during the procurement process in the field with descriptions from interviews and documents. The procurement process was possible to describe in a frame of decision theory. The staff at the nuclear power plant used a MAUT-inspired model, with expert judgments of weights for different attributes, in the evaluation of alternatives. Both compensatory and non-compensatory decision rules were used in the procurement process. Nuclear safety was evaluated in a non-compensatory manner following regulatory criteria and could not be described in a EU or SEU framework. Costs were evaluated in trade-off compensatory rules, which means that a weakness in one consideration might be compensated by strength in another consideration.

In Study III of this thesis a decision theory much different from EV and SEU was tested, Diff Con. The static nature of EV and SEU was challenged and it was shown how the overall attractiveness of the chosen alternative was upgraded, and the non-chosen alternative downgraded before and also after the decision. The number of reasons pro and con alternatives gave a more complete picture than overall attractiveness and increased from the first to the last session. Reasons supporting the chosen alternative increased in strength, reasons against the non-chosen alternative decreased. Positive feelings concerning the decision dominated and increased though not statistically significant. Negative feeling decreased significantly from the first to the last session. In informal comments participants reported that the Study had also served as a decision aid. In all, the Study showed that EV and SEU models are insufficient to describe the human decision processes.
To summarize, this thesis aimed to study decision processes and structures with medium to long-term consequences for the organization and the individual. Here, it was studied to what extent classical economic theory in the form of Expected Value (EV) applied to procurement judgments, how procurement routines in a nuclear power plant could be described by a process oriented approach to decision-making and classical decision theory and how a real life career decision of a decision maker could be described by process oriented decision theory. Thus the general theme of the thesis was to investigate the application of different decision theoretic approaches in different contexts.

Specific research questions in the form of hypotheses, descriptions, analyses and predictions were focused. The first question aimed at investigating how the structure of procurement decisions in the perspective of the tenderer affected judgments of procurement offers in the form of maximally accepted costs (WP) for creating an offer and the possible profit of a successful offer. The main hypotheses of the investigation were (i) that bidders deviate from classical economic theory as expressed by the Expected Value-theory. (ii) That judgments from larger companies accept greater maximum cost offering compared to a smaller company, (iii) how probabilities and profit were used to form maximum bidding cost judgments to win a contract.

The second research question aimed at describing and analyzing parts of the decision processes in the procurement routines carried out by the staff on site in a nuclear industry to describe the procurement process.

The third research question aimed at predicting how (i) differentiation and consolidation processes changed and/or distorted the reasons pro and con the alternatives before and after the final decision, (ii) the change/distortion would be in a direction so that the difference be-
tween the strength of the reasons for the chosen and against the non chosen alternative would be greater later in the pre-decision and the post-decision processes and create between alternative coherence, (iii) differentiation and consolidation processes gradually created within alternative coherence during the decision process. That is, different measures speaking for or against an alternative will converge over time so that the correlations between different measures will increase, (iv) that overall positive feeling associated with the decision should increase and negative feeling would decrease with increasing differentiation.

6.1 Procurement Judgments and Classical Economic Theory.

The hypothesis (i) in this study predicted that bidders deviate from classical economic theory as expressed by the Expected Value-theory. EV applies to objective probabilities and monetary values and is applicable when people correctly calculate known profits and probability to compute best (in this case) monetary value. In Study I of this thesis, SEU (V) model (Anderson & Shanteau, 1970) described the data and in this respect, the bidders deviated from classical economic theory as expressed by EV.

Hypothesis (ii) predicted that judgments from larger companies accepted greater maximum cost offering compared to a smaller company. A core theme in the reasoning in EU (Von Neumann & Morgenstern, 1947) is that a game or a situation is not evaluated in the perspective of monetary gains but in the view of which consequence the result has in the level of wealth of the decision maker and with a diminishing marginal utility with increasing value. Also SEU and Prospect Theory (PT) have assumptions concerning the level of wealth. In line with this reasoning, one could think that data would show that the participants would differ in their offering cost when owning a company with smaller yearly turnover than when owning a company with larger yearly turnover. The participants were not sensitive to the circumstance that the company differed in size in terms of yearly turnovers and therefore, EV could not be ruled out for that finding. Thus, theories involving psychological aspects (Edwards, 1954; Kahneman
Question (iii) investigated in an explorative manner how probabilities and profit were used to form maximum bidding cost (WP) judgments. The participants in Study I in this thesis were sensitive to the probabilities, and slightly more sensitive to the profits. Concerning both probability and profit, the participants were less sensitive than indicated by the given scale values. Further, the participants in Study I of this thesis overestimated the lowest probability and underestimated higher probabilities. According to PT (Kahneman & Tversky, 1979) one of the central characteristics of the estimated weight function of probabilities is that, for small probabilities, (probabilities close to zero) the function is over weighted, \( w(p) > p \) and, for large probabilities, (probabilities close to one) the function is under weighted \( w(p) < p \). This might be an explanation of why people buy insurance even at small probabilities of loss and lottery tickets at small probabilities of winning.

Profit and probability levels in Study I in this thesis showed a fan structure of significant linear functions providing support for a multiplicative combination of subjective probability and profit (Anderson, 1981; Weiss, 2006). In an experiment by Anderson and Shanteau, 1970, stimulus with objective probabilities and small monetary value were used. The results showed a linear fan pattern that supported a multiplicative model and the objective and subjective probabilities was non-linearly related. In this experiment the monetary values were quite small and the setting was a gambling situation with probabilities formed from the roll of a dice. The results were later verified by Shanteau (1974). With the findings in Study I of this thesis, there is an empirical extension to large amounts of money and another area than gambling.

6.2 Procurement Routines In a Nuclear Power Plant and Decision Theory.

The second research question aimed at investigating to what extent procurement routines in a nuclear power plant could be described by a process oriented approach to decision-making and classical decision theory. The question was investigated through describing and analyzing...
ing parts of the decision processes in the procurement routines carried out by the staff on site in a nuclear industry.

In Study II, it was found that the procurement process could be described in a frame of decision theory in a manner that the entire decision process was described from a point where the organization wants or judges that a change is necessary change and investigates the possibilities for such a change (Janis & Mann, 1977). In addition the organization determined goal attributes used to describe the changes that the organization wanted to reach. The process went on with announcing quotation, collecting information, in order to receive procurement decision alternatives to be evaluated in a final decision. In the process of procurement, there were sub-processes where decision rules were used (in the nuclear plant case compensatory and non compensatory decision rules) as Diff Con theory (Svenson, 2003). The non-compensatory rule concerned issues as nuclear safety and economical possibilities. The compensatory decision rule was handled by a MAUT inspired instrument.

**MAUT** covers the rational evaluation and choice between alternatives in a multi-attribute decision task and is often used as a decision aid. A decision problem’s attributes can be divided into sub attributes, processed in the same way as in SEU (von Winterfeldt & Edwards, 1986). According to the interviews and other studies (e.g. Sanayei, Mosavi, Abdi & Mohaghar, 2008) procurement often involves multi-attribute decision-making. Price span is one aspect that makes a frame for the decision, but inside that frame a lot of other attributes are of concern as running cost, performance, aspects of safety and others. MAUT was found to be useful in various fields, for example: nuclear emergency management analysis (Hämäläinen, Lindstedt & Sinko, 2000), the complex multi criteria problem of choosing supplier and defining optimum order (Sanayei, Mosavi, Abdi & Mohaghar, 2008), assessment of supply chains in “lean and green supply chain” methods (Kainuma & Tawara, 2005), tool for experts in identifying 24 factors representative of Nursing Practice Models (Brennan & Anthony, 2000).

The results of Study II showed that, the staff of the nuclear power plant used a MAUT-inspired model in the evaluations of alternatives
and both compensatory and non-compensatory decision rules were used in the procurement process. The MAUT-inspired model used at the nuclear plant differed from a conventional MAUT in the way that the judged attributes were formulated mostly as questions, and the “answer” for each alternative was given in judged (risk) probabilities expressed in categories of numbers and judged consequences, also expressed in categories of numbers indicating the probability that an attribute could occur. The number assigned to probability and the number assigned to the consequence was then multiplied giving a value con the candidate (a higher value speaks against choosing the candidate if the attribute is not desirable). The offering in a value pro the procurement candidate was evaluated through integration of the (1) commercial judgment, (2) judgment of accountability/stability, (3) quality system, (4) judgment of technique. Weights were assigned from 2 to 4 by grading judgments running from, “less important” til “essential” respectively. This weight was multiplied by a numerical judgment for each offer, for each section (2-4) giving a value pro the candidate (a higher value speaks for choosing the candidate). The method has some similarities to the method used in Study III, with reasons pro and cons a decision alternative. In Study III, reasons were given numerical values representing the reasons; strengths pro and con an alternative. The staff at the nuclear power plant used a multiplicative model for evaluating offers to reach the decision of a winning candidate were one part of the evaluation was an evaluation of risk and the other part was an integrated evaluation of the supplier. The multiplicative model for assessing risk included judged probabilities for the occurrence of a situation x judged consequence. The integrated supplier evaluation included weights of attributes such as price, stability, quality system and technique. The weights were judged on their importance for the project x a numerical rating for each attribute. In Study I, there was found (on group level) that participants integrated probabilities (risk) and large monetary values in a multiplicative manner to form integrated judgments in a procurement setting. The same result but for small monetary values were found by Anderson and Shanteau (1970) and Shanteau (1970b; 1974).

In Study II, it was found that decisions were based on multiplicative, adding and subtracting operations, in a way similar to a fully developed MAUT. Von Winterfeldt and Edwards (1986) stated that a deci-
Nuclear safety is one important and particular aspect of procurement in Study II, and it was evaluated in a non-compensatory manner following the authorities regulatory criteria while costs were evaluated in trade-off compensatory rules. Nuclear safety above the regulators and law requirements were not integrated in a compensatory manner when procurement alternatives were evaluated. The MAUT-inspired model used in the industry was a locally developed model. A recommendation was made, in the report of Study II, to develop further the decision-aid used as a tool when judging offer. One hint of a suggestion was, for the development of long term quality/safety progress, to, after having treated issues, for example, concerning safety, in a non-compensatory manner to screen out candidates not reaching required levels, to integrate candidates at the “enough” level or “overdoing” the attribute in a compensatory manner. From a competition point of view, numbers of potential suppliers were often too small. With larger numbers of potential suppliers, there could be a more competitive situation on, for example, the criterion price. There was a feedback system of experience from previous contracts, but the information was of little use since it was not documented so that it was possible to conduct a quick and efficient information search. This was a weakness when safety and quality information was needed quickly as part of information used in the selection of a winning project supplier.

6.3 Process Oriented Decision Theory, Diff Con, and Individual Real Life Career Decision.

The third main research question concerned how a real life career decision could be described by a process oriented decision theory. This main research question was investigated through five predictions (i-v): The first and second predictions were: (i) differentiation and consolidation processes changed and/or would distort the reasons pro and con the decision alternatives before and after the final decision (ii) the changes/distortions would be in a direction so that the difference be-
between the strength of the reasons for the chosen and against the non-chosen alternative will be greater later in the pre-decision and the post-decision processes and also create between alternative coherence. In this Study, the numbers of reasons against the non-chosen alternative increased over sessions. In a test with Diff Con SUM-index (reasons (supporting chosen + against non-chosen) – (against the chosen + supporting the chosen)) there was a significant increase from the first to the last session. This supports predictions i and ii. The reasons supporting the chosen alternative increased significantly over sessions in strength, and a Diff Con SUM-index for strength ratings supported a difference between sessions 1 to 4. Diff Con (Svenson, 1992, 1996, 2003, 2006) describes decision-making as an ongoing process in which one alternative is gradually differentiated from competing alternatives, a description which supports the results in Study III. To specify, Diff Con describes that value/attractiveness evaluations are restructured both before and after a decision in a manner that a chosen alternative is upgraded in attractiveness and/or the non-chosen alternative downgraded in order to complete a decision and later to further support a decision made (Svenson, 1992, 1996, 2003, 2006). Facts and evaluations of facts, the attractiveness of the facts, are treated in the decision process in a way so that structuring and restructuring of both facts and evaluations of facts may occur in the process of reaching a decision that is coherent with the chosen alternative as the best and of the non-chosen alternative as a rejected alternative (between alternative coherence) (Holyoak & Simon, 1999; Simon, Pham, Le & Holyoak, 2001; Glöckner & Betsch, 2008). The results in Study III give proof of between alternative coherence both in the strength ratings of the reasons and the global attractiveness rating of each decision alternative.

The strength of the reasons supporting the chosen alternative were, in Study III in this thesis, in average stronger than the strength of the reasons against the non-chosen. This indicated that the choice was a positive choice of the preferred alternative rather than a rejection of a non-preferred alternative. This is interesting and in line with the findings that positive feelings towards the decision was strong in comparison with negative feeling. The strong positive feelings towards the decision in comparison with the uprating of the chosen alternative rather than rejection of the non-chosen alternative raises questions
concerning what the process could look like if the decision scenery would be the other way around.

The third prediction was (iii) differentiation and consolidation processes gradually created within alternative coherence during the decision process. That is, different measures speaking for or against an alternative will converge over time so that the correlations between different measures of the same alternative will increase. In Study III, attractiveness of the chosen alternative was upgraded before and after the decision, and the non-chosen alternative was downgraded. The correlations between confidence and attractiveness increased for the chosen alternative for the first three sessions with a significant decrease at session four.

According to Bond, Carlson, Meloy, Russo and Tanner (2007), within alternative coherence can appear in the phases of pre-decision differentiation and post-decision consolidation. This means, that an alternative that is a preliminary choice, is gradually restructured during the decision process into a stronger correlation between its decision supporting attributes, at the end than at the start of the decision process. A non-chosen alternative is restructured to achieve greater within coherence as a rejected alternative (Bond, Carlson, Meloy, Russo & Tanner, 2007).

The fourth prediction of Study III in this thesis was: (iv) overall positive feeling associated with the decision should increase and negative feeling would decrease with increasing differentiation. Positive feelings dominated and increased though not statistically significant. The negative feeling decreased significantly from the first to the last session. A core issue, in the Theory of Dissonance, (Festinger, 1957, 1964) was to point out that post decision conflicts (dissonance) led to cognitive processing in order to minimize the tension (negative feeling) by a spreading of alternatives in favor of the attractiveness of the chosen alternative and disfavor of the attractiveness of the non-chosen alternative. When the spreading of the alternatives occurred the negative feeling of the decision was reduced just as our results show by the spreading of alternatives in attractiveness and strength of reasons. The cognitive restructuring in Study III happens both in the pre-decision and the post-decision phases, and the reduction of negative feeling
happens between the pre and post decision phases. The Theory of Cognitive Dissonance was developed into a Conflict, Choice and Commitment Theory by Janis and Mann (1977). The central issue for the development was to show that the restructuring of the decision problem and the biases in the information search start already in the pre-decision phase. The results of Study III are in line with this theory. The post-decision conflict remained only if the restructuring in the pre-decision phase were not completed successfully. Berkman and Liberman (2011) found that participants rationalized by scoring that they never wanted the rejected alternative a striking result indicating a spread of alternatives as postulated by Diff Con and empirically verified by the results in Study III. Using fMRI, Berkman and Liberman (2011) could track that decision-related attitude change that occurred as an immediate byproduct of conflict resolution processes during decision-making. Support was found for the conclusion that dissonance reduction was a consequence of brain down-regulation of distress or arousal responses, by selection of more decision-consistent interpretations of the stimuli. These findings also support the findings from Study III concerning spreading of alternatives, between alternative coherence and reduction of negative feelings as the decision process evolves. Sanfey, Rilling, Aronson, Nystrom and Cohen, (2003) found that conflict or distress early in the decision-making process may be comforted by increased activity in particular brain regions. The particular brain regions have the capability of both to ease a shift toward decision-consistent attitudes, and regulate the activity in other brain regions responsible of experiences of arousal, affective distress or discomfort (Sanfey et. al., 2003). Focusing on brain activity during pre- and post-decision stimulus ratings, it was found that brain activity in particular areas of the brain during initial ratings predicted subsequent selection of items (quite as in the Diff Cons selection of a preliminary alternative). Changes in activity in the same brain area during ratings following decision making was highly correlated with attitude change (Sharot, De Martino, Dolan, 2009). The results above supports the results found in Study III. It seems like process tracing of affect and its relation to differentiation and consolidation processes could fruitfully be investigated with the help of fMRI.

Diff Con applied not only to aspects on attributes but also to self-created reasons pro and con alternatives. Seemingly natural ways of
thinking about decisions are in terms of reasons pro and con of the different alternatives (Shafir, Simonson & Tversky, 1993). This approach was used in Study III of this thesis unlike the traditional way of treating attributes when analyzing decisions. The smallest unit traditionally analyzed, aspects (of an attribute), was in this Study replaced by a reason. The importance of an aspect was replaced by the strength of the reason. Different reasons can be used for different alternatives rather than having all alternatives characterized by the same set of attributes as in many traditional studies, which use theoretical frameworks derived from expected utility theories. In conclusion, Study III showed that it is possible to develop and extend Diff Con to include self-created reasons pro and con alternatives.

6.4 Methodological Issues

The first research problem of the thesis, Study I, was conducted in a laboratory setting with procurement and vignettes with scenarios and it is not straightforward to generalize the results to a real procurement situation. Hence, the ecological validity of this Study for applied settings would have to be validated in further field studies. Data were analyzed on a group level. But the behavior of some participants when integrating probabilities and value might be different from the multiplicative integration found on the group level (Anderson, 1981).

Study II, which was a field study of the procurement process is valid for the plant but the results may have limited generalizability to other industries. However, since the participants in the Study recognized and agreed with descriptions and considerations suggested in the Study this supported the ecological validity (Patton, 1980). The triangulation design of the Study used data from: (a) interviews with different persons active in procurement (b) written procedures. Different researchers were involved with the interviews and analysis, which guards against a single researcher bias (Patton, 1980).

Study III, about decision processes before and after a real decision problem had a limited generalizability depending on the sample of participants who participated in the study – one class of students of clinical psychology. Therefore, it is not sure that there would have
been the same processes with other participants as in other studies of differentiation and consolidation of attractiveness. Still, the results showed that the present participants differentiated and consolidated their decisions. There was no straightforward question asking the participants if they had made up their mind already before the formal decision, and for students who might have made their decisions earlier, the analyses of the results indicating differentiation could have reflected both differentiation and consolidation processes.
7.0 Conclusions

This thesis focused on three general research questions related to decision processes and structures with medium to long-term consequences for an individual or an organization. It has been possible to answer some of the research questions and to find some extensions to earlier findings. The first research question concerned to what extent classical economic theory (EV) applies to procurement judgments. The answer to that question was that EV in general did not apply to economical decisions in a procurement setting except for one aspect. The money a person wanted to invest in an offer was judged without considering the size of the company. Although, the subjects used a multiplicative model of risk and value they did not use objective monetary or probability values as prescribed by EV.

The second, explorative, research question concerned procurement routines in a nuclear power plant and how they could be described by a process-oriented approach to decision-making, and classical decision theory. The description and the analysis of material showed that the procurement process could be described from a process perspective and also in parts, by classical MAUT decision theory. First, the need for change was judged and the decision to start a procurement process was made. Then, a stage of information search started in order to generate decision alternatives for a final run of offers. Formal decision rules were used, and a MAUT-inspired, computer based, instrument was used as an aid in the decision process and evaluation of alternatives. The MAUT-inspired instrument used reasons pro and con alternatives, as in Study III.
The third general research question concerned a real life career decision. The question was if such a decision could be described by the process oriented Diff Con decision theory. The results showed that it was possible to extend, and develop Diff Con to include participants’ own reasons pro and con alternatives.

The research in this thesis concerned decision processes and structures involved in decision-making with medium to long-term consequences for the organization or individual. Even though the studies seem quite heterogeneous, I think that this thesis with its dual perspectives: applied and theoretical, has contributed to further our knowledge about decision-making in both a theoretical and applied sense.
8.0 Future Research

An interesting area of research is exemplified by studies conducted by e.g. Ludvig, Madan, and Spetch (2013) concerning which effects experience has on judgment and decision-making. Studies of procurement decisions and comparing decision makers responsible for small respectively large companies in a real world context are a needed extension of Study I in the present thesis. Further ahead, one may find studies with a neuropsychological approach such as in Gonzalez, Dana, Koshino and Just, (2005) examination of cognitive functions with fMRI on risky decisions and framing effect or one might refer to van Bömmel, Song, Majer, Mohr, Heekeren and Härdle (2013) study of Risk Patterns and Correlated Brain Activities in generalization to procurement decisions although in real world studies there might be some practical and economical difficulties.

Concerning further research about Procurement decision making in a nuclear power plant it would be of interest to analyze procurement with special safety requirements during the actual procurement process and focus, for example, on different roles in the process and how the written routines is used in practice during the judgment and decision process involved in procurement.

Future research concerning process oriented decision theory, DiffCon, it would be interesting to focus on participants rating their reasons pro and con each alternative after their training courses was finished. Another question to investigate further in this area is the development of between- and within coherence. The between alternative coherence was strong and persistent through the decision process. The within alternative coherence on the other hand decreased already a couple of weeks after the decision was made. The finding has similarities with results reported by Simon, Krawczyk, Bleicher and Holyoak (2008) and needs further investigation. Positive feelings toward the
decision alternatives were strong and rather constant over the decision process, the initial negative feelings decreased significantly over time. It would be interesting to investigate further the relationship between differentiation and consolidation and degrees of positive and negative feelings elicited by each of the alternatives and the decision problem. It would also be interesting to study differentiation and consolidation in decisions where negative feelings instead of positive feelings toward the decision dominate. Differentiation and consolidation processes in a situation where positive feelings dominate may differ from situations when negative feelings dominate (Isen & Labroo, 2003). Also, process tracing of affect in decision making and its relation to differentiation and consolidation processes might be fruitfully be investigated fMRI (Berkman & Liberman, 2011; Sanfey, Rilling, Aronson, Nystrom & Cohen, 2003; Sharot, De Martino & Dolan, 2009).

One interesting comment from the participants during the investigation in Study III worth noting was that some of the students reported that they used the investigation as a decision aid. This invites further research relating to the present findings and extensions to decision aids.


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