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The work described in this document was performed as part of the xDELIA project ("Boosting Deliberate Practice and Handling Biases through Immersive Cognitive and Emotional Reinforcement Strategies & Tools") which is funded under contract No. 231830 of the European Community. The project is a collaboration between CIMNE (coordinating partner), Forschungszentrum Informatik, Open University, Blekinge Tekniska Högskola (Game and Media Arts Laboratory), Erasmus University Rotterdam (Erasmus Centre for Neuroeconomics), University of Bristol (Personal Finance Research Centre), and Saxo Bank A/S. The opinions, findings and conclusions expressed in this report are those of the authors alone and do not necessarily reflect those of the EC or any other organisation involved in the project.

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# Revisions Done

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<td>February 11\textsuperscript{th}, 2010</td>
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<td>February 23\textsuperscript{rd}, 2010</td>
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Executive Summary

This document is a snapshot of the evolving state-of-the-art (SOA) knowledge base located on the project’s internal Wiki. The role of the SOA in the project is to help bridge the knowledge gap between the different disciplines involved in xDelia. Moreover, the SOA is an evolving document. While at the start of the project, most of the contributions to the SOA were principally (and almost necessarily) written from a more insular, discipline-centred perspective, they have strictly focused on aspects that are most relevant for xDelia. Moreover, some of the contributions (see for instance chapter 3, the SOA on serious games) have been revised and adapted, with the insights gained over the last year in mind. The resulting document is rather long and unwieldy. One should bear in mind here that the SOA lives on a Wiki where it is distributed over several pages that have grown substantially in numbers over the last year.

Three broad subject areas contribute to the SoA: (1) decision making, emotion regulation, and practice-based learning (WP2), (2) serious games (WP4), and (3) sensors and emotion state monitoring (WP5). There is a separate deliverable that covers aspects of financial capability (D5-3.1, WP3).

Decision making and emotion regulation (WP2)

The first part of the SOA focuses on (1) emotions and emotion regulation, their role in decision-making and how to measure them; (3) decision-making biases, and iv) practice-based learning. The discussions centre on aspects that are relevant in the context of trading and investments – and for xDelia – and refers to the decision making and emotion literature for further readings. Questions and issues discussed include how emotions are formed, what existing measures of emotions there are, the role of emotions in decision-making, what strategies exist to regulate emotions, how decisions are affected by emotions, and how we can measure emotion regulation. Moreover, a section on practice-based learning illustrates the range techniques used by organisations and individuals in developing expert skills for different job roles, especially during the formative stages.

Serious games – Design, learning, and evaluation (WP4)

Serious games touch on a number of research areas that have to be understood and put into relation with each other with a view to support the development of learning interventions. The conceptual and empirical part of the SOA on serious games discusses game design, learning process and outcome, and evaluation. In this second edition of the SOA, we have tried to relate the specifically game-oriented concerns to the concrete goals and needs of the project, although there still remains some work to be done for the third edition (m18). In particular, the SOA discusses both broader and game-specific learning models and the different ways in which they can inform the game development process. The section on game design briefly discusses the role that motivation, learning, cognition, and target users play in the design process. This is followed by a discussion on transfer, that is, the extent to which specific knowledge, skills, or behaviours learned in the game world translate to the real world context. Finally, we discuss evaluation approaches proposed by serious games researchers and practitioners and also those that are found in other research fields such as health promotion and prevention.

Serious games – Technology options (WP4)

This section provides an overview of available software tools in the market. Different types of tools are reviewed because the range of prototypes within xDelia is expected to be wide, ranging from mobile phone games, small web application, and more complex games, to tools for awareness of emotions. Moreover, a participatory approach to game design is applied in xDelia. These conditions make it highly probable that different tools will be used dependent on the type of game created.

Sensors and emotion state monitoring (WP5)
While the SOA of WP2 outlined how emotions and emotion regulation can be measured from a methodological point of view, this section discusses how these methods can be implemented using sensor technologies and models for physiological signal processing. This is of particular importance since the kind of sensors that provide robust and acceptable signals in controlled laboratory experiments, might not be suitable for field research, either because they overly restrict mobility in a naturalistic setting or they do not provide signals of sufficient quality in a filed setting. This section offers an overview of physiological signals used for emotion recognition based on sensor data. It contains a short description about the physiological signals themselves, followed by an overview of studies that have been conducted using these signals.

**Experimental economics (WP2, WP5)**

This section introduces the reader to the state of the art of research on emotions in experimental economics. The focus is on laboratory auctions because auctions are a simple model for the stock market mechanism and allow for isolating relevant decision situations. Thus studying behavior in laboratory auctions yields valuable information for understanding decision behavior of traders and investors. Since xDe lia is aiming at introducing sensor technology as a means of monitoring and changing behavior in decision making a new research methodology called physioeconomics is introduced.
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1 Introduction

1.1 Document Purpose and Scope

The principal objective of this document is to provide a knowledge basis that facilitates a shared understanding of the project among xDelia partners. The document is divided into the following sections:

- **Section 1 “Introduction”:** provides a description of the structure and scope of this document.
- **Section 2 “SoA on Decision Making and Emotion Regulation (WP2)”:** outlines the existing research deemed relevant for WP2.
- **Section 3 “SoA on Serious Games (WP4)”:** outlines the existing research deemed relevant for WP4.
- **Section 4 “SoA on Emotional State Monitoring (WP5)”:** outlines the existing research deemed relevant for WP5.
- **Section 5 “SoA on Experimental Economics (WP2, WP5)”:** introduces the state-of-the-art on emotions in experimental economics, mainly focusing on laboratory auctions

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<th>Description</th>
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<tr>
<td>AAPB</td>
<td>Association for Applied Psychophysiology and Biofeedback</td>
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<tr>
<td>AARD</td>
<td>Affect-Autonomic Response Discrepancy</td>
</tr>
<tr>
<td>A/D</td>
<td>Analog-to-Digital</td>
</tr>
<tr>
<td>ADT</td>
<td>Android Development Tool</td>
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<tr>
<td>ANS</td>
<td>Autonomic Nervous System</td>
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<tr>
<td>API</td>
<td>Application Programming Interface</td>
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<tr>
<td>ASCA</td>
<td>Ascending auction</td>
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<tr>
<td>BARS</td>
<td>Behaviourally Anchored Rating Scale</td>
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<tr>
<td>BCIA</td>
<td>Biofeedback Certification Institution of America</td>
</tr>
<tr>
<td>BIN</td>
<td>Buy It Now</td>
</tr>
<tr>
<td>BTA</td>
<td>Better Than Average</td>
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<tr>
<td>CAN</td>
<td>Central Autonomic Network</td>
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<tr>
<td>CBT</td>
<td>Cognitive Behaviour Therapy</td>
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<td>CDA</td>
<td>Continuous Double Auction</td>
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<tr>
<td>CERQ</td>
<td>Cognitive Emotion Regulation Questionnaire</td>
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<td>CISS</td>
<td>Coping Inventory for Stressful Situations</td>
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<tr>
<td>Abbreviation</td>
<td>Full Form</td>
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<tr>
<td>CRESST</td>
<td>Center for Research on Evaluation, Standard, and Student Testing</td>
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<td>DES</td>
<td>Differential Emotions Scale</td>
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<td>DLL</td>
<td>Dynamic-Link Library</td>
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<td>DOW</td>
<td>Description of Work</td>
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<td>DUA</td>
<td>Dutch Auction</td>
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<td>EAC</td>
<td>Emotional Approach Coping</td>
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<td>ECG</td>
<td>Electrocardiography</td>
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<td>Electrodermal Reaction</td>
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<td>Electromyography</td>
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<td>Emotion Regulation Questionnaire</td>
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<td>FACS</td>
<td>Facial Action Coding System</td>
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<td>fEMG</td>
<td>Facial Electromyography</td>
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<td>FFT</td>
<td>Fast Fourier Transformation</td>
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<td>fMRI</td>
<td>Functional Magnetic Resonance Imaging</td>
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<td>First-Price Sealed-Bid</td>
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<td>Functional Transcranial Doppler-Sonography</td>
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<td>GROUBA</td>
<td>Group Buying Auction</td>
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<tr>
<td>GUI</td>
<td>Graphical User Interface</td>
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<td>HF</td>
<td>High Frequency</td>
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<td>HGE</td>
<td>Haaf's Game Engine</td>
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<td>HRV</td>
<td>Heart Rate Variability</td>
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<td>IAPS</td>
<td>International Affective Picture System</td>
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<td>IDE</td>
<td>Integrated Development Environment</td>
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<td>IRS</td>
<td>Internal Revenue Service</td>
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<tr>
<td>ISI</td>
<td>Institute for Scientific Information</td>
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<tr>
<td>ISNR</td>
<td>International Society for Neurofeedback and Research</td>
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<tr>
<td>LED</td>
<td>Light-Emitting Diode</td>
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<tr>
<td>LF</td>
<td>Low Frequency</td>
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<tr>
<td>LUNIA</td>
<td>Lowest Unique Auction</td>
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<tr>
<td>MBA</td>
<td>Master of Business Administration</td>
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<tr>
<td>MCI</td>
<td>Multidimensional Coping Inventory</td>
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<tr>
<td>MEG</td>
<td>Magnetencephalography</td>
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<tr>
<td>MR</td>
<td>Magnetic Resonance</td>
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<tr>
<td>MRI</td>
<td>Magnetic Resonance Imaging</td>
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<tr>
<td>MSSD</td>
<td>Mean Squared Difference of Successive NN intervals</td>
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<tr>
<td>NA</td>
<td>Negative Affect</td>
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<tr>
<td>NN</td>
<td>Normal to Normal</td>
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<td>Description</td>
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<tr>
<td>NPC</td>
<td>Non-Player Character</td>
</tr>
<tr>
<td>NYSE</td>
<td>New York Stock Exchange</td>
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<tr>
<td>Ogre</td>
<td>Object-oriented Graphics Rendering Engine</td>
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<td>OS</td>
<td>Operating System</td>
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<td>Positive Affect</td>
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<td>Pleasure Arousal Dominance</td>
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<td>Positive And Negative Affect Schedule</td>
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<td>PGR</td>
<td>Proportion of Gains Realised</td>
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<td>PLR</td>
<td>Proportion of Losses Realised</td>
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<td>Proxy Auction</td>
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<td>Reward/Punishment</td>
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<td>RMSSD</td>
<td>Square Root of Mean Squared Differences of Successive NN intervals</td>
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<td>Standard Deviation of Average NN</td>
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<td>Simple Direct media Layer</td>
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<td>Standard Deviation of NN</td>
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<td>Visual Self Report</td>
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<td>Voice Over Internet Protocol</td>
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<td>What You See Is What You Get</td>
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<td>XML</td>
<td>Extensible Markup Language</td>
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2 SoA on Decision Making and Emotion Regulation (WP2)

2.1 Introduction

The purpose of the literature review provided in the following sections is to outline the existing research deemed relevant for work package 2 at this stage. The review covers literature in the fields of i) emotions, their role in decision-making and their measures; ii) emotion-regulation, its role in decision-making and its measures; iii) key decision-making biases and iv) practice-based learning. The section on emotions focuses on the literature on how emotions are formed, various types of emotions, existing measures of emotions and their role in decision-making. The emotion regulation section provides a review of research on the emotion regulation process, various strategies adopted for regulating emotions, advantages & disadvantages of various strategies and measures of emotion-regulation. Further, the section on key decision-making biases provides a detailed outline of various economic and behavioural theories such as prospect theory, mental accounting, loss aversion etc. Lastly, the practice-based learning section provides a review of the research on various techniques used by organisations and individuals in imbibing skills necessary for the job role in the formative stages of an employee, the effectiveness, advantages and disadvantages of various skills.

2.2 Key Decision Making Biases

2.2.1 Introduction

The purpose of this subsection is to review key concepts in investor decision making and key decision making biases. The subsections that follow present a brief outline of prominent decision making biases and conclude with a section on the relevance of these biases for the current research.

2.2.2 Prospect Theory

Kahneman and Tversky (1979) presented a critique of expected utility theory as a descriptive model of decision making under risk and developed an alternative model called prospect theory. Expected utility theory has dominated the analysis of decision making under risk. It has been generally accepted as a normative model of rational choice (Keeney and Raiffa, 1976) and widely applied as a descriptive model of economic behaviour (Friedman and Savage, 1948). Thus it is assumed that all reasonable people would wish to obey the axioms of the theory and that most people actually do most of the time (Neumann and Morgenstern, 1944). However, Kahneman and Tversky (1979) argued that utility theory, as it is commonly interpreted and applied, is not an adequate descriptive model and propose an alternative account of choice under risk (Kahneman and Tversky 1979, p. 263). Kahneman and Tversky (1979) reviewed several empirical effects which appeared to invalidate expected utility theory as a descriptive model and presented an alternative account of individual decision making under risk, called prospect theory (Kahneman and Tversky 1979, p. 274). Prospect theory suggests the hypothesis that investors display a disposition to sell winners and ride losers when standard theory suggests otherwise (Shefrin and Statman 1985, p. 779). Prospect theory distinguishes two phases in the choice process: an early phase of editing and subsequent phase of evaluation. The function of the
editing phase is to organize and reformulate the options so as to simplify subsequent evaluation and choice (Kahneman and Tversky 1979, p. 274). ‘Significantly, the editing phase frames all choices in terms of potential gains and/ or losses relative to a fixed reference point’ (Shefrin and Statman 1985, p. 779).

In the evaluation stage decision makers employ an S-shaped valuation function which is i) defined on deviations from the reference point; ii) generally concave for gains and commonly convex for losses; iii) steeper for losses than gains (Kahneman and Tversky 1979, p. 279). This reflects risk aversion in the domain of gains and risk seeking in the domain of losses (Shefrin and Statman 1985, p. 779).

The following figure displays the proposed value function:

![Figure 2.1 – S-shaped valuation function (Source: Kahneman and Tversky 1979, p. 279)](image)

‘The S-shaped value function is steepest at the reference point in marked contrast to the utility function postulated by Markowitz (1952) which is relatively shallow in that region’ (Kahneman and Tversky 1979, p. 279). Thaler (1985) made use of the value function in his work on mental accounting and consumer choice. In Thaler’s (1985) view, the assumed shape of the value function incorporated three behavioural principles. Firstly, the function was defined over perceived gains and losses relative to some natural reference point, rather than wealth or consumption as in the standard theory. Thus, people appeared to respond more to perceived changes than to absolute levels. Secondly, the value function was assumed to be concave for gains and convex for losses. ‘Both the gain and loss functions display diminishing sensitivity’ (Thaler 1999, p. 185). This feature captured the difference between $10 and $20 seems greater than the difference between $110 and $120, irrespective of the signs of the amount in question. Third, the loss function was steeper than the gain function, the notion that losses loom larger than gains. ‘Losing $100 hurts more than gaining $100 yields pleasure….’ (Thaler 1999, p. 185).

### 2.2.3 Mental Accounting

Mental accounting is the set of cognitive operations used by individuals and households to organize, evaluate, and keep track of financial activities (Thaler, 1999, p: 183). Thaler (1999) argues that the components of mental accounting violate the economic principle of fungibility. ‘Money in one
mental account is not a perfect substitute of money in another account’ (Thaler 1999, p.185). In order to provide a foundation for the way that decision makers frame gambles, Thaler (1999) constructed a framework known as mental accounting. ‘The main idea underlying mental accounting is that decision makers tend to segregate different types of gambles they face into separate accounts and then apply prospect theoretic decision rules to each account by ignoring possible interaction’ (Shefrin and Statman, 1985, p 780). ‘Mental accounting serves to explain why an investor is likely to refrain from readjusting his reference point for a stock. When the stock is purchased, a new mental account is opened. A running score is then kept in this account indicating gains or losses relative to a purchase price’ (Shefrin and Statman, 1985, p 780). Thaler and Johnson (1990) argue that decision makers encounter considerable difficulty in closing mental accounts at a loss.

Gross (1982) suggested that investors may resist the realization of a loss because it stands as proof that their first judgment was wrong. Moreover, the regret at having erred may be exacerbated by having to admit the mistake to others (a spouse, the IRS). ‘For all those reasons and more, investors as a whole are reluctant to take losses, even when they feel that to so is the right course of action….’. In his manual for stockbrokers Gross (1982) used the term “transfer your assets” to overcome the major obstacle standing in the way of loss realization, namely, the need to close a mental account at a loss. ‘A client who transfers his assets does not close his original mental account, and therefore does not have to come to terms with his loss’ (Gross, 1982). ‘The fundamental reluctance is not so much loss realization as the closure of a mental account at a loss’ (Shefrin and Statman, 1985, p 781).

2.2.4 Hedonic Editing

An aspect which is missing from the mental accounting theory is why would an investor create separate mental accounts? In answer to this question Thaler (1985; 1999) introduced the hedonic editing hypothesis. He states (1999, p. 187) “One possible place to start in building a model of how people code combinations of events is to assume they do so to make themselves as happy as possible.” The hedonic editing hypothesis argues that not only do people create separate mental accounts but they also separate gains and integrate losses to maximise happiness. Specifically, Thaler (1999, p. 187) relates the hedonic editing hypothesis to prospect theory and derives four principles to maximize utility:

1. Segregate gains (because the gain function is concave).
2. Integrate losses (because the loss function is convex).
3. Integrate smaller losses with larger gains (to offset loss aversion).
4. Segregate small gains (silver linings) from larger losses (because the gain function is steepest at the origin, the utility of a small gain can exceed the utility of slightly reducing a large loss).

Evidence of the hedonic editing was found for retail share market investors who cluster loss selling and separate winner selling of shares (Lim, 2006). Furthermore, the hedonic editing hypothesis was also correlated with the disposition effect (Kumar & Lim, 2008).

2.2.5 Loss Aversion

Much of the preceding discussion emphasises a marked aversion for loss realization. ‘Losing $100 hurts more than gaining $100 yields pleasure…. The influence of loss aversion on mental accounting is enormous’ (Thaler 1999, 185). ‘The positive counterpart to regret is pride. While closing a stock account at a loss induces regret, closing at a gain induces pride. The quest for pride, and the avoidance of regret lead to a disposition to realize gains and defer losses,’ (Shefrin and Statman, 1985: p.781-82). However, there is asymmetry between the strength of pride and regret and losses loom larger than gains (Kahneman and Tversky, 1979). Asymmetry between the strength of pride and
regret (regret is stronger) leads inaction to be favoured over action (Kahneman and Tversky, 1979; Thaler, 1985). Thus, investors who are prone to this bias may be reluctant to realize both gains and losses (Shefrin and Statman, 1985, p 782).

The concept of loss aversion in prospect theory has been applied directly to traders. Garvey et al (2007) and Coval & Shumway (2005) specifically investigated whether or not prior losses or gains would influence subsequent risky behaviour. They split a traders day into morning and afternoon sessions and compared morning profitability to afternoon risk taking behaviour. They found a small but significant effect that traders “are far more likely to take on additional afternoon risk following morning losses than following morning gains” (Coval & Shumway, 2005, p. 3).

2.2.6 Self Control

Thaler and Shefrin’s (1981) in their work introduces the conflict between short-run and long-run preferences by viewing the individual as an organization. Their approach states that at any point in time, the organization consists of a planner and a doer. The planner is concerned with lifetime utility, while the doer exists only for one period and is completely selfish, or myopic. Because of the doer’s strength in influencing individual action, the planner is seen as exhibiting will-power or employing precommitment devices. (Thaler and Shefrin 1981, p.394). ‘In order to control the doer’s actions, the planner requires some psychic technology capable of affecting the doer’s behaviour. 1) The doer can be given discretion in which case either his preferences must be modified or his incentives must be altered, or 2) the doer’s set of choices may instead be limited by imposing rules that change the constraints the doer faces’ (Thaler and Shefrin 1981, p. 395). For altering incentives, individuals use three basic techniques to alter the doer’s incentives. First the doer’s preferences can be modified directly. Second, inputs to a saving program can be explicitly monitored via weekly budgets. Third, incentives can be explicitly altered (Thaler and Shefrin 1981, p.397). If the cost of monitoring and persuasion are high, individuals will resort to rules that restrict the doer’s opportunities (Thaler and Shefrin 1981, p.397) similar to ‘strategy of precommitment’ (Strotz 1955-56, p.173).

Shefrin and Statman (1985) in their analysis of the disposition effect adapt the planner-doer model. They let doer utility be a function of the status of various mental accounts. In their view, investors ride losers to postpone regret, and sell winners “too quickly” because they want to hasten the feeling of pride at having chosen correctly in the past. The (rational) planner may not be strong enough to prevent the (emotional) reactions of the doer from interfering with rational decision making (Thaler and Shefrin, 1981). Investors use various techniques to reduce this conflict. ‘Professional traders often adhere to iron-clad rules that mandate the realization of a loss, once it reaches a predetermined percentage of the original purchase price’ (Shefrin and Statman 1985, p.782-783). A stop-loss order is one way to do the same. A stop loss is a device used by investors to try to circumvent the propensity to ride losses by fixing in advance a price at which the stock will automatically be sold. These are usually promoted as devices to limit risk, but their main advantages may be in allowing an investor to make loss realization at a predetermined point automatically (Shefrin and Statman 1985, p.783).

2.2.7 Disposition Effect

Shefrin and Statman (1985) sought to determine whether investors exhibit a reluctance to realize losses (disposition to “ride losers) even when the prospects of standard theory prescribe realization (Shefrin and Statman 1985, p. 777-8). They developed a positive (descriptive) theory of capital gain and loss realisation in which investors tend to “sell winners too early and ride losers too long” and referred to this tendency as the “disposition effect” (Shefrin and Statman 1985, p. 778). Whilst Shefrin & Statman (1985) explain four psychological reasons for why the disposition effect occurs, the aforementioned prospect theory and mental accounting are the explanations which dominate
Disposition effect research (Brown, Chappel, Da Silva Rosa, & Walter, 2006; Chen, Kim, Nofsinger, & Rui, 2007; Dhar & Zhu, 2006; Feng & Seasholes, 2005; Kumar and Lim, 2008 Odean, 1998a; Shapiro & Venezia, 2001). This view is epitomised by Odean (1998a, p. 1776) who states the “disposition effect is one implication of extending Kahneman and Tversky’s (1979) prospect theory to investments.”

A further consideration is capital gains tax which suggests that losses should be realized while they are short-term, while gains should be realized only when they are long-term. However, the disposition to sell winners too early and ride losers too long operates in the opposite direction (Shefrin and Statman 1985, p.785). In particular they find that tax considerations alone cannot explain the observed patterns of loss and gain realization, and that the patterns are consistent with a combined effect of tax considerations and a disposition to sell winners and ride losers (Shefrin and Statman 1985, p.788). Namely, that a reversal of the disposition effect occurs in the month prior to the tax year end (Odean 1998).

2.2.8 Overconfidence

The notion of overconfidence stems from cognitive calibration research which compared a person’s confidence in and performance at certain tasks. If a person predicts that they are more often correct than actually prove to be, they are deemed to be overconfident. Research has found that in an experimental setting the majority of people are overconfident, or in other words, perceived ability is a lot higher than actual performance (for a review see Lichtenstein et al., 1982). In a review of overconfidence research from a behavioural finance perspective, Glaser et al. (2004) outlined different aspects of overconfidence: miscalibration (Biais et al., 2005, Glaser and Weber, 2007), the better than average effect (Glaser and Weber, 2007; Oberlechner & Osler 2008), and excessive optimism (Langer & Roth 1975). Of these the better than average effect (BTA) seems of most relevance to traders.

The BTA effect is where traders “rate their own abilities too highly compared to others” (Odean, 1998). Originally, the concept stemmed from Svensson’s (1981) research which found that 82% of drivers believe their skills and ability are in the top 30%. Taylor & Brown (1988) have found that people may need to have unrealistically positive views of themselves to maintain a positive self image. In a study of over 400 traders Oberlechner & Osler (2008) found that currency traders were prone to the BTA and that experience did not attenuate this. Furthermore, Glaser and Weber (2007) found that the BTA correlated with increased trading volume, a commonly theorised effect of overconfidence (Odean, 1998; Barber & Odean, 2001)

2.2.9 Illusion of Control

In situations where a person may have little control over events they may tend to foster illusions to believe that chance events are within their realm of control. People deprived of a sense of control make active efforts to restore it cognitively (Fiske & Depret, 1998). Langer (1975) conceived the term illusion of control to describe this tendency and showed through a series of experiments that people act as if chance events are subject to personal control. Langer (1975) demonstrated not only the prevalence of the illusion of control, but also that people would behave as if they could exercise control in a chance situation where ‘skill cues’ were present. By skill cues, Langer meant properties of the situation more normally associated with the exercise of skills, in particular the exercise of choice, competition, familiarity with the stimulus, and involvement in decisions.

Fenton-O’Creevy et al. (2003) argue that the conditions in which traders operate are antecedents to the illusion of control. Specifically, stress (Friedland et al. 1992), competition (Langer 1975),
implemental mind set (Gollwitzer and Kinney, 1989) and choice, involvement and familiarity (Langer 1975) induce an illusion of control and are common place in the trading environment (Kahn & Cooper, 1989; Fenton O’Creely et al. 2005). Fenton-O’Creely et al. (2003) found that some traders were susceptibility to the illusion of control and this was negatively correlated with performance.

2.2.10 Relevance of These Biases for the Research

The above biases were selected as the basis for this research project for two reasons. The first reason is that there is variance between individuals in their tendency to exhibit these biases. For the disposition effect Shapira & Venzia (2001) found that one in five investors did not trade with this bias. Also Weber & Welfens (2008) found that 35% of investors did not exhibit the disposition effect and that the disposition effect was stable across time and situations. Fenton-O’Creevy et al. (2003) found individual differences between traders in their susceptibility to the illusion of control concluding this susceptibility is trait based. Likewise, Garvey et al. (2007) found variability in a trader’s propensity to exhibit loss aversion. These findings suggest that there is an underlying trait based explanation of why a trader may exhibit one or more of these biases.

The second reason for researching these biases is that they are related to role that affect can take in decision making. Neurological research has found an intertwined relationship between risk assessment in economic decision making and affect based responses (Bechara & Damasio 1997; Bechara et al. 2005). Research has also related affect based reactions to the aforementioned biases. Some specific examples of this are as follows; De Martino et al. (2006) found that the prospect theory based framing effect was correlated with activation of the emotion part of the brain. They state “increased activation in the amygdala was associated with subjects tendency to be risk averse in the Gain frame and risk-seeking in the Loss frame, supporting the hypothesis that the framing effect is driven by an affect heuristic underwritten by an emotional system” (De Martino et al., 2006, p. 686). Likewise, experimental research has related the tendency to experience loss aversion with use of amygdala and the prefrontal cortex (Shiv et al, 2005 Bechara et al 2007). Mental accounting and the hedonic editing hypothesis (Thaler, 1999) are centred on the need to maintain positive affect. This is also related to research by Labouvie- Vief and colleagues (2003; Labouvie-Vief & Medler 2002; Labouvie- Vief et al 2007) who found individual differences in the need to maintain positive affect or the willingness to integrate negative affect. The creation of illusions about one’s own ability (BTA) or ones control over situations (illusion of control) is inherently linked to a positive self image (Talbyor & Brown, 1988). These illusions are orientated towards the regulation of affect at the personality level (Koole, 2009).

In summary, the biases chosen to research were done so because there is evidence that there are stable differences between people in the tendency to exhibit them. Also when examined more closely, an undercurrent theme for explaining why these biases occur is affect based responses. Therefore by measuring the way in which traders and investors regulate emotions we intend to explain the tendency to exhibit these biases.

2.3 Measuring Decision Making Biases

2.3.1 Introduction

This section looks at how the trader biases which were outlined in section 2.2 can be measured. It outlines how the disposition effect, loss aversion, illusion of control and overconfidence can be measured by review previous work on this.
2.3.2 Measuring the Disposition Effect

The disposition effect is a term coined by Shefrin & Statman (1985) to describe the tendency for investors and traders to hold losing positions longer than winning ones. This section details several methods used to measure the disposition effect through the analysis of trading data. There are several methods of measuring the disposition effect because different methods are required depending on trading frequency. Therefore, the methods are discussed for those who trade frequently (traders) and those who trade less frequently (investors).

2.3.2.1 Traders (professional traders and day traders)

Traders generally have a high frequency of positions during a trading day and tend not to carry positions over night. As they are opening and closing positions regularly in the market it is possible to measure the amount of time they hold a position. The disposition effect is calculated by measuring amount of time it takes to complete a roundtrip trade (Garvey & Murphy, 2004; Locke & Mann, 2005). A roundtrip trade is when a trader both opens and closes a position in a financial market. A simple example of this is a trader buying 1000 Dell shares at 10.00 am then selling 1000 Dell shares at 10.10am. Using roundtrips trades to calculate the disposition effect involves comparing the open price to closing price of each roundtrip trade to classify it as either a gain or a loss. Then the mean holding period of roundtrip gains and losses is calculated and then tested to identify whether or not a significant difference exists (for example see Garvey & Murphy, 2004; Jordan & Diltz, 2004). If losses are held on average longer than gains, then the disposition effect occurs. For example Garvey and Murphy (2004) found that losing roundtrips were held on average 268 seconds (mean) whereas winning roundtrips were held on average for 166 seconds (mean) with a difference of 102 seconds which was significant.

Filtering the trading data so that only roundtrip data exists is a difficult process because a trader can open or close two or more positions on the same financial instrument in the market. For example a trader could buy 500 Dell shares at $12.28 and then 1 minute later buys 500 more at $12.24 to open a position. Then, 2 minutes later, sells 1000 Dell shares at $12.27 to close the position. In this situation is it unclear whether there were 1 or 2 roundtrip positions, whether they were profitable and what the duration of each was? The approach taken in the literature when 2 or more open and close positions occur is use a weighted average approach (Garvey & Murphy, 2004; Locke & Mann, 2005). This approach is used for both the price and duration of roundtrip trades.

One problem that this method doesn’t account for is price fluctuates while a position is being held. For example, a long (buy) position could open at $10, then the price drops to $9.90 for 8 minutes, after which it moves to $10.05 for 2 minutes at which point it is sold. In this situation, the trade has been held for the majority of the time at a loss yet it will be recorded as round trip gain trade. Using a roundtrip trade duration method for assessing the disposition effect will not detect this. So in addition to comparing the duration of roundtrip trades, Locke & Mann (2005) also measure a trader’s market exposure. This involves comparing the traders’ position to the average weighted market price for every minute the position is open. From this they can determine the length of time a trader has a held negative position.

2.3.2.2 Private investors (household investors)

Private investors hold assets for a longer period, trade rather infrequently and may have days where they don’t monitor share price changes at all. For this reason the majority of research uses a different...
methodology to measure the disposition effect. Odean’s (1998) method of calculating the disposition effect analyses an investor’s portfolio only on the day that the investor sells an investment. The approach of this method is to compare the profitability of the share sold to other shares held to determine whether or not an investor is more inclined to sell a winner or a loser.

Making this comparison involves a number of different steps. This first is to classify the share sold as either a realised gain or realised loss by comparing the purchase price to sale price. Then, the other shares in the investor’s portfolio are classified as a paper gain or a paper loss. Paper gains and paper losses are determined by comparing their purchase price to the daily high or daily low price. From this information the proportion of gains realised and proportion of losses realised are determined using the formula below:

\[
\frac{\text{Realized Gains}}{\text{Realized Gains} + \text{Paper Gains}} = \text{Proportion of Gains Realized (PGR)}
\]

\[
\frac{\text{Realized Losses}}{\text{Realized Losses} + \text{Paper Losses}} = \text{Proportion of Losses Realized (PLR)}
\]

The disposition effect is the difference between the PLR and PGR where if the PLR is greater than the PGR then the disposition occurs.

Feng & Seasholes (2005) critique Odean’s (1998) method as it only analyses data on the day which an investor sells an investment. In replacement of this they suggest a different method using survival analysis. This is a statistical model that measures how long an investment survives in a portfolio before it is traded. Feng & Seasholes (2005) calculate the probability of a share being sold from a portfolio for each day after its purchase date, giving the baseline hazard function. The disposition effect is calculated by comparing the survival function of shares trading at a gain and the survival function of shares trading at a loss to the baseline hazard function. If the shares trading at a loss are being held for longer, then their survival function will be above the average and visa versa for shares trading at a gain. Instead of presenting this information as survival curves Feng & Seasholes (2005) follow tradition and present it as a hazard ratio. The disposition effect occurs if the hazard ratio for a shares trading at a loss is less than one as this indicates a decrease in the probability of sale. Likewise, if the hazard ratio for shares trading at a gain is greater than 1 then it is an increase in the probability of sale and reflects the disposition effect (for more information refer to Feng & Seasholes (2005)).

### 2.3.3 Measuring Loss Aversion

One aspect of prospect theory (Kahneman & Tversky, 1979) which receives a lot of attention is the concept of loss aversion. This is, that after experiencing losses, risk appetite increases or as Kahneman & Tversky (1979, p. 287) state “a person who has not made peace with his losses is likely to accept gambles that would be unacceptable to him otherwise”. In relation to traders, Garvey et al (2007) and Coval & Shumay (2005) have found that traders appear loss averse because they take above average risk in the afternoon when they have experienced losses in the morning. How these studies measured this, is outlined below.

The first task that Garvey et al. (2007) undertook was to split the trading days into a morning session (9.30am to 12.45 pm) and an afternoon session (12.45pm to 4pm). This allowed them to compare risk taking and profitability for the morning and afternoon sessions. They then constructed a measure of risk which is comprised of four elements:

1. **The number of trades completed**- where trading more frequently was construed as riskier
2. **The average dollar size per trade**- where if the average was larger, then it is riskier
3. The **total dollar amount traded** - where if the total is larger, then it is riskier.
4. **Absolute price change per round trip trade** - They found that 80% of round trip trades involved an absolute price change of 1% or less. They argue that if a trader deviates from his or her typical average absolute price change during a trading period they are engaging in riskier activity.

The next task was to measure the profitability of traders in the morning. Because traders vary in their trading performance and behaviour (e.g. frequency of trades), Garvey et al (2007) measure risk variables and morning profit on an individual basis and then standardise these measurements. To explain how the variables are standardised the example of morning profit will be used. The morning profit data is observed every day and from this a trader specific mean and trader specific standard deviation is calculated. They then use the trader-specific mean to de-mean the trader’s morning net profit figures (to 'de-mean' they subtract the trader specific mean from each trader’s morning profit observation). Then they divide the de-meaned data by the trader-specific standard deviation of each trader. This gives them a standardised morning profit figure for each trader on each day. This same standardization procedure is used to standardize the other variables as well (Garvey et al., 2007, p. 78).

The next step is to disaggregate the data by morning’s net gains and net losses and report the corresponding afternoon risk measures. To do this they take mean, median and standard deviation of each. We have included a table and graph from Garvey et al. (2007 p. 78-79) to show how they presented the preliminary findings.

### Exhibit 2
Standardized Morning Net Profits and Afternoon Risk Measures

<table>
<thead>
<tr>
<th>Trader/Days with a morning net gain – (6,279 observations)</th>
<th>Mean</th>
<th>Median</th>
<th>Std. Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Morning net gains</td>
<td>0.694</td>
<td>0.531</td>
<td>0.620</td>
</tr>
<tr>
<td>Afternoon Risk Measures</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of trades</td>
<td>-0.041</td>
<td>-0.188</td>
<td>0.960</td>
</tr>
<tr>
<td>Absolute price change</td>
<td>-0.061</td>
<td>-0.246</td>
<td>0.889</td>
</tr>
<tr>
<td>Average trade size</td>
<td>-0.064</td>
<td>-0.311</td>
<td>0.977</td>
</tr>
<tr>
<td>Aggregate trade size</td>
<td>-0.067</td>
<td>-0.344</td>
<td>0.945</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Trader/Days with a morning net loss – (9,973 observations)</th>
<th>Mean</th>
<th>Median</th>
<th>Std. Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Morning net gains</td>
<td>-0.761</td>
<td>-0.550</td>
<td>0.741</td>
</tr>
<tr>
<td>Afternoon Risk Measures</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of trades</td>
<td>0.045</td>
<td>-0.114</td>
<td>1.031</td>
</tr>
<tr>
<td>Absolute price change</td>
<td>0.067</td>
<td>-0.181</td>
<td>1.096</td>
</tr>
<tr>
<td>Average trade size</td>
<td>0.070</td>
<td>-0.173</td>
<td>1.011</td>
</tr>
<tr>
<td>Aggregate trade size</td>
<td>0.074</td>
<td>-0.231</td>
<td>1.044</td>
</tr>
</tbody>
</table>
The final step Garvey et al. (2007) take is to test the robustness of the results. To do this they employ four regressions. This first is a trader specific regression model which uses this calculation:

\[ Risk^A_{i,t} = \alpha_i + \beta_x \pi^M_{i,t} + \beta_R \text{Risk}^M_{i,t} + \varepsilon_{i,t} \]

where \( Risk^A_{i,t} \) equals one of the four standardized afternoon risk measures for trader \( i \) at time \( t \), \( \pi^M_{i,t} \) is trader \( i \)'s morning net profit, \( \text{Risk}^M_{i,t} \) is trader \( i \)'s morning risk measure at time \( t \), and \( \varepsilon_{i,t} \) is a random error term.

The second is a fixed effects logit regression model which determines the probability that a trader’s above-average afternoon risk-taking is dependent on the trader’s morning net profits. The form is outlined below:

\[ P(\text{Risk}^A_{i,t} > 0) = \frac{e^{\alpha_i + \beta_x \pi^M_{i,t} + \beta_R \text{Risk}^M_{i,t}}}{1 + e^{\alpha_i + \beta_x \pi^M_{i,t} + \beta_R \text{Risk}^M_{i,t}}} \]

And finally they estimate two Fama and MacBeth (1973) regression models to find out if certain days and/or certain traders exhibit loss aversion. They run a trader by trader regression and then average the coefficients across the traders. This is also repeated for the days (for more details see Garvey et al., 2007 p.79-80).

2.3.3.1 An additional measure of risk

Coval & Shumway (2005) adopt a very similar analysis to Garvey et al (2007), however, they offer an additional measure of risk which is worth examining. Coval & Shumway (2005) argue that whilst the number trades and the size of the trades are an indication of risk, one needs to consider the risk posed by market volatility. Furthermore, the level of risk may be nonconstant across a market in one day. Or in other words, at certain times of the day a market will be high risk or low risk to trade in. To take this consideration into account, they analyse historical price data for every minute in the market over 9 years and calculate an absolute price change for one minute to the next. They then use
an ordered logit regression to measure the risk a given position faces. To summarise the logit regression they state (p. 10):

A logit function of the probability of various potential absolute price changes over the next minute is regressed on the magnitude of price changes in the preceding 5 minutes and time-of-day dummy variables for each 5-minute period during the trading day. The fitted values from this regression are then used to construct an expected absolute price change for each minute of each full trading day in 1998. Since our risk measure is an expected absolute price change, it roughly corresponds to a one standard deviation measure of price change risk associated with each 1-minute interval. Finally, a trader’s risk is calculated by multiplying each minute’s risk measure by the trader’s position at the beginning of the minute, and adjusting the trader’s risk for the minute by any changes in inventory, and therefore risk, that occur during the minute.

2.3.4 Measuring the Illusion of Control

Fenton-O’Creevy et al (2003) investigated the illusion of control on sample of 118 traders from 4 investment banks and offers one of the most innovative techniques to measure this bias. The illusion of control was measured by a computer based task, written in Visual Basic. Although other measures of the illusion of control use paper and pencil methods (Langer, 1975), Fenton-O’Creevy et al (2003) chose a computer based task for three reasons. First, it proved to be novel and grab attention of participants. Second, it mimicked the trading environment in two ways noisy feedback and decision making under conditions of limited information. Third, it followed prior research which measured the illusion of control behaviourally (Gollwitzer & Kinney, 1989). Fenton-O’Creevy et al (2003, p60-1) outline the computer based task as follows:

After an initial interview, participants were invited to engage in a computer task, during which they were asked to make judgments of their control over changes in the value of an index. A welcome screen introduced the program and collected some personal details. The program then informed participants that they would be asked to play a game. They were told:

When the game starts you will see a chart, similar to the picture shown below. The vertical axis represents an index with values between -2000 and 2000. The horizontal axis shows time. The index starts at zero and every half second for 50 seconds the index is increased or decreased by some amount. Changes in the index are partly random, but three keys on the keyboard may have some effect on the index. The possible effects are to raise or lower the index by some amount, to increase the size of the random movements, or no effect. There is some time lag to the effects. The keys are ‘Z’, ‘X’, and ‘C’. There is no advantage to pressing keys more than once in any half second. Your task is to raise the index as high as possible by the end of 50 seconds. At the end of the game the final value of the index will be added to your pool of points.

The display viewed by participants is shown in Figure 2.2:
The program generated the index by overlaying a random walk onto an underlying rising trend (falling in run 3 and level in 4). The keys pressed by participants had no effect on the index.

At the end of the 50 s, participants were told their score (the level reached by the index) and asked to rate their success in increasing the index by using the keys (by setting a slider bar from 1 ‘not at all successful’ to 100 ‘very successful’). The game was repeated another three times. Rounds 1 and 2 were set up to guarantee that participants experienced an increase in points. In Round 3, participants lost points, and in Round 4, participants’ scores stayed constant (with some small random variation).

Movements in the index were unrelated to participants’ efforts. The random element (around 10% of achieved index level) introduced some variation in outcome between candidates and hence increased measurement error. However, we chose to add in this element to reduce the possibility that participants would compare scores and establish that their actions had no effect, thus contaminating data collection from later participants.

For each round, participants’ rating of their success in raising the value of the index was recorded. This gave a total of four indicators of illusion of control. Individual differences in level of illusion of control elicited by the game were taken to be a measure (with error) of an underlying individual propensity to illusion of control. Factor analysis (on a pilot sample of 130 MBA students) showed the four measures to load on a single factor (50% explained variance), \( \alpha = .68 \). Hence, a single illusion of control scale was calculated as the mean of all four indicators (trader sample \( M = 41.96, \ SD = 19.38, \ \alpha = .71 \)).
2.3.5 Measuring Overconfidence (the Better than Average Effect)

Whilst Glaser and Weber (2007) outline four different measures of overconfidence, they found that the better than average effect (BTA) was correlated with the increased trading volume for a sample of private investors. They also found that the BTA did not correlate with other measures of overconfidence. Oberlechner & Osler (2008) found similar results for a sample of professional traders. Below the two methods of measuring the BTA as used by Glaser and Weber (2007) and Oberlechner & Osler (2008) will be outlined.

2.3.5.1 BTA for private investors

Glaser & Weber (2007) measured the BTA using an online questionnaire which they sent out via email. The BTA was measured by asking investors to assess their ability at trading relative to other private investors. The two questions which were used to measure the BTA effect are (Glaser & Weber 2007, p 15):

Question 1: What percentage of customers of your discount brokerage house have better skills (e.g. in the way they interpret information; general knowledge) than you at identifying stocks with above average performance in the future? (Please give a number between 0% and 100%)

Question 2: What percentage of customers of your discount brokerage house had higher returns than you in the four year period from January 1997 to December 2000? (Please give a number between 0% and 100%)

The better than average effect is calculated as an average by subtracting the answer from 50 and then dividing by 50 for each of the questions. Glaser & Weber (2007) found a slight better than average effect but with high standard deviations indicating large individual differences.

Although the questions above can be improved, they do offer a starting point for measuring how an investor perceives their ability. However, the robustness of the BTA measure is dependent on how it compares with an investor’s performance in the share market. If the BTA score correlated with actual returns, the belief in one’s investment ability would be justified. However, Glaser & Weber (2007) found that high past portfolio returns are not correlated with an investor’s high self assessments.

The measure of performance involves calculating the gross monthly portfolio performance of each investor. To do this they assume that all shares are bought and sold at the end of the month and ignore intra-month trading. Barber and Odean (2000) show that these simplifying assumptions do not bias the measurement of performance. Glaser & Weber (2007, p 28) outline the calculation of gross monthly portfolio return as follows:

The gross portfolio return $R_{gt}^b$ of investor $b$ in month $t$ is calculated as follows:

$$R_{gt}^b = \sum_{i=1}^{S_{ht}} w_{iht} R_{it}$$

with

$$w_{iht} = \frac{P_{iht} n_{iht}}{\sum_{i=1}^{S_{ht}} P_{iht} n_{iht}}$$

$R_{it}$ is the return of stock $i$ in month $t$, $S_{ht}$ is the number of stocks held by individual $b$ in month $t$, $P_{iht}$ is the price of stock $i$ at the beginning of month $t$, and $n_{iht}$ is the number of stocks of company $i$ held by investor $b$ in month $t$. $w_{iht}$ is the beginning-of-month-$t$ market value of the...
holding of stock $i$ of investor $b$ divided by the beginning-of-month-$t$ market value of the whole stock portfolio of investor $b$.

This measure of portfolio return allows a comparison between self reported BTA and actual portfolio performance to identify discrepancies between the two.

### 2.3.5.2 BTA for traders

Oberlechner & Osler (2008) investigated the BTA for currency traders but they used the term hubris instead of BTA. Oberlechner & Osler (2008, p 12) summarised how they asked traders to assess their own ability:

Our tests for hubris are based on responses to the following question: “How successful do you see yourself as a foreign exchange trader?” The top rank of 7 was assigned to “Much more successful than other foreign exchange traders;” the bottom rank of 1 was assigned to “Much less successful than other foreign exchange traders”; “Average” was assigned to the middle rank of 4.

The average score for traders was 5.06 and the vast majority of traders rated themselves as better than average (Oberlechner & Osler, 2008). To examine the robustness of this measure Oberlechner & Olser (2008) also compared the self-evaluation to performance. Unlike, Glaser and Weber (2007) who used actual performance, Oberlechner & Osler (2008) asked the traders immediate supervisors to rate their subordinates along three dimensions: “trading potential,” “trading profits,” and “overall contribution to the organization”. These ranking were then used as the ‘true’ distribution of rankings to compare with the traders self reported rankings. To ensure the accuracy of these evaluations, the supervisors were specifically instructed to compare individuals to others with similar responsibilities at the same institutional rank.

To statistically test the difference between these scores a bootstrap analysis was completed due to the low sample size. Oberlechner & Osler (2008, p 33) describe this analysis and outline their results as follows:

**Bootstrap Tests of Overconfidence on Self-Assessments**

…this table presents results of a bootstrap test of the hypothesis that the participants are overconfident, on average, as suggested by the high share of participants rating themselves above average and the small share rating themselves below average. The null hypothesis is that the participants are not overconfident. The statistical significance of the observed shares was found by calculating the distribution of shares that would have been observed for 1,000 sets of $N$ traders had the true distribution of success ratings been represented by the ratings submitted by superiors, where $N$ is the number of individuals with a self-rating and a complete set of ratings by their superior within a given rank-responsibility combination. This should represent the distribution of these shares under the null, for that group. The table shows the observed share and its marginal significance. Values of 0.000 indicate that the most extreme simulated share was less extreme than the observed share.

<table>
<thead>
<tr>
<th></th>
<th>Overall contribution: Simulated share</th>
<th>Potential: Simulated share</th>
<th>Profits: Simulated share</th>
</tr>
</thead>
<tbody>
<tr>
<td>Senior interbank traders Above average (5, 6, 7)</td>
<td>77.5</td>
<td>0.000</td>
<td>0.003</td>
</tr>
</tbody>
</table>
2.4 Emotion and Decision Making

2.4.1 Introduction

An *emotion* is defined as a collection of changes in body and brain states triggered by a dedicated brain system that responds to specific contents of one’s perceptions, actual or recalled, relative to a particular object or event (Damasio 1994, 1999). ‘A diversity of reactions is regarded as an emotion’ (Poels & Dewitte, 2006). Sorensen (2008) discusses emotions in consumer research and is of the view that emotions have been reflected by the several concepts: Affect, hedonism/hedonic, mood, feelings, and emotions. Sorensen (2008) further suggests that there is a widespread tendency in consumer research to not defining emotions but, rather, to explain them by a list of emotion-words that characterizes specific discrete emotions (happy, sad etc) or by two groups of emotions, positive and negative valenced emotions.

2.4.1.1 The emotional continuum

Poels & Dewitte (2006) suggest that a distinction needs to made between two types of emotions that operate on a continuum depending on how much cognitive processing they require before the emotion is constituted. At the left end of the continuum (see Figure 2.3) they placed emotions that occur automatically, referred to as “lower-order emotions” (Zajonc, 1980). These are spontaneous and uncontrollable emotional reactions (Shiv and Fedorikhin, 1999). ‘These types of emotions mainly involve pleasure and arousal reactions that do not require to be cognitively labeled as a specific emotion’ (Poels & Dewitte, 2006). At the right end of the continuum Poels & Dewitte (2006) placed the emotions that depend on deeper cognitive procession of the situation. These are referred to as “higher-order emotions” (Lazarus, 1991). ‘These types of emotions are more complex than lower-order emotions in the sense that higher-order emotions need to be consciously labeled as a specific emotion’ (Poels & Dewitte, 2006). ‘Some basic emotions, like fear, anger, and happiness, are situated somewhere in between lower-order and higher-order emotions’ (Poels & Dewitte, 2006).

<table>
<thead>
<tr>
<th>Below average (1, 2, 3)</th>
<th>5.6</th>
<th>0.000</th>
<th>0.003</th>
<th>0.000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Senior salespersons</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Above average (5, 6, 7)</td>
<td>76.7</td>
<td>0.009</td>
<td>0.014</td>
<td>0.000</td>
</tr>
<tr>
<td>Below average (1, 2, 3)</td>
<td>5.6</td>
<td>0.001</td>
<td>0.000</td>
<td>0.001</td>
</tr>
</tbody>
</table>

Below average (1, 2, 3) 5.6 0.000 0.003 0.000

Senior salespersons

Above average (5, 6, 7) 76.7 0.009 0.014 0.000

Below average (1, 2, 3) 5.6 0.001 0.000 0.001
2.4.2 Emotions in Decision Making: Evidence from Neuroscience

There exists extensive evidence from neuro-scientific research that emotions not only have an important effect on decision outcomes, but that emotions are closely intertwined with cognitive processes to the extent that they are seen as a key facilitator of effective decision making (Damasio, 1994; Bechara et al., 1997, Anderson et al., 1999, Bechara & Damasio, 2005). Sound and rational decision-making depends on prior accurate emotion processing (Bachara & Damasio, 2005). Bechara & Damasio (2005) studied several patients with lesions of the ventromedial prefrontal (VM) cortex who showed impairments in judgment and decision-making in real-life settings, in spite of maintaining a normal intellect. Patients with bilateral damage to the VM prefrontal cortex develop severe impairments in personal and social decision-making. They have difficulties planning their workday, as well as difficulties in choosing friends, partners, and activities. The actions they elect to pursue often lead to losses of diverse order, e.g., financial losses, losses in social standing, losses of family and friends. The choices they make are no longer advantageous—the patients often decide against their best interests—and are remarkably different from the kinds of choices they were known to make in the pre-morbid period. They are unable to learn from previous mistakes as reflected by repeated engagement in decisions that lead to negative consequences.

While the real-life decision-making of these patients was found to be impaired, their problem-solving abilities in laboratory settings remain largely normal. The patients had normal intellect, as measured by a variety of conventional neuropsychological tests (Bechara et al., 1998; Damasio et al., 1990; Eslinger & Damasio, 1985), and thus, explaining their disturbance in terms of defects in knowledge pertinent to the situation, general intellectual compromise, defects in language comprehension or expression, working memory, or attention; became particularly difficult (Anderson et al., 1999; Anderson et al., 1991; Bechara et al., 1998; Saver & Damasio, 1991). This observation of VM patients who remained intact on standard neuropsychological tests, yet had a compromised ability to express emotion and experience feelings in appropriate situations, i.e., despite normal intellect, there were abnormalities in emotion and feeling, along with the abnormalities in decision-making, led to the somatic marker hypothesis (Damasio, 1994).

The hypothesis attributes these patients’ inability to make advantageous decisions in real-life to a defect in an emotional mechanism that rapidly signals the prospective consequences of an action, and accordingly assists in the selection of an advantageous response option (Damasio, 1994). The hypothesis specifies a number of structures and operations required for the normal operation of decision-making. Deprived of this emotional signal, these patients rely on a reasoned cost-benefit analysis of numerous and often conflicting options involving both immediate and future consequences. The impairment degrades the speed of deliberation (e.g., choosing between two brands of cereal may take a patient a very long time because of endless reasoned analyses of the pros and cons of each brand), and also degrades the adequacy of the choice, i.e., patients may choose disadvantageously. Term emotion tends to mean different things to the layman, the psychologist, and the physiologist, Bechara & Damasio (2005) use the term “somatic” to refer to the collection of body related responses that hallmark an emotion.

Bechara et al. (1997) and Anderson et al. (1999) studied normal subjects, VM, and amygdala patients. The goal was to assess somatic state activation while subjects were making decisions during the gambling task. The patients were asked to perform the gambling task while their Skin Conductance responses (SCRs) were recorded (Bechara et al., 1997, Anderson et al., 1999). In a gambling task that simulates real-life decision-making in the way it factors uncertainty, rewards, and penalties, the
players are given four decks of cards, a loan of $2000 facsimile U.S. bills, and asked to play so that they can lose the least amount of money and win the most (1). Turning each card carries an immediate reward ($100 in decks A and B and $50 in decks C and D). Unpredictably, however, the turning of some cards also carries a penalty (which is large in decks A and B and small in decks C and D). Playing mostly from the disadvantageous decks (A and B) leads to an overall loss. Playing from the advantageous decks (C and D) leads to an overall gain. The players have no way of predicting when a penalty will arise in a given deck, no way to calculate with precision the net gain or loss from each deck, and no knowledge of how many cards they must turn to end the game (the game is stopped after 100 card selections). Normal subjects, generated SCRs when they received reward or punishment. Most important, as they became experienced with the task, they began to generate SCRs prior to the selection of any cards, i.e., during the time when they were pondering from which deck to choose (Figure 2.4).

These anticipatory SCRs were more pronounced before picking a card from the risky decks A and B, when compared to the safe decks C and D. The VM patients generated SCRs to reward or punishment, albeit the responses were slightly lower than those from normal controls, but the amygdala patients completely failed to generate SCRs in reaction to reward or punishment. Furthermore, the VM as well as the amygdala patients entirely failed to generate SCRs before picking a card (Figure 2.5).
Based on these results, Bechara & Damasio (2005) suggest that when the amygdala is damaged, the patient can no longer register how painful it feels when one loses money. This in turn “misleads” the VM cortex regarding how painful it should feel if a decision led to money loss. Together, the results provide support for the notion that decision-making is guided by emotional (somatic) signaling generated in anticipation of future events. Without the ability to generate these emotional signals, the patients fail to avoid the decks that lead to painful losses, and instead they sample the wrong decks until they go broke in a manner that is very similar to how they behave in real life. Thus both
emotional parts of the brain, the amygdala and VM cortex assist with rational decisions (Bechara et al. 1997; Anderson et al. 1999; Bechara & Damasio, 2005).

2.4.3 Emotions in Financial Decision Making

The study of financial decision making, until recently, has been more influenced by the assumptions of financial economics than psychology. The prime influence on research into markets and market behavior has been that of neo-classical financial economics. Traders within such markets have been understood as profit maximisers who act on price information, which summarises all available knowledge about asset values (Fama, 1991; Fama, 1998). These markets are designed to be transparent and have low transaction costs such that profit opportunities are only fleetingly available and market imperfections are eradicated (MacKenzie, 2006). Within this paradigm there are strong assumptions about investor rationality and the nature of investor preferences.

Understanding of markets and market behavior has been qualified by the advent of behavioral finance (De Bondt, Palm, & Wolff, 2004; Thaler, 1993), which has drawn upon the insights of cognitive psychology to incorporate the “irrational” elements of cognitive biases and collective sentiments, such as herding behavior, into models of financial decision making. Behavioral finance has had some success in modeling investor behavior and explaining well known deviations of market behavior from the predictions of the efficient markets hypothesis – a mainstay of the neo-classical paradigm (Fama, 1991). However, within this field of study, the main role accorded to emotions to date is as an interference with rational cognition, or as by-products of the decision process rather than integral and primary in their effects on choice and action (e.g. Shefrin, 2000; Peterson, 2007). In contrast, the trader practitioner literature is full of references to emotion and ‘market sentiment’. ‘Market practitioners and news commentators routinely employ concepts borrowed from psychology to frame and also to make sense of market events and collective behaviour, and emotions, mood, and sentiments often take on a central role here. A burgeoning empirical literature that provides evidence on investor behaviour and market anomalies is witness to the importance of moods and emotions such as optimism, anxiety, hope, and regret in routine financial decision making’ (Fenton-O’Creevy et al., 2008).

Kamstra, Kramer, and Levi (2003) present international evidence that seasonal depression, which correlates with the length of the day, has a negative effect on stock returns. The role of emotion and its impact on trader performance has been extensively analysed and reported by Fenton-O’Creevy et al. (2008) in a large-scale study that involved 118 traders from four leading London-based investment banks. They found that successful expert traders are more likely to engage in self-monitoring and in emotion regulation, and that this carries important benefits in terms of trading performance. ‘Even within such an analysis-intensive domain as financial trading, emotion plays a central role; and workers and their managers are frequently preoccupied with the effective regulation and use of emotions in their work’ (Fenton O’Creevy et al., 2008).

Important changes have also occurred with regard to our understanding of the relationship between cognition and emotion. Advances in neuroscience are demonstrating that, as Phelps (2006, p. 46) concludes in a recent review that the mechanisms of emotion and cognition are intertwined from the early stages of perception through to complex reasoning processes. While there is evidence of the biasing effect of non-relevant emotions on decision-making (Loewenstein & Lerner, 2003) there is also evidence of the essential role emotions play in directing attention among multiple stimuli and in providing an experience-based affective weighting to response options (e.g. Damasio, 1994; Bechara et al., 1997). In this view, emotions are a kind of radar and rapid response system, constructing and carrying meaning across the flow of experience. Fenton-O’Creevy et al. (2008) suggest that the most important lesson to take away from these new developments is that the widespread view of emotions as an inhibiting influence on cognition is both incorrect and misleading, and that affective
engagement with self and the environment is key to successful decision making. “Basic emotions such as fear are adaptive responses conditioned by evolutionary pressures and are critically important for generating quick responses in perilous situations, when a premeditated assessment of options would entail existential risks and thus threaten survival” (Fenton-O’Creevy et al., 2008). What is more, recent evidence from research with brain-damaged patients (Damasio, 1994) has demonstrated that emotions are an essential element of effectual decision making. Without them, individuals would get caught up in details, be unable to focus on the task at hand or prioritise the available options, and, in fact, be incapable of deciding at all.

2.4.4 Emotion and Cognition

Cognition as a field of study within psychology emerged in the middle of the last century as a reaction to the dominance of behaviorism (Miller, 2003). A guiding metaphor for much of cognitive psychology has been the brain-as-computer; an analogy which leaves little place for emotion except as a disturbance of optimal cognitive function or as a signaling system to accompany action and experience. Thinking has been understood as quite apart from feeling. However, over the past two decades a new influence on theories of cognition has been emerging, via advances in neuroscience. These have begun to build a compelling account of the inter-relationship of cognition and emotion. In a major review of this research and its implications for the study of cognition, Phelps (2006) concludes that understanding the role and significance of emotion is critical to understanding cognition. It has become increasingly apparent that human cognition is not only affected by emotion, but that emotion is central to our cognitive functioning.

Towards the close of the twentieth century a major debate in cognitive psychology concerned the primacy of emotion and cognition. One side of the debate argued that affect often precedes cognition (Zajonc, 1984) whilst the other argued that cognitive activity is a necessary precondition of emotion (Lazarus, 1984). However, as we have observed, more recent work in cognitive neuroscience has established strong reciprocal links between emotion and cognition. In particular work on the role of brain structures such as the ventromedial pre-frontal cortex, the amygdala and the hippocampus has lent support to dual processing theories of cognition (Bechara et al., 1997; Buck, 1999), which suggest that decision-making is underpinned by two parallel processes.

2.4.4.1 Dual processing theories

System one (with earlier evolutionary origins) is rapid; pattern recognition activates emotionally weighted biases which in turn activate stored behavioral repertoires. This second process is non-conscious, shows important parallels to processes of perception and has been linked to intuitive decision making (Dane & Pratt, 2007; Epstein et al., 1996).

System two, the slower process, involves conscious deliberation and analysis (the executive function); facts are represented and weighed, options are generated and compared, potential outcomes are modeled, learned reasoning strategies are applied. These dual processes have been described by Epstein and colleagues as the intuitive-experiential and the analytical-rational systems. Figure 2.6 outlines one such dual process theory (Bechara et al., 1997). The first process is associated with conscious volition and conscious analysis, the second with automaticity and, affectively weighted, pattern recognition.
Models of the dual process approach, such as outlined above, consider these two decision approaches not as completely separate but as interacting; a position which, as we have noted above, is increasingly supported by neuroscience research. Conscious analysis of a situation can affect emotional appraisal and immediate affective response may be one input among others into deliberation.

Most of our behaviors and (associated decisions) happen in an automatic fashion, with minimal active participation by the conscious self unless we are confronted with a novel situation (Bargh, Chen, & Burrows, 1996). These automatic processes are efficient in use of cognitive resources but tend to be inflexible. An important minority of behavior involves overriding automatic responses (deliberative behavior), where one pays conscious, effortful attention to a situation, makes a decision and implements a response. This mode of cognition is a flexible but cognitively expensive process.

As we have noted above, conscious deliberation occurs in parallel with more rapid, affectively-cued processing. However, the human brain’s capacity for conscious deliberation is limited and can be depleted, much as a muscle can become exhausted (Baumeister, Bratslavsky, Muraven, & Tice, 1998; Muraven & Baumeister, 2000). Thus, most especially in fast-paced and demanding environments, conscious deliberation is reserved for tasks that are accorded the highest priority. Noting the interaction between both modes of cognition, we would also expect, that in many cases, emotional cues will be important in the process of conscious deliberative decision-making and that disregarding them would be an effortful process.

Thus one might expect that traders and investors, like others, will engage in a great deal of automatic behavior, given the volume of decision demands, and according to this analysis, draw significantly on emotional cues (Finucane et al., 2000). Such decision-making shortcuts are likely to be important to traders’ performance when effective decision making depends on appropriately deploying attention, and responsiveness to market information, under conditions of complexity and time pressure. There is some empirical evidence which supports this view, for example Lo & Repin (2002) carried out a small-scale study of the physiological responses (blood pressure and skin conductance) of
professional traders (N=10) to actual market events. They found emotions to be a significant factor in the real-time financial decision-making of both novice and experienced traders, although less experienced traders had stronger emotional responses to short-term market fluctuations than more experienced traders.

2.4.5 Emotion and Performance

There is evidence both for emotions as detrimental to and as enhancing decision-making performance.

2.4.5.1 Negative impact of emotion on performance

First, there is a range of evidence that emotions can induce bias in decision-making.

- Emotions can bias information retrieval; for example there is evidence that it is most easy to recall experiences which are congruent with current emotional state (Meyer, Gayle et al. 1990).
- Emotions can directly bias the cognitive processes engaged in decision-making; for example fear and anger have significant (and opposite) effects on risk perceptions (Lerner & Keltner, 2001; Lerner, Small et al. 2004).
- Emotions can bias the value attached to outcomes; for example intense negative emotions enhance valuation of short-term outcomes regardless of negative long term consequences (Gray, 1999).

There is evidence from laboratory studies of financial decision-making under risk that low levels of emotional experience lead to higher levels of performance through greater risk neutrality (that is, a more constant association between objective gain and subjective value (Schunk & Betsch, 2006)). Lo, Repin & Steenbarger (2005) found some clear associations between day-traders’ emotions (as measured by an emotional-state survey), their decision making, and performance (N=80). Investors who experienced more intense positive and negative emotional reactions to gain and loss were poorer performers than those with more attenuated emotional responses. The authors suggested that rapid, emotional decision making is unsuited to the complex, information rich environment of trading. The trading practitioner literature also tends to promote the view that emotions are detrimental to decision making, exemplified in the following quotation from highly rated trader Bruce Kovner.

“Whenever a trader says ‘I wish’ or ‘I hope’, he is engaging in a destructive way of thinking because it takes away from the diagnostic thought process” (Schwager, 1993).

2.4.5.2 Positive effects of emotion on performance

However, other research suggests that not only do we rely on emotional cues in rapid, automatic decision-making, but also that this confers a tangible advantage to everyday decision making. For example, patients who have suffered damage to the areas of the brain responsible for expressing and experiencing emotion suffer significantly impaired decision-making in their daily lives while apparently having unimpaired intellectual capacities and performing normally on problem-solving tasks in the laboratory. While these patients have a normal ability to reason, they are unable to use learned emotional cues to weight options and pay selective attention (Brickner 1932; Bechara & Damasio, 2005).

Again, some research on financial decision making points to the positive role emotions may play. Seo & Barrett (2007) carried out a study of investment club members (N=101), using an internet-based
investment simulation accompanied by emotional-state surveys. They found that individuals who experienced more intense emotions achieved higher decision-making performance.

Coates & Herbert (2008) tracked levels of testosterone and cortisol, hormones associated with fight/flight responses, in the saliva samples of 17 professional traders for 8 days (sampling twice per day). They found elevated morning samples of testosterone (known to be associated with persistence, fearlessness and risk appetite) to be positively associated with that day’s profit and loss; and found cortisol (known to be associated with risk aversion and enhanced awareness of risk) to be higher in conditions of greater market volatility. Thus it seems that support for two contrasting perspectives can be derived from the literature: one, that emotions are a kind of radar that help traders navigate through the intense information environment that they seek to master, and two, that emotional reactions to past loss and gain prevent dispassionate appraisal of current and future goals, i.e. the “interference” hypothesis about how emotions impact on cognition and behavior.

2.4.5.3 A possible reconciliation of these perspectives

Accounts of emotions as bias focus primarily on the role of non-relevant emotions. By contrast, accounts of emotions as information focus primarily on the role of emotions in encapsulating prior relevant experience. In principle, these two perspectives may not then be in contradiction. It thus seems likely that Emotion Regulation (e.g. down-regulating non-relevant emotions while remaining sensitive to relevant emotions) may play an important role in emotion performance effects.

2.5 Measurement of Emotions

2.5.1 Introduction

Three overall approaches to the measurement of emotions in consumer research are found: Self report, autonomic measures and brain imaging. ‘Self report is the most commonly used technique to measure emotions especially in consumer research and this is primarily verbal self report. However the method is found to have severe limitations. Brain imaging and especially fMRI has contributed significantly to the progress in cognitive neuroscience and the technique has also entered consumer research in form of neuroeconomics or consumer neuroscience often focusing on emotional aspects and decision making’ (Sorensen, 2008).

2.5.2 Self Report

‘Self report is the most commonly used method for measuring emotions especially connected to consumer behavior’ (Sorensen 2008). The main reason for this is that self report involves relatively smaller expenses and does not demand skills that are uncommon to find among consumer researchers (Sorensen 2008). Self report measures register the respondent’s subjective feeling (Poels and Dewitte, 2006).

2.5.2.1 Verbal self report (VeSR)

‘VeSR is the most expanded method of measuring emotions in a consumer context. This method can be applied in experimental designs, in questionnaires and in interviews. Research is conducted using open ended questions or a battery of emotion items measured by semantic differential or Likert
scales’ (Sorensen 2008). ‘In verbal self report, individuals are asked to express their emotions verbally by means of open-ended questions or to rate their emotions on a battery of emotion items by using semantic differential or Likert scales’ (Poels and Dewitte, 2006).

**Differential Emotions Scale**

The Differential Emotions Scale (DES) was originally developed by Izard and colleagues to measure the 10 basic emotions of interest, joy, surprise, sadness, anger, disgust, contempt, fear, shame/shyness, and guilt (Izard et al., 1993; Stone 1995). The DES has several versions but in each form, the participant is instructed to rate each term on a multipoint rating scale; depending on the particular instructions that are used, respondents rate their current feelings, their feelings over the past week, or their long term trait affectivity. The most recent version of the scale, the DES-IV, includes 12 scales by (1) measuring shame and shyness separately and (2) adding a new scale that assesses inner-directed hostility (Izard et al., 1993).

Izard’s Differential Emotions Scale has been criticized for being too narrow and with too much emphasis on negative emotions (Richins, 1997). This makes it unsuited for measuring emotions related to many consumption situations e.g. experiential consumption, where positive emotions play a central role. The biggest problem with the instrument however, is that many of the scales display only low to moderate internal consistencies (Watson & Vaidya, 2003) in large part due to the small number of items that compose each scale (Gray & Watson, 2007).

**Plutchik’s Primary Emotions**

Plutchik (1980) also used an evolutionary perspective to identify eight primary emotions that are survival oriented.

| Plutchik’s primary emotions | Fear, anger, joy, sadness, acceptance, disgust, expectancy, surprise |

Later he developed the *Emotions Profile Index* (EPI) (Plutchik & Kellerman, 1974), which was used to measure human emotions. The index contains 62 forced-choice emotion descriptor pairs. Responses are transformed into scales representing each of the eight emotions. Plutchik’s primary emotions are assessed to be too narrow since they are all survival related.

**PAD-Model (Pleasure-Arousal-Dominance)**

Mehrabian and Russell’s (1974) PAD-model (Pleasure-arousal-dominance) is founded in general psychological emotion research. The idea of the PAD model is that the full spectrum of human emotions can be described by three independent, bipolar dimensions: Pleasure, arousal and dominance. PAD contains 18 semantic differential items, six for each P, A and D. PAD was not specifically intended for measuring emotions and is thus not suitable for measuring specific emotions.

**PANAS-Model (Positive And Negative Affect Schedule)**

The Positive and Negative Affect Schedule (PANAS) was introduced in 1988 by Watson, Clark and Tellegen as a brief measure of the two major dimensions of affect. The PANAS can measure either state or trait affect, with a slight modification in the instructions to the participant. Positive and negative affect are each measured by 10 items; sample items include active, enthusiastic, and proud for Positive Affect (PA) and upset, afraid and guilty for Negative Affect (NA). Participants rate the extent to which they have felt each mood term using a 5-point scale on which 1= very slightly or not at all and 5= extremely. The brief PANAS scale was developed from the 60 adjectives used by Zevon and Tellegen (1982) through factor analysis to create scales that were “pure markers of either PA or NA; terms that had a substantial loading on one factor but a near-zero loading on the other” (Watson...
The resulting 10-item scales show excellent internal consistency and convergent and discriminant validity (Watson & Clark, 1997). The PANAS has been applied to measure product and service satisfaction by Mano and Oliver (1993) and to measure post-purchase affect by Mooradian and Oliver (1997) and finally to measure negative affect in advertising by Huang (1997).

### PANAS-X

Watson et al. (1988) created the original PANAS to assess the higher order dimensions of Positive Affect and Negative Affect. Watson and Clark (1994) subsequently expanded this instrument by including 11 factor-analytically devised scales that assess specific, lower order affects. As with PANAS the participants rate the extent to which they experienced each mood term on a 5-point scale. Watson and Clark (1994) report extensive reliability and validity data on these scales.

### State Trait Emotion Measure (STEM)

STEM (Levine and Xu, 2005) includes scales on ten emotions, five positive and five negative, thought to be important in work settings. The scale requests ratings of specific emotions experienced at a particular time (State) and generally (Trait). The scale consists of five positive and five negative emotions including, anger, anxiety, attentiveness/energy, contentment, envy, guilt/shame, joy, love, pride and sadness. Participants are asked to rate on a 10 point scale analogous to BARS about these specific emotions experienced at a particular time (State) and generally (Trait). The Cronbach’s alpha reliabilities for the scale were .84 (state) and .87 (trait) for the five positive emotions and .61 (state) and .65 (trait) for the five negative emotions.

An example of the scale for joy is given below:

**Joy**

Joy is a pleasant emotion. It arises when we, or others we identify strongly with, make progress toward achieving important goals, and when the achievements are part of a pattern that we expect will continue. Some examples include:

1. Winning a well-deserved award for our work
2. Receiving a high prestige assignment from our boss
3. Getting a big raise because of our excellent work
4. Achieving a promotion that fulfills our career plan
5. Development of a new, successful product in our work team

Bodily signals include smiling and an outgoing bearing. We tend to approach others, to increase our verbal output, and to be more willing to behave in helpful ways.

Please circle the number on the 10-point scale below (where 1 is little or none and 10 is highest) the extent of joy you felt during your most recent day of work. In making your response don’t think about the other emotions you may feel with or instead of joy.
Please circle the number on the 10-point scale below (where 1 is little or none and 10 is highest) the extent of joy you generally feel when you are working. In making your response don’t think about the other emotions you may feel with or instead of joy.

Summary of Verbal Self Report

‘The advantages of using VeSR (Verbal Self Report) are that it is relatively simple, cheap and quick to use’ (Poels & Dewitte, 2006; Sorensen, 2008). However there are some important limitations. They involve a long list of emotion adjectives and the rating can cause fatigue in the respondents which can damage the reliability. (Poels & Dewitte, 2006; Sorensen, 2008). ‘The most important limitation of verbal self report involves an inevitable amount of cognitive processing, which may distort the original emotional reaction in case of lower-order emotions’ (Poels & Dewitte, 2006). ‘It can be argued that what is measured is the perception of the emotional response rather than the emotional response itself. The impact of this on validity thus depends on what the purpose of the study is’ (Sorensen, 2008). Other validity problems can be inability to report emotions, because respondent are not aware about exactly how they feel, or unwillingness to report their emotions because of social concerns (Poels & Dewitte, 2006).

2.5.2.2 Visual self report (ViSR)

ViSR has a lot in common with the VeSR techniques. Similar to verbal self report, visual self report instruments measure subjective feelings. Instead of relying on a list of words, responses of visual self report are based on cartoon-like figures representing different emotions or emotional states.

The main approaches used are:
- Self Assessment Manikin (SAM), (Lang, 1980)
- AdSAM (Morris et al., 2002).
- PrEmo (Desmet, 2002)

SAM

SAM is based on Mehrabian and Russell’s (1974) PAD-dimension (Pleasure-Arousal-Dominance). Respondents indicate which figures best represent their emotional states. As Figure 2.7 illustrates, SAM is a graphic figure that ranges from smiling and happy to frowning and unhappy in representing the hedonic valence dimension. For the arousal dimension, SAM ranges from excited and wide eyed to relaxed and sleepy. Participants indicate feeling neither happy nor unhappy (i.e. neutral), or neither calm nor aroused, using the midpoint if each scale. In this version of SAM, the participant can fill in any of the five figures depicting each scale or the box between any two figures, resulting in a 9-point rating scale for each dimension.
AdSAM

Morris et al. (2002) developed AdSAM, a further development of SAM where 232 emotion words were scored on SAM and plotted in a two-dimensional space with pleasure and arousal on the two axes. SAM has shown problems related to the dominance dimension, which respondents seem to experience difficulties in relating to. Furthermore, the arousal pictures might have an interpretation issue related to reading the figure.

PrEMO

Desmet (2002) developed the visual instrument PrEmo. PrEmo uses 14 animations of 1-2 seconds. Each animation represents a specific emotion. Respondents indicate how strongly the target stimulus makes them experience each of the 14 emotions represented by the puppets. With PrEmo, more than one specific emotion can be registered, making it suitable to study mixed emotions. ProEmo was originally developed to measure emotional response to design but has also been applied to advertising (Poels and Dewitte, 2006). ProEmo is considered user-friendly, valid, and cheap (Poels and Dewitte, 2006). ProEmo further makes it possible to measure more separate emotional aspects than SAM, and due to the animations contra the still drawings, this can help the interpretation of the drawings.

The advantages of using visual self-report instead of verbal self-report is that it is faster and less boring than verbal self-report. Visual data are also suitable for cross-cultural research and research with children (Morris, 1995; Poels & Dewitte, 2006). However, as pointed out by Poels and Dewitte (2006) ViSR does not solve the issue concerning the cognitive bias. It is still the perception of the emotion and not the actual emotion that is being measured. The significance of this bias tendency depends on the objective of the research and should only be considered a problem on validity when measuring lower-order emotions.
2.5.2.3 Moment-to-moment ratings

‘In moment-to-moment ratings respondents are asked to rate an advertising stimulus by indicating in real time the strength of the perceived magnitude of an emotional dimension or a specific emotion in relation a neutral reference point’ (Poels and Dewitte, 2006). Aaker, Stayman, and Hagerty (1986) were the first to use the technique and proposed the ‘warmth monitor’. ‘The warmth monitor involves a respondent moving a pencil down paper while viewing a commercial, moving it to the left and right to reflect how warm his or her feelings are at any given time. As one commercial ends and another begins the respondent draws a horizontal line’ (Aaker, Stayman, and Hagerty, 1986).

‘The respondent is instructed to keep a constant rate of speed down the page and not look down while watching the commercials. Experience with using the warmth monitor on several hundred subjects suggests that it is easy to understand and use. With practice most respondents do not need to look down at all and others do so only rarely. Subjects are typically asked to practice the warmth monitor on three sets of two commercials each. The practice serves to make respondents comfortable with the warmth monitor, familiar with the scale anchors (to reduce cognitive processing), and capable of moving down the page at a steady, comfortable rate’ (Aaker, Stayman, and Hagerty, 1986).
The technique has mostly been used to measure emotions in advertising. A similar tool was used by Baumgartner, Suja n & Padgette (1997) integrating moment-to-moment ratings into overall ad judgement. Rossiter & Thornton (2004) identified fear pattern of an ad, based on moment-to-moment ratings of fear-to-relief taken for its duration. Moment-to-moment ratings offer immediate and continuous measures of emotional response. It is cheap, and easy to understand and use, however it is important to notice that it only measures one dimension. Vanden Abeele & MaClachlan (1994) found it a reliable instrument for measuring warmth in advertising but suggest a lack of discriminant validity. The experience of using moment-to-moment ratings is primarily related to an advertising context.

### 2.5.3 Autonomic Measures

‘Emotions are accompanied by bodily reactions that are partially beyond an individual’s control. These “autonomic” reactions include facial expressions (e.g. smiling, frowning) and physiological reactions (e.g. sweating) primarily caused by changes in the autonomic nervous system’ (Poels & Dewitte, 2006). ‘Since it measures rely on bodily reactions that are partially beyond an individual’s control. It therefore overcomes the cognitive bias linked to self report’ (Sorensen, 2008). ‘The autonomic reactions are manifestations of lower order emotional processes’ (Poels & Dewitte, 2006).
2.5.3.1 Facial expressions

Measurement of facial expressions is commonly used in psychology. Applying this method requires specific professional competences. ‘All humans are capable to some extent to read other peoples facial expressions and use them in social interaction, however using the method for doing scholarly research calls for a more systematic and scientific approach to reading facial expressions, which is uncommon to find among consumer researchers’ (Sorensen, 2008).

Facial Action Coding System (FACS)

A technique for manipulating expressions has been used in a number of studies by Levenson, Ekman, and their colleagues. Ekman and his colleagues developed a very precise system (the Facial Action Coding System, or FACS; Ekman and Friesen, 1978) for identifying emotional expressions by coding the movements of individual facial muscles. In a series of studies (e.g. Levenson, 1992; Levenson, Ekman, Heider, & Friesen, 1992) instructed participants how to contract the muscles identified by the FACS to form specific expression of six emotions. In each of these studies the corresponding emotional feeling was induced. FACS codes visible facial muscle movement and links to specific emotions. The FACS-driven technique also affects psychophysiological responses, producing distinctive patterns of heart rate, skin temperature, and skin conductance for each of the specific emotions. FACS has been used by Derbaix (1995) to compare verbal emotional responses and coding of facial expressions to a set of commercials. Derbaix (1995) found that FACS is not suitable to use in advertising studies, because the changes in muscular activity are often too vague to measure with FACS.

Facial electromyography (EMG)

EMG measures facial expressions more precise than FACS since it can measure facial muscle activity even though there are no changes in facial expressions. It has proven to register facial muscle activity when no changes in facial expression were found by means of the FACS (Cacioppo et al., 1986). Two different muscle are important in facial EMG: the corrugator and the zygomatic muscle. ‘The corrugator muscle is located above the nose close to they eyebrow and contractions in this muscle are involved in frowning. The zygomatic muscle is situated around the cheeks and controls smiling. In facial EMG electrodes that register muscle contractions are placed on these two muscles’ (Poels & Dewitte, 2006). Lang et al. (1993) undertook a study that showed there was increased activity in the zygomatic muscle when exposed to positive pictures and increased activity in the corrugator muscle when subjects were shown negative pictures.

‘The critic of this method is linked to the setting of the measurement, since it must be conducted in a lab’ (Sorensen, 2008). Furthermore respondents may be affected by the fact that they know they are being measured and therefore try to control muscle reactions (Bolls, Lang and Potter, 2001). ‘Facial EMG is susceptible to noise, for example, evoked by sudden movements of the subject which reduces reliability’ (Poels & Dewitte, 2006).

2.5.3.2 Electrodermal reaction

Electrodermal reaction (EDR) or Skin conductance (SC) measures activation of the autonomic nervous system. Activation of the autonomic nervous system indicates ‘arousal’ (Ravaja, 2004). EDR or SC given an indication of electrical conductance of the skin related to the level of sweat in the eccrine sweat glands. These sweat glands are involved in emotion-evoked sweating (Poels & Dewitte, 2006). Skin conductance can be measured on the whole body but are more sensitive on the palms and soles of the feet (Dawson, Schell and Filion, 2000). When there is more activation of the
autonomic nervous system, there will be more sweat secretion and consequently a higher level of SC (Poels & Dewitte, 2006).

‘EDR is a sensitive measure of arousal. However it requires a lot of experience and sensitive equipment. It is therefore best carried out by experts (Poels & Dewitte, 2006; Sorensen, 2008). ‘EDR only measures the occurrence of arousal not the valence of the arousal, which can be both positive and negative. Another problem with using EDR are the individual variation and situational factors such as fatigue, medication etc can influence SC responses’ (Hopkins and Fletcher, 1994), which makes it hard to know what you are measuring.

2.5.3.3 Cardiovascular responses

‘Heart rate can be used as an indicator of various phenomena: Attention, arousal and cognitive or physical effort’ (Poels and Dewitte, 2006). Heart rate allows for measure of the valence of arousal (Greenwald, Cook and Lang, 1989). Heart rate can be operationalized as number of milliseconds since the previous heart beat (Lang, 1990). In order to differentiate heart rate measures indicating attention to commercials from measures indicating arousal responses to commercials, Lang (1990) looked at phasic (i.e. short term) changes in heart rate for attention and at tonic (i.e. long term) changes as an indication of arousal. She came to the conclusion that for both attention and arousal heart rate can be a valid real time and continuous measure.

Generally heart rate measures are considered to be a valid measure of arousal, valence or attention. However results need to be interpreted with caution since several phenomena can occur at the same time, affecting the heart rate in different direction thus causing bias (Poels and Dewitte, 2006). Heart rate as indicator of emotional response should not be used as single measurement method but could be combined with e.g. skin conductance to indicate valence (Hopkins and Fletcher, 1994). Heart rate has been used as a method for measuring the impact of arousal on information processing capacity (Sanbonmatsu and Kardes (1988) and for measuring emotional response to advertising stimuli (Lang, 1990; Bolls, Lang & Potter, 2001).

2.5.3.4 Eye-tracking

Eye-tracking have mostly been applied to studies in advertising research where attention play a large role. But can also be used in in-store decision-making (retail-stores). It has been used to study attention toward health warnings in cigarette advertisements among adolescents (Krugman et al. (1994) and to study attention wear-out and the impact of repetition on advertising effectiveness (Pieters, Rosenbergen and Wedel, 1999). Eye tracking methods are also used for studying emotion in animals (Parr & Gothard, 2007). Parr & Gothard (2007) discuss use of the technique in for studying emotions in animals. Conventional noninvasive eye tracking involves the use of a high speed digital video camera surrounded by a series of infrared light-emitting diodes (LEDs) that produce an infrared beam aimed at the eye. Part of the beam is absorbed through the pupil and part is reflected by the cornea. The pupil and/or the corneal reflection are captured by the camera, and their x-y position is transmitted to a computer according to preset sampling frequency. These are either converted by an A/D converter and further processed or directed via digital interface to a data acquisition card. Almost all eye trackers require precise calibration for the eye positing measures to be meaningful. This is done by requesting the subject to look at specific locations on a presentation surface such as a computer monitor, and adjusting the gain and the output of the system to actual distance between the calibration points.
2.5.3.5 Summary of autonomic measures

Autonomic measures have the advantage that they can measure emotional reaction in real time without cognitive bias and thus appear to provide the most valid tool for measuring lower order emotions. However since some autonomic responses can be an indicator of several aspects of an emotion or of aspects related to emotions (e.g. attention), it is often difficult to establish a clear-cut relation between emotional reactions and autonomic responses (Poels and Dewitte, 2006). In order to increase the effectiveness of these measures, it is better to use multiple autonomic measures on one respondent at the same time (Bagozzi, 1991; Plutchik, 2003).

2.5.4 Brain Imaging

‘Brain imaging is a new method in consumer research. The method has entered from neuroscience and offers the opportunity for interesting new insights. Emotions are pointed out as an area of specific relevance’ (Sorensen, 2008). ‘The ultimate way of studying the role of emotions in advertising, is by directly looking into the brain’ (Poels and Dewitte, 2006). Initial approaches to measuring response of the peripheral nervous system to advertising stimuli such as skin conductance measurement were already applied in the late seventies (Kroeber-Riel, 1979). Methods of measuring electric brain waves were also employed in this context (Rothschild et al. 1988). These studies contributed substantially to consumer research by measuring amplitudes of neurophysiologic activation. However, due to methodological problems such as evaluating the valence (positive vs. negative) of the activations, these studies were unable to answer satisfactorily the question of how consumers process emotional responses to advertising stimuli. With technological innovations in the field of functional brain imaging the methodological problems of the former approaches appear to have been addressed. ‘Functional brain imaging methods facilitate the analysis of human brain functions directly while the testpersons perceive advertising stimuli’ (Ahlert, Kenning and Plassmann, 2006). Neuroscientific approaches divide the brain into different areas with the help of brain atlases and coordinate systems (Kenning and Plassmann 2005).

Overview of neuroscientific techniques

For a clear technical review of the neuroscientific techniques, Ahlert, Kenning and Plassmann (2006) is referred to in this section. It is possible to differentiate between different neuroscientific methods. These can be grouped into two main categories according to the underlying mechanisms. See table below:

<table>
<thead>
<tr>
<th>Changes in electric currents</th>
<th>Changes in metabolism</th>
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<tbody>
<tr>
<td>Electroencephalography (EEG)</td>
<td>Positron-Emissions-Tomography (PET)</td>
</tr>
<tr>
<td>Magnetencephalography (MEG)</td>
<td>Functional transcranial Doppler-Sonography (FTCD)</td>
</tr>
<tr>
<td></td>
<td>Functional Magnetic Resonance Imaging (fMRI)</td>
</tr>
</tbody>
</table>

Table 2.1 – Overview of neuroscientific methods (Source: Ahlert, Kenning and Plassmann, 2006)

2.5.4.1 Electroencephalography (EEG)

‘Electroencephalography (EEG) is an important tool for studying the temporal dynamics of the large-scale neuronal circuits within the human brain. EEG measures voltage fluctuations on the
scalp. The underlying currents occur remotely from the electrodes (across skin, skull and meninges) in cortex areas near the surface. An electrode on the skin “detects” the summed potential of a huge number of neurons’ (Ahlert, Kenning and Plassmann, 2006). EEG has been applied in advertising research to study television ads versus print ads in magazines (Krugman, 1971), to study response to TV commercials (Rothschild et al., 1988), memory for components of TV commercials (Rothschild and Hyun, 1990) and to study the impact of affect on memory in advertising (Ambler and Burne, 1999). ‘The main shortcoming of EEG is the so-called inverse problem, i.e. localizing the sources of currents in the brain from scalp measurements, because an infinite number of source configurations can generate identical potentials on the skin’ (Ahlert, Kenning and Plassmann, 2006).

2.5.4.2 Magnetoencephalography (MEG)

‘Magnetoencephalography (MEG) is sensitive to changes in magnetic fields induced by electrical brain activity’ (Ahlert, Kenning and Plassmann, 2006). The temporal resolution is comparable to the EEG, so that this modality can, for example, resolve the temporal sequence of different cortical activities involved in decision-making (Ambler et al. 2004, Braeutigam et al. 2001). ‘However, in contrast to the EEG, MEG is also able to depict deeper brain structures. Nonetheless, the inverse problem still applies to MEG and accurate source localization depends on valid assumptions as well’ (Ahlert, Kenning and Plassmann, 2006).

MEG has been applied by Ioannides et al. (2000) to measure differences in brain activation during exposure to affective and cognitive ad stimuli. Ioannides et al. (2000) were the first to use MEG in advertising research. Ambler et al. (2004) used MEG to study brand choice in a super-market frame and the role of familiarity of the brand.

2.5.4.3 Positron emission topography (PET)

Positron emissions tomography (PET) is a nuclear medicine technology through which metabolic processes in the body can be investigated (Aine 1995). ‘Positrons, the antiparticles of electrons, are emitted by certain radio-nuclides. These nuclides have the same chemical properties as their non-radioactive isotopes and can replace the latter in biologically relevant molecules. The spatial distribution of these modified molecules can be detected and visualized by a PET-scanner. This device is sensitive to the radiation resulting from the annihilation of the emitted positrons when they collide with their antiparticles, the electrons. In this manner, the distribution and metabolism of a large variety of biologically relevant molecules, e.g. modified glucose or neurotransmitters, and also brain perfusion can be visualized in tomograms after the injection or inhalation of tiny amounts of the labeled substances. Spatial resolution is quite high (theoretically down to ~2 mm), but temporal resolution is low. Measurements are fairly expensive, and, because radioactive tracers are used, the application to healthy test persons is restricted’ (Ahlert, Kenning and Plassmann, 2006).

PET is not often used in consumer research but there have been examples of use in other areas of Neuroeconomics e.g. to study punishment in trust games (Camerer, Loewenstein and Pralec, 2004).

2.5.4.4 Functional transcranial Doppler sonography (fTCD)

‘By means of functional transcranial Doppler sonography (fTCD), eventrelated changes in cerebral blood flow velocity are measured simultaneously within two cerebral arteries by ultrasound (Deppe, Ringelstein and Knecht 2004). Thus, fTCD is a blood-flow-sensitive counterpart to PET and fMRI with high temporal, but limited spatial resolution, because this method basically integrates changes in cerebral blood flow induced by neural activity in those parts of the brain that are supplied by the respective cerebral arteries. Before experiments are planned, the researcher must therefore have a
good idea of the respective vascular territories in which relevant activation changes are most likely to occur. Nevertheless, in contrast to PET and fMRI, the equipment for fTCD is less expensive and - even more important - easily portable. When the brain areas involved in economically relevant behavior have been identified, for example by PET or fMRI, experiments based on fTCD can then conducted with high temporal resolution in various “non-artificial” environments, as e.g. the point of sale (Ahlert, Kenning and Plassmann, 2006).

2.5.4.5 Functional Magnetic Resonance Imaging (fMRI)

Functional magnetic resonance tomography (fMRI) is currently the most popular technology in this area. FMRI is a technique for estimating neural activity non-invasively. Whereas conventional MRI provides images of structure (e.g., bone vs. muscle vs. fat), functional MRI provides images that estimate function (brain activity). This procedure uses magnetic fields and radio waves in order to depict different kinds of body tissue. The strength of transmitted MR signals varies according to the density of different kinds of body tissue and the strength of the magnetic field. The MR signals are captured by detectors and, by means of a computer, converted into coloured maps through mathematical and statistical procedures. Activations in specific regions can be isolated with the aid of mathematical transformations and statistical inference. Generally, the temporal resolution of fMRI is higher than that of PET, but clearly lower than that of EEG, MEG and fTCD. The spatial resolution is relatively high. In contrast to fTCD, the need for a MR-scanner makes measurements at the point-of-sale rather difficult. Also, the noise and the narrow scanner bore require sophisticated study designs to obtain results transferable to ‘real’, economically relevant situations (Ahlert, Kenning and Plassmann, 2006).

2.5.4.6 Summary

Brain imaging methods are extremely expensive and require expert knowledge as well as having severe technological limitations for experimental designs (Sorensen 2008). Furthermore knowledge within neuroscience is still relatively young and therefore the complexity of the problems investigated must be relatively simple. The use in consumer research is so far relatively limited and thus are the examples of use related to measurement of emotions in consumer research (Sorensen, 2008).

2.6 Coping

2.6.1 Introduction

Research on coping can be traced to the work of Lazarus (1966). Coping is conceptualised as a response to environmental and psychological demands in particular stressful situations (Folkman and Lazarus, 1985). Major contributors to the field have been Folkman, Lazarus (eg. Folkman and Lazarus, 1980, 1985; Lazarus and Folkman, 1984), Carver (eg. Carver and Scheier, 1981; Carver et al., 1989), Endler and Parker (eg. Endler and Parker, 1989, 1990). Lazarus (1966) pointed that stress consists of three processes; a) primary appraisal (process of perceiving threat to oneself), b) secondary appraisal (process of bringing to mind a potential response to threat) and c) coping (process of executing that response). Pearlin and Schooler (1978) interviewed a large cross-section of adults and categorised coping behaviour into three styles; a) responses that change the situation, b) responses that change the meaning or appraisal of the stress and c) responses aimed at controlling distressful feelings. Folkman and Lazarus (1980) developed a measure of Coping called Ways of Coping Checklist (WCC). They distinguished between two general types of coping; a) problem-
focussed coping (aimed at solving the problem or doing something to alter the source of stress) and b) emotion-focussed coping (aimed at reducing or managing the emotional distress that is associated with the situation). The WCC is composed of 68-items in yes/no format that include a variety of behavioural and cognitive strategies as both modalities are used for problem- and emotion-focussed coping. The WCC has been critiqued by various researchers. Aldwin et al. (1980) factor analysed WCC and found seven factors, six related to emotion-focussed coping and one related to problem-focussed coping. In addition, intercorrelations among subscales were reported to be high, even between the problem-focussed coping scale and various emotion-related coping scales. Another factor-analysis on WCC on a larger sample, Vitaliano et al. (1985) found six factors, from which five interpretable coping scales were created, which were different from those derived by Folkman and Lazarus (1980) and Aldwin et al. (1980). These factors often diverge sharply in character to the extent of being inversely correlated (Scheier et al., 1986).

Folkman and Lazarus (1985) revised the WCC by rewriting, adding and deleting a few items. The resulting 66 items were administered on a 4-point likert scale. The resulting scale (named WCQ; Folkman and Lazarus, 1988) concluded with eight subscales; a Planful Problem Solving Scale, a Seeking Social Support scale and six emotion-focussed scales. In another study using WCQ (Ways of Coping Questionnaire), Folkman et al. (1986) reported eight subscales, which were different from those reported in Folkman and Lazarus (1985). Both WCC and WCQ have been critiqued as empirical support for validity and reliability, provided by Folkman and Lazarus is limited.

Billings and Moos (1981) studied a large cross-section of adults, respondents were chosen from those who had experienced a recent personal stressful event. They were asked to complete a 19-item, yes/no format scale. Billings and Moos (1981) divided the coping responses, similar to Pearlin and Schooler (1978), into; a) active-behavioural coping, b) avoidance coping and c) active cognitive coping. The three scales had reliabilities ranging between 0.44 to 0.80. In an extension of their research, Billings and Moos (1984) studied adults about to enter treatment for depression. They were asked to complete complete a 31-item, 4-point likert scale questionnaire. Billings and Moos (1984) reclassified coping responses as; a) appraisal-focussed coping, b) problem-focussed coping and c) emotion-focussed coping. However, they did not report any empirical evidence and the scales had reliabilities between 0.41 to 0.66.

2.6.2 Major Contributors to Research on Coping

2.6.2.1 COPE (Carver et al., 1989)

Carver et al. (1989) developed COPE, which included 13 conceptually distinct scales, based on theoretical arguments and on previous research. They included five scales for problem-focussed coping (active coping, planning, suppression of competing activities, restraint coping, seeking of instrumental social support), five scales for emotion-focussed coping (seeking of emotional social support, positive reinterpretation, acceptance, denial, turning to religion) and three scales to measure coping responses that are less useful (focus on and venting of emotions, behavioural disengagement, mental disengagement). Amongst the scales for problem-focussed coping; a) active coping is defined as the process of taking active steps to try to remove or circumvent the stressor, b) planning is thinking about how to cope with a stressor i.e. coming up with action strategies, thinking about what steps to take and how best to handle the problem, c) suppression of competing activities means putting other projects aside to avoid becoming distracted in order to concentrate on the challenge at hand, d) restraint coping is waiting until an appropriate opportunity present itself to act on, to avoid acting prematurely and e) seeking social support for instrumental reasons includes seeking advice, assistance or information. The emotion-focussed coping was assessed by five scales; a) seeking social support for emotional reasons is getting moral support, sympathy, or understanding, b) positive
reinterpretation and growth, Lazarus and Folkman (1984) regarded this tendency (which they termed positive reappraisal) as a type of emotion focused coping: coping aimed at managing distress emotions rather than at dealing with the stressor per se, c) denial a response that sometimes emerges in primary appraisal and it can be argued that denial only creates additional problems unless the stressor can profitably be ignored, d) acceptance, the opposite of denial, was argued to be a functional coping response, in that a person who accepts the reality of a stressful situation would seem to be a person who is engaged in the attempt to deal with the situation and e) turning to religion as a coping response, data collected recently by McCrae and Costa (1986) suggest that such a coping tactic may be quite important to many people. Carver et al. (1989) argued that in principle it would be possible to have multiple religion-related scales assessing each of various functions religion can play, however they opted instead for a single scale that assessed, in a general way, the tendency to turn to religion in times of stress.

Carver et al. (1989) used three “less useful” scales; a) focusing on and venting of emotions, the tendency to focus on whatever distress or upset one is experiencing and to ventilate those feelings (eg. Scheff, 1979). Carver et al. (1989) argued that such a response may sometimes be functional, however, focusing on these emotions (particularly for long periods) can impede adjustment (Felton, Revenson, & Hinrichsen, 1984). Hence, focusing on the distress may also distract people from active coping efforts and movement beyond the distress, b) behavioural disengagement is reducing one’s effort to deal with the stressor, even giving up the attempt to attain goals with which the stressor is interfering, identified with terms such as helplessness and c) Mental disengagement is a variation on behavioral disengagement, postulated to occur when conditions prevent behavioral disengagement (Carver et al., 1983). Mental disengagement occurs via a wide variety of activities that serve to distract the person from thinking about the behavioral dimension or goal with which the stressor is interfering.

The 13 scales (4 items each) were put together in an inventory, named COPE (see Table 2.2). The inventory had two formats; dispositional and situational, to account for individual differences. Carver et al. (1989) reported acceptable validity and internal consistency reliability for the scale.

<table>
<thead>
<tr>
<th>Scale name and items</th>
<th>Loading</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Active coping</strong></td>
<td></td>
</tr>
<tr>
<td>I take additional action to try to get rid of the problem.</td>
<td>.42</td>
</tr>
<tr>
<td>I concentrate my efforts on doing something about it.</td>
<td>.37</td>
</tr>
<tr>
<td>I do what has to be done, one step at a time.</td>
<td>.33</td>
</tr>
<tr>
<td>I take direct action to get around the problem.</td>
<td>.29</td>
</tr>
<tr>
<td><strong>Planning</strong></td>
<td></td>
</tr>
<tr>
<td>I try to come up with a strategy about what to do.</td>
<td>.73</td>
</tr>
<tr>
<td>I make a plan of action.</td>
<td>.68</td>
</tr>
<tr>
<td>I think hard about what steps to take.</td>
<td>.53</td>
</tr>
<tr>
<td>I think about how I might best handle the problem.</td>
<td>.49</td>
</tr>
<tr>
<td><strong>Suppression of competing activities</strong></td>
<td></td>
</tr>
<tr>
<td>I put aside other activities in order to concentrate on this.</td>
<td>.68</td>
</tr>
<tr>
<td>I focus on dealing with this problem, and if necessary let other things slide a little.</td>
<td>.55</td>
</tr>
<tr>
<td>I keep myself from getting distracted by other thoughts or activities.</td>
<td>.51</td>
</tr>
<tr>
<td>I try hard to prevent other things from interfering with my efforts at dealing with this.</td>
<td>.48</td>
</tr>
<tr>
<td><strong>Restraint coping</strong></td>
<td></td>
</tr>
<tr>
<td>I force myself to wait for the right time to do something.</td>
<td>.71</td>
</tr>
<tr>
<td>I hold off doing anything about it until the situation permits.</td>
<td>.67</td>
</tr>
<tr>
<td>I make sure not to make matters worse by acting too soon.</td>
<td>.62</td>
</tr>
<tr>
<td>I restrain myself from doing anything too quickly.</td>
<td>.40</td>
</tr>
<tr>
<td>Seeking social support for instrumental reasons</td>
<td></td>
</tr>
<tr>
<td>---------------------------------------------</td>
<td>----------</td>
</tr>
<tr>
<td>I ask people who have had similar experiences what they did.</td>
<td>.66</td>
</tr>
<tr>
<td>I try to get advice from someone about what to do.</td>
<td>.65</td>
</tr>
<tr>
<td>I talk to someone to find out more about the situation.</td>
<td>.60</td>
</tr>
<tr>
<td>I talk to someone who could do something concrete about the problem.</td>
<td>.55</td>
</tr>
<tr>
<td>Seeking social support for emotional reasons</td>
<td></td>
</tr>
<tr>
<td>I talk to someone about how I feel.</td>
<td>.71</td>
</tr>
<tr>
<td>I try to get emotional support from friends or relatives.</td>
<td>.71</td>
</tr>
<tr>
<td>I discuss my feelings with someone.</td>
<td>.69</td>
</tr>
<tr>
<td>I get sympathy and understanding from someone.</td>
<td>.58</td>
</tr>
<tr>
<td>Positive reinterpretation &amp; growth</td>
<td></td>
</tr>
<tr>
<td>I look for something good in what is happening.</td>
<td>.75</td>
</tr>
<tr>
<td>I try to see it in a different light, to make it seem more positive.</td>
<td>.59</td>
</tr>
<tr>
<td>I learn something from the experience.</td>
<td>.23</td>
</tr>
<tr>
<td>I try to grow as a person as a result of the experience.</td>
<td>.19</td>
</tr>
<tr>
<td>Acceptance</td>
<td></td>
</tr>
<tr>
<td>I learn to live with it.</td>
<td>.68</td>
</tr>
<tr>
<td>I accept that this has happened and that it can't be changed.</td>
<td>.60</td>
</tr>
<tr>
<td>I get used to the idea that it happened.</td>
<td>.43</td>
</tr>
<tr>
<td>I accept the reality of the fact that it happened.</td>
<td>.38</td>
</tr>
<tr>
<td>Turning to religion</td>
<td></td>
</tr>
<tr>
<td>I seek God's help.</td>
<td>.95</td>
</tr>
<tr>
<td>I put my trust in God.</td>
<td>.88</td>
</tr>
<tr>
<td>I try to find comfort in my religion.</td>
<td>.84</td>
</tr>
<tr>
<td>I pray more than usual.</td>
<td>.81</td>
</tr>
<tr>
<td>Focus on &amp; venting of emotions</td>
<td></td>
</tr>
<tr>
<td>I get upset and let my emotions out.</td>
<td>.79</td>
</tr>
<tr>
<td>I let my feelings out.</td>
<td>.76</td>
</tr>
<tr>
<td>I feel a lot of emotional distress and I find myself expressing those feelings a lot.</td>
<td>.57</td>
</tr>
<tr>
<td>I get upset, and am really aware of it.</td>
<td>.45</td>
</tr>
<tr>
<td>Denial</td>
<td></td>
</tr>
<tr>
<td>I refuse to believe that it has happened.</td>
<td>.75</td>
</tr>
<tr>
<td>I pretend that it hasn't really happened.</td>
<td>.72</td>
</tr>
<tr>
<td>I act as though it hasn't even happened.</td>
<td>.52</td>
</tr>
<tr>
<td>I say to myself &quot;this isn't real.&quot;</td>
<td>.46</td>
</tr>
<tr>
<td>Behavioral disengagement</td>
<td></td>
</tr>
<tr>
<td>I give up the attempt to get what I want.</td>
<td>.49</td>
</tr>
<tr>
<td>I just give up trying to reach my goal.</td>
<td>.42</td>
</tr>
<tr>
<td>I admit to myself that I can't deal with it, and quit trying.</td>
<td>.37</td>
</tr>
<tr>
<td>I reduce the amount of effort I'm putting into solving the problem.</td>
<td>.30</td>
</tr>
<tr>
<td>Mental disengagement</td>
<td></td>
</tr>
<tr>
<td>I turn to work or other substitute activities to take my mind off things.</td>
<td>.45</td>
</tr>
<tr>
<td>I go to movies or watch TV, to think about it less.</td>
<td>.43</td>
</tr>
<tr>
<td>I daydream about things other than this.</td>
<td>.28</td>
</tr>
<tr>
<td>I sleep more than usual.</td>
<td>.23</td>
</tr>
<tr>
<td>Alcohol-drug disengagement</td>
<td></td>
</tr>
<tr>
<td>I drink alcohol or take drugs, in order to think about it less.</td>
<td></td>
</tr>
</tbody>
</table>

Table 2.2 – COPE Scales. Items listed by a priori scale assignment, with loadings on the factor to which each item pertains. Note: Items are listed in order of strength of loading. Loadings for active coping and planning come from a...
single factor that incorporated both scales. Loadings for seeking social support for instrumental reasons and seeking social support for emotional reasons come from a single factor that incorporated both scales. (Source: Carver et al., 1989)

2.6.2.2 MCI (Endler and Parker, 1990)

Endler and Parker (1990) developed the Multidimensional Coping Inventory (MCI). They identified the two basic coping strategies of problem-focussed coping, emotion-focussed coping and added a third basic strategy, avoidance, which can include either person-oriented or task-oriented strategies. The MCI was developed on both empirical and logical bases. They adopted an inter-individual approach, which uses coping scores aggregated over different measurement occasions or scores collected on a single occasion that represent a stable index of the individual’s coping processes and styles.

The first stage in developing the MCI was to create a list of items that represented a wide range of possible coping behaviors. Seven psychologists and graduate students in psychology generated items on their own and evaluated items from a variety of existing coping inventories and from the literature on strategies of coping in diverse situations. In the initial stage, 120 items were selected by this group as covering a wide variety of coping behaviors. The research team shortened the list to 70 items by removing redundant items or questions that seemed biased towards certain groups of individuals. The items were factor-analysed with varimax rotation, which left a total of 44 items. Subscales for the MCI were derived from the factor analysis of the 44 coping items. The 19 items that loaded on the Task factor were summed to produce the Task subscale, the 12 items that loaded on the Emotion factor were summed to produce the Emotion subscale, and the 13 items that loaded on the Avoidance factor were summed to produce the Avoidance subscale.

Having determined that the subscales of the MCI possessed moderate to high stability and internal consistency, Endler and Parker (1990) assessed the construct and criterion validity of the MCI. The MCI Task-oriented subscale was highly correlated with the WCQ Problem-Focused subscale. Both scales were developed to assess a similar construct. The factor analyses of the MCI yielded three factors: Task, Emotion, and Avoidance. A reanalysis of the 44 items of the MCI yielded three factors (with 19, 12, and 13 items respectively on Task, Emotion, and Avoidance). Although there were no male-female differences on Task-oriented coping, women report significantly more Emotion-oriented and Avoidance-oriented coping than men. Endler and Parker (1990) pointed that there is an interaction between gender and type of coping that affects the level of coping responses. Women scored higher on Avoidance-oriented coping than men because women have been reported to be more socially responsive than men (Freedman, 1979). The strength of the association between coping and measures like depression, anxiety, Type A behavior, neuroticism, and extraversion was found to vary across the Task, Emotion, and Avoidance coping scales.

<table>
<thead>
<tr>
<th>Selected items from the MCI</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Task-Oriented Coping Subscale</strong></td>
</tr>
<tr>
<td>15. Outline my priorities</td>
</tr>
<tr>
<td>36. Work to understand the situation</td>
</tr>
<tr>
<td>39. Think about the event and learn from my mistakes</td>
</tr>
<tr>
<td>51. Analyze the problem before reacting</td>
</tr>
<tr>
<td>54. Adjust my priorities</td>
</tr>
<tr>
<td><strong>Emotion-Oriented Coping Subscale</strong></td>
</tr>
<tr>
<td>6. Blame myself for procrastinating</td>
</tr>
<tr>
<td>22. Become very tense</td>
</tr>
</tbody>
</table>
26. Blame myself for being too emotional about the situation  
27. Daydream about a better time or place  
64. Fantasize about how things might turn out
Avoidance-Oriented Coping Subscale
17. Treat myself to a favorite food or snack  
41. Visit a friend  
44. Spend time with a special person  
58. See a movie  
59. Take time off and get away from the situation

Table 2.3 – Selected items from the MCI (Source: Endler and Parker, 1990)

Similar ways of coping have been derived by various researchers; Engagement (Responses that are oriented toward either the source of stress, or toward one’s emotions and thoughts) and disengagement (responses that are oriented away from the stressor or one’s emotions/thoughts) (Compas et al., 2001), Control (Proactive take-charge approach) and escape (staying clear of the person or situation or trying not to get concerned about it) (Latack & Havlovic, 1992), Primary coping (Efforts to influence objective events or conditions), secondary coping (efforts to maximize one's fit with the current situation ) and relinquishment of control coping (relinquishment of control) (Rudolph et al., 1995), Alloplastic coping (Coping directed toward changing the environment ) vs. autoplastic coping (coping directed toward changing the Self) (Perrez & Reicherts, 1992), Behavioral coping (Taking action or doing something ) and cognitive coping (mental strategies and self-talk) (Latack & Havlovic, 1992).

2.6.2.3 Category systems of coping (Skinner et al., 2003)

Reviewing the literature on coping, Compas et al. (2001) stated, “In spite of the clear need to distinguish among the dimensions or subtypes of coping, there has been little consensus regarding the dimensions or categories that best discriminate among different coping strategies in childhood and adolescence”. The same holds true for adulthood and old age (Skinner et al., 2003). Little consensus can be found about how to conceptualize or measure the central constructs in the field, namely, ways of coping. “Lack of consensus about core categories has slowed progress in the field” (Skinner et al., 2003). Skinner et al. (2003) identified that due to lack of such consensus, it was important in order to provide a full account of coping, a category system must be created which should accommodate all relevant instances and lower order ways of coping; at the same time, to meaningfully link these actions with longer term processes of adaptation and development, the categories must be organized with respect to their functions. They noted “…because of domain and age differences in coping, however, any comprehensive consideration needs to include category systems designed for use with multiple age groups and multiple stressors”. They reviewed and critiqued existing work on coping and eliminated the weaknesses of previous researches to arrive at these categories. In order to arrive at such a category system, Skinner et al. (2003) gave few criteria:

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Category definitions are conceptually clear. The criteria for category membership are precise and unambiguous</td>
</tr>
<tr>
<td>2</td>
<td>Categories are mutually exclusive. Each way of coping belongs to one, and only one, category</td>
</tr>
<tr>
<td>3</td>
<td>The set of categories is comprehensive or exhaustive. All core ways of coping can be accommodated by the set of categories</td>
</tr>
</tbody>
</table>
4. Categories are functionally homogenous. All ways of coping within a category serve the same set of functions.

5. Categories are functionally distinct. Categories are different from each other in the set of functions they serve.

6. Categories are generative. Categories allow for the identification and derivation of multiple lower order ways of coping that belong to them.

7. Categories are flexible. Categories are applicable across stressors, contexts, and age levels.

Table 2.4 – Criteria for coping category system (Source: Skinner et al., 2003)

Skinner et al. (2003) concluded that the field of coping has succeeded in generating a relatively comprehensive list of lower order categories, reflecting a broad band of coping instances. Instances have been identified from reviews of existing instruments and theories as well as from content analyses of narratives, open-ended interviews, and in vivo observations of coping. They noted that coping options are constrained by many factors; instances of coping have been drawn from a variety of domains, stressors, and age groups. They argued Confirmatory Factor Analysis based on clearly defined categories and unambiguous items is the best strategy for identifying lower order categories that are unidimensional and discriminable. They noted that these steps have resulted in a long list of lower order categories that probably includes members from all the major families of coping. They pointed that identification of higher order categories is a more complex task. They argued that single functions (e.g., problem vs. emotion focused) are not good action categories because any given way of coping is likely to serve many functions. Further, they pointed that topological distinctions (e.g., approach vs. avoidance, active vs. passive, or cognitive vs. behavioral) are not good action categories, because all ways of coping are multidimensional. They argued that action types (e.g., proximity seeking, mastery, accommodation) are the best higher order categories. Sets of multidimensional multifunctional families of coping can be tested using confirmatory hierarchical analyses. The few systems validated in their review, as well as several rational classifications of long lists of lower order categories collected in reviews, converge on a set of about a dozen families of coping. They noted alternative schemes have been suggested with respect to how these higher order categories should themselves be organized, especially problematic are families of coping that refer to constructive emotional approach (emotion regulation, cognitive restructuring) and social support. Skinner et al. (2003) concluded that next steps in the resolution of some of these disagreements should include analysis of the adaptive functions of these higher order families coupled with studies focused on their functional homogeneity and distinctiveness; criteria of generativity and flexibility may contribute to decisions about the best labels for coping families.

2.6.2.4 EAC (Austenfeld and Stanton, 2004)

Austenfeld and Stanton (2004) researched coping through emotional approach and to establish if emotion-focussed coping is related to dysfunctionality. They critiqued existing scales and aimed at developing a scale to measure emotion-focussed coping. They constructed a questionnaire incorporating: (1) 35 items relevant to coping through acknowledging, processing, and expressing emotion from four published coping measures including the COPE (Carver et al., 1989), CISS (Endler & Parker, 1990), Coping Responses Inventory (Moos, 1988) and Coping Strategies Inventory (Tobin et al. 1989); (2) 11 preliminary author-constructed EAC items intended to be free of distress or self-deprecation; (3) an anchor subscale of 5 items indicating psychopathology; and (4) a 5-item anchor subscale free of psychopathological content. A random sample of PhD-level psychologists with specialization in clinical psychology completed the questionnaire. The majority (19/35 items) of the published, emotion-oriented, coping items but none of the author-constructed items were rated as symptomatic of psychopathology. In a follow-up study the above coping items were administered...
along with measures of adjustment, and the coping items were subjected to factor analysis. Two distinct factors emerged, consisting of items confounded with distress or self-deprecation and unconfounded coping items. The confounded scale was more highly correlated with concurrent measures of adjustment (i.e., depression, hostility, negative physical symptoms) than the unconfounded scale. Findings suggested that the unconfounded EAC items possessed adequate discriminant validity, whereas the confounded items overlapped significantly with measures of poor functioning, particularly in men. Taken together, findings suggested that published measures of emotion-focused coping, and specifically those designed to assess coping through emotional processing and expression, had limited discriminant validity vis-a`-vis measures of psychological and physical health.

These problems in operationalization of emotion-focused coping led Austenfield and Stanton (2004) to conclude that coping through processing and expressing emotion had not been granted a fair test with regard to its predictive utility. Hence, they aimed at creating a psychometrically sound, valid measures of coping through identifying, processing, and expressing emotion. As a follow-up to their preliminary study (Stanton et al., 1994), they specifically conceptualized the constituent EAC constructs and generated an expanded item set designed to tap these constructs, without any content indicating distress or self-deprecation (Stanton et al., 2000b). Factor analyses on the author-constructed items yielded two distinct EAC factors: emotional processing and emotional expression. In both dispositional and situational versions, the scales demonstrate high internal consistency reliability ($\alpha = .72$ to .94)

Further studies by Austenfield and Stanton (2004) suggested that coping through emotional processing and expression predicted adjustment over time. Relations between EAC and adjustment held when relevant personality attributes (e.g., neuroticism) and other coping strategies were controlled statistically, suggesting that the influence of EAC is not simply an epiphenomenon of personality or social parameters involved in emotional processing and expression (e.g., seeking social support).

### 2.6.3 Repressive Coping

The idea of repressive coping was developed from stress research findings which often found discrepancies between an individuals self reported anxiety and their actual behaviour and/or physiological responses (Weinberger et al., 1979). The behaviour which was of most interest was a person reported low levels of anxiety yet had high levels by physiological anxiety. A person who demonstrates this tendency is commonly referred to as a repressor. This review articulates two methods of identifying repressors. The first is a tradition method offered by Weinberger et al. (1979) which involves data obtained from self report based questionnaire. The second method is affect-autonomic response discrepancy (AARD) offered by Coifman et al. (2007) and involves comparing data from self report questionnaires to data from physiological measures.

#### 2.6.3.1 Measuring repressive coping

The traditional method of measuring repressive coping involves administering two self report questionnaires which can construct a matrix of coping style. Specifically, Weinberger et al. (1979) administered the Taylor Manifest Anxiety Scale (Taylor, 1953) and the Marlowe-Crowe Social Desirability Scale (Crowne & Marlowe, 1964) self report questionnaires to categorise participants into four categories of coping style. These are:

1. Low anxious subjects (low defensive and anxiety)
2. Non-defensive/ High anxious (low defensive and high anxiety)
3. Defensive/ high anxious (high defensive and anxiety)
4. Repressors: (high defensive and low anxiety)

The basis behind this typology is that repressors will down play their anxiety in order to appear more socially desirable. In support of these constructs, Weinberger et al. (1979) measured the physiological reactions and reaction time of participants with different coping styles to validate these measures. For a review of research which uses the Weinberger et al. (1979) framework, see the appendix of Furnham et al. (2003) and Derakanshan et al. (2007).

Introducing AARD

Coifman et al. (2007) disagree with the traditional method of measuring repressive coping. Their argument against the traditional self-report based measure is that it lacks validity because repressive coping is relatively automatic and self-deceptive. Therefore, self report questionnaires will not identify it. In place of the Weinberger (1979) method they developed AARD. AARD was developed from research by Newton & Contrada (1992) and Bonanno et al. (1995) who labelled it verbal autonomic response dissociation. Research has repeatedly found differences between responses to self-report questionnaires and physiological data (Mauss, Levenson, McCarter, Wilhelm, & Gross, 2005; Mauss, Wilhelm, & Gross, 2004; Schwerdtfeger, 2004) so this measurement incorporates these discrepancies to detect repressors. In an experiment, if a participant has reports low reported distress yet high arousal they are a repressor or if they have high reported distress and low arousal they are a sensitizer.

Measuring AARD

To measure repressive coping using the AARD technique, Coifman et al. (2007) compare self reported affect measurement to physiological affect measurements. The self-reported measured is a negative affect scale which involves participants rating, on a 7 Likert point scale, the extent to which they experienced four negative affects (fear, guilt, anger & sadness). Affect ratings are made after the ‘event’ has taken place and are indicative of the participants subjective emotion experience. The scores on the four negative affects are aggregated for one overall negative affect score and this was also standardised.

During the ‘event’ the autonomic activity is measured through physiological data. Although heart rate was used by in previous studies (Bonanno et al., 1995; Newton & Contrada, 1992), Coifman et al. (2007) argue that skin conductance response (SCR) is better to identify repressive coping. They summarise how SCRs were administered by stating (Coifman et al., 2007, p. 750):

…by passing a constant voltage (0.5 V) between two electrodes (Beckman Coulter, Fullerton, CA) filled with an electrolyte of sodium chloride in Unibase (Parke–Davis, New York, NY). Electrodes were applied to the palmar surface of the distal phalanges of the first and third fingers of the nondominant hand. The signal was sampled at 400 Hz with an isolated bioelectric amplifier system (Model CUA-07BA, SA Instrumentation, Encinitas, CA). SCRs were identified as any rate exceeding 0.02 µS. The signal was filtered with a 60-Hz notch filter, and customized software was used to reduce the data and remove artifacts.

AARD uses the change of the SCR between the resting and event period to measure physiological reaction. To do this, Coifman et al. (2007) regressed the resting SCR data on the event SCR data. The physiological reaction is the standardised residual from this regression analysis. AARD is calculated by subtracting the standardised SCR change data from standardised negative affect score.

Assessing the reliability of AARD

To ensure that AARD is an independent measure, Coifman et al. (2007) completed two tests. Firstly, they tested to make sure the self report and autonomic variables were not correlated. There research
showed that they were not. Secondly, they needed to make sure that the two components of AARD (SCR and negative affect) would show opposite predictive dimensions on the other variables used in the study. In this study other variables were anxiety, depression or posttraumatic stress disorder (PTSD). Coifman et al. (2007) regressed the SCR and negative affect with the total of anxiety, depression and PTSD measures. This showed that negative affect had a positive relationship with the other variables and the SCR had a negative relationship. This validated that the AARD measure was valid for this experiment.

2.7 Emotion Regulation

2.7.1 Introduction

Emotion Regulation can be defined as “all the extrinsic and intrinsic processes responsible for monitoring, evaluating, and modifying emotional reactions, especially their intensive and temporal features” (Thompson, 1994). Emotion regulation can also be defined as the set of processes whereby people seek to redirect the spontaneous flow of their emotions (Koole, 2009). Emotion regulation refers to the processes by which we influence which emotions we have, when we have them, and how we experience and express them (Gross, 1998b). “People can control virtually every aspect of emotional processing, including how emotion directs attention (Rothermund et al., 2008), the cognitive appraisals that shape emotional experience (Gross, 1998a), and the physiological consequences of emotion (Porges, 2007). These and other processes whereby people manage their own emotions are commonly referred to as emotion regulation” (Koole, 2009). Emotion regulation can manifest itself in explicit ways. For instance, people may rapidly shift their attention away from threatening stimuli (Langens & Morth, 2003), or overcome traumatic experiences by writing about them (Pennebaker & Chung, 2007), and that people may choose to hit a pillow instead of lashing out at the true cause of their anger (Bushman et al., 2001).

“During emotion regulation, people may increase, maintain, or decrease positive and negative emotions. Accordingly, emotion regulation often involves changes in emotional responding” (Koole, 2009). Many examples of emotion regulation are conscious, however, emotion regulation may also occur without conscious awareness (Gross, 2002), such as when one exaggerates one’s joy upon receiving an unattractive present (Cole, 1986). Because emotions are multicomponental processes that unfold over time, emotion regulation involves changes in “emotion dynamics” (Thompson, 1990), or the latency, rise time, magnitude, duration, and offset of responses in behavioral, experiential, or physiological domains.

Emotion regulation also involves changes in how response components are interrelated as the emotion unfolds, such as when increases in physiological responding occur in the absence of overt behavior. (Gross, 1998b) “Emotional responding appears to be organised in terms of a few fundamental dimensions, including valence, arousal, and approach avoidance. The influence of emotion regulation on people’s emotional states is therefore likely to be similarly dimensional. In other words, emotion regulation may not be so much concerned with getting people in or out of discrete emotional states like anger, sadness, or joy. Rather, emotion regulation may change people’s emotional states along dimensions such as valence, arousal, and approach avoidance” (Koole, 2009). ‘Accounts of emotions as bias focus primarily on the role of non-relevant emotions. By contrast, accounts of emotions as information focus primarily on the role of emotions in encapsulating prior relevant experience’ (Fenton O’Creery et al., 2008). In principle, these two perspectives may not then be in contradiction. Schwarz and Clore (1983; 2003) have shown that on the one hand we use emotions as a source of relevant information when making-decisions, but that, on the other hand, we are easily misled into misattributing non-relevant emotions from prior events to current experience.
“We have a bias to attributing experienced emotion to current events. It thus seems likely that the regulation of emotion (in particular, down-regulating non-relevant emotions while remaining sensitive to relevant emotions) may play an important role in emotion performance effects” (Fenton O’Creevy et al, 2008).

Much trader talk about emotion concerns their approaches to regulating moods and emotions and how these develop with experience (Fenton O’Creevy et al, 2008).

2.7.2 Emotion Regulation Strategies

People choose situations and modify situations; situations require attention and appraisal; and lead to an emotional response. Attempts to manage emotions, then, may focus at any of these stages. Situations may be selected or avoided, and they can be modified. Attention can be focused on particularly emotionally salient elements of a situation; distractions can be sought to avoid emotion; situations may be appraised in a particular fashion or reframed to modify an emotional response; and responses may be modulated or suppressed.

Particular attention has been paid in recent research to the difference in outcomes between antecedent focused-emotion regulation strategies, which seek to change emotions before emotion responses have become fully activated and response-focused regulation strategies, which modify behavior and emotion expression once the emotion response is underway.

At the broadest level, Gross (2002) distinguished between antecedent-focused and response-focused emotion regulation strategies. Antecedent-focused strategies refer to things done before the emotion response tendencies have become fully activated and have changed our behavior and peripheral physiological responding. Response-focused strategies refer to things done once an emotion is already underway, after the response tendencies have already been generated.

More specifically, Gross (2001; Gross & Thompson, 2007), distinguishes a series of different stages in emotion episodes and five associated emotion regulation strategies. These are summarized in Figure 2.10 below.
Each of these has been elaborated by Gross (2001 and 2002; Gross & Thompson, 2007). “Situation selection involves complex trade-offs between short- and long-term emotional benefits. For example, a shy person’s efforts to decrease anxiety by avoiding social situations may provide short-term relief at the cost of longer term social isolation (Leary, 1986)” (Gross, 2002). Gross and Thompson (2007) state situation selection “involves taking actions that make it more (or less) likely that one will end up in a situation one expects will give rise to desirable (or undesirable) emotions”. Situation modification is referred to as the process of modifying the situation in order to alter its emotional impact (Gross, 2001 and 2002), which is the same as Problem-Focused coping (eg. Carver et al, 1989). Gross and Thompson (2007) noted that situation modification is related to modifying external, physical environments.

Further Gross and Thompson (2007) state, “Situation selection and situation modification help shape the individual’s situation. However, it also is possible to regulate emotions without actually changing the environment. Situations have many aspects, and attentional deployment refers to how individuals direct their attention within a given situation in order to influence their emotions”. Situations have different aspects and attentional deployment is used to select which of the many aspects of the situation one decides to focus on (Gross, 2002). Cognitive change refers to selecting which of the many possible meanings one attaches attach to the chosen aspect (Gross, 2001 and 2002). “Cognitive change refers to changing how one appraises the situation one is in so as to alter its emotional significance, either by changing how one thinks about the situation or about one’s capacity to manage the demands it poses” (Gross & Thompson, 2007). Response modulation refers to attempts to influence emotion response tendencies once they already have been elicited (Gross, 2001 & 2002). “Response modulation refers to influencing physiological, experiential, or behavioral responding as directly as possible” (Gross & Thompson, 2007).
Of these specific episodes, situation modification (same as Problem focused coping, Gross 2002) has been discussed in a later section on Coping. Much of the research has been focused on cognitive change and response modulation.

Gross (2002; Gross & John, 2003) cited cognitive reappraisal as a form of cognitive change, which involves construing a potentially emotion-elicitin g situation in a way that changes its emotional impact (Lazarus & Alfert, 1964). Reappraisal is an antecedent-focused strategy that occurs early, and intervenes before the emotion response tendencies have been fully generated. This means that reappraisal can thus efficiently alter the entire subsequent emotion trajectory. In addition, when used to down-regulate negative emotion, reappraisal should successfully reduce the experiential and behavioral components of negative emotion.

Expressive suppression is a form of response modulation that involves inhibiting ongoing emotion-expressive behavior (Gross, 1998a). Suppression is a response-focused strategy, which comes relatively late in the emotion-generative process, and primarily modifies the behavioral aspect of the emotion response tendencies. Suppression should thus be effective in decreasing the behavioral expression of negative emotion, but might have the unintended side effect of also clamping down on the expression of positive emotion. At the same time, suppression will not be helpful in reducing the experience of negative emotion, which is not directly targeted by suppression and may thus continue to linger and accumulate unresolved. Moreover, because suppression comes late in the emotion generative process, it requires the individual to effortfully manage emotion response tendencies as they continually arise. These repeated efforts may consume cognitive resources that could otherwise be used for optimal performance in the social contexts in which the emotions arise. Moreover, suppression creates in the individual a sense of incongruence, or discrepancy, between inner experience and outer expression (Rogers, 1951). This sense of not being true to oneself, of being inauthentic rather than honest with others (Sheldon et al, 1997), may well lead to negative feelings about the self and alienate the individual not only from the self but also from others.

2.7.3 Consequences of Emotion Regulation

In order to study the consequences of emotion regulation, Gross and John (2003) conducted a series of tests. Their hypotheses were, “Compared with individuals who rarely use reappraisal, individuals who habitually use reappraisal should experience and express more positive, and less negative, emotion, have closer relationships with others, and have higher levels of personal well-being. By contrast, the second hypothesis read, “compared with individuals who rarely use suppression, individuals who chronically use suppression should experience and express less positive emotion, express less negative emotion behaviorally yet experience similar or even greater levels of negative emotion, have relationships that are less emotionally close, and have lower levels of well-being”.

2.7.3.1 Affective consequences

Lazarus & Opton (1966) provided evidence that reappraisal-like processes could influence emotional responding. Gross (2002) reported that existing literature suggested that suppression led to decreases in positive emotion experience, but did not say much regarding physiological effects.

As a result of the analysis using disgust as an emotion, Gross (2002) reported that both suppression and reappraisal decreased expressive behavior. Also reappraisal decreased experience, whereas suppression had no effect on experience. Reporting on physiological changes, Gross (2002) reported that Suppression decreased disgust-expressive behavior, and increased sympathetic activation of the cardiovascular and electrodermal systems, however, reappraisal had no observable consequences in terms of sympathetic activation of the cardiovascular or electrodermal systems.
In their study, Gross and John (2003) aimed at studying individual differences in consequences of emotion regulation. They presented hypotheses about emotion experience and emotion expression under the head of affect. For reappraisal, theory and their prior experimental studies suggested, greater experience and expression of positive emotion, and less experience and expression of negative emotion. By contrast, hypotheses for frequent use of suppression for positive emotion were that suppression should relate to less experience and less expression of positive emotion. For negative emotion, it was predicted that suppression does not reduce negative emotion experience, that is, suppression leaves intact whatever level of negative emotion the individual happens to experience. Thus, everything else being equal, individuals who typically suppressed were expected to experience the same levels of negative affect as nonsuppressors. However, findings from their previous study suggested that everything else was not equal, and that the chronic use of suppression in everyday life itself lead to greater negative experience. In particular, people who frequently used suppression were acutely aware of their lack of authenticity and experiencing incongruence between self and experience, which had been previously linked to distress and depressive symptoms (Sheldon et al., 1997). Thus, using suppression in everyday life expectedly had another undesirable consequence, namely greater negative emotion experience. Another prediction that was made was that individuals who typically suppress should show less emotion expressive behavior than nonsuppressors. However, it was noted that if frequent use of suppression itself lead to increased levels of negative emotion experience, repeated use of suppression might only partially offset the chronic experience of negative emotion, leading to modest or even no absolute differences between suppressors and nonsuppressors in negative emotion-expressive behavior.

On their analyses, Gross and John (2003) reported that suppressors felt more negative emotions than nonsuppressors, but that difference was not apparent in their expressive behavior, as reported both by their peers and by themselves. Nonetheless, direct peer ratings of suppression indicated that peers were able to detect when individuals used suppression to regulate their emotions. This peer finding was noted as particularly noteworthy given that suppressors were apparently successful in their attempts to suppress the considerable negative emotion they felt, so that compared with nonsuppressors, they expressed less emotion than they actually felt. As far as affective profile was concerned, suppressors were reported to both experience and express less positive emotion than nonsuppressors, and they felt more negative emotions. Although suppressors’ efforts to suppress these negative emotions were expected to succeed to the point that they expressed no more negative emotion in their behavior than individuals who rarely use suppression, however, their peers detected their suppression efforts. Related studies have also reported similar results using different emotions (eg. Sadness and amusement, Gross & Levenson, 1997; embarrassment, Harris, 2001).

2.7.3.2 Cognitive consequences

Gross (2002) noted that suppression as a regulation strategy requires constant cognitive effort throughout the emotional event and reduces cognitive resources available for retention of the event at a later time. However, reappraisal occurs early in the emotion-generative process and thus, leaving cognitive resources available, making it easier to remember the event.

Gross (2002) borrowed from analysis of Richards and Gross (2000), who, through two studies concluded that suppression, but not reappraisal, led to memory impairment for social information presented while the individual was regulating emotions. This finding suggested that using suppression as a regulation strategy is cognitively taxing in a way that reappraisal is not. Further, they reported that suppression had a greater impact on verbal memory than non-verbal memory, which in turn suggested that it was the process of engaging in suppression, which was cognitively costly, rather than the amount of emotion suppressed. These findings were replicated by Gross and John’s (2003) research on individual differences, where they reported that those who scored higher on suppression scale of ERQ (discussed later) had a worse memory and performed worse on an objective memory
test. They found no impact of reappraisal on memory. Gross and John (2003) reported that these findings held even on controlling for Neuroticism and social desirability.

2.7.3.3 Social consequences

Based on existing literature, Gross (2002) observed that since suppression decreases both negative and positive emotion-expressive behavior, it can mask important social signals that could be available to social interaction partners and the need of controlling facial and vocal expressions can distract the suppressor, making them less responsive. Hence, it was predicted that suppression should have negative social consequences. By contrast, it was predicted reappraisal should have positive social consequences, as it is not as cognitively taxing as suppression. Gross and John (2003) noted that interactions with others are potent triggers for emotions, and individuals often regulate their emotions to achieve their social goals and maintain good relations with significant others. Thus, the chronic use of suppression and reappraisal was assumed to have important, but rather different, consequences for interpersonal functioning.

Butler et al. (2003) analysed social interaction through two people discussing an upsetting topic. As predicted, Gross (2002) reported that findings showed that interacting with a suppressing partner is more physiologically activating than interacting with a partner who shows greater positive emotion and responsiveness. Gross and John (2003) showed that suppression had a quite different pattern of social consequences. Individuals habitually using suppression were less likely to share with others not only their negative but also their positive emotions. They were also reported to have substantially more avoidance (discomfort with closeness and sharing) in close relationships. This lack of emotional closeness with others was also reflected in independent peer reports. Although their emotional distance was clearly noticed by their peers, the suppressors were not generally disliked; their peers were reported to feel relatively neutral about them. In the domain of social support, however, suppressors were reported to receive lesser social support across all forms and this effect was strongest for emotional support.

2.7.3.4 Consequences on well-being

Gross and John (2003) noted that their previous studies suggested that individual differences in the use of reappraisal and suppression are meaningfully related to emotion experience and expression, as well as to important interpersonal outcomes. This study tested whether the habitual use of reappraisal and of suppression differed in their longer-term cumulative impact on well-being.

The results showed reappraisers were more satisfied with their lives, more optimistic, and had better self-esteem. Suppressors were reported to be less satisfied both with themselves and their relationships, more pessimistic about their future, and more prone to depression, indicating a pervasive and fundamentally troubled sense of well-being.

There is empirical evidence for a relationship between emotion regulation strategies and a range of important outcomes. Different emotion regulation strategies have been shown to have differential effects on outcomes including cognitive performance, health, and social interaction. In particular, antecedent-focused emotion regulation, compared with response-focused emotion regulation, is less cognitively costly, has more positive social outcomes, and is associated with better health outcomes (Gross, 2002).
2.7.4 Interrelations between Emotional Regulation Strategies and Other Important Fields

In an attempt to validate their new measure of emotion regulation, ERQ (discussed later), Gross and John (2003) noted, “...when evaluating measures of new constructs is to establish a nomological net by assessing convergent and discriminant relations with conceptually relevant constructs”. They considered perceived emotion regulation success, inauthenticity, coping and mood regulation.

They administered ERQ on the chosen sample. In addition, they cited and collected data on a range of subjects using various studies (eg. Trait Meta-Mood Scale, Salovey et al, 1995; Rumination, Nolen-Hoeksema, 1987; Mood Regulation, Catanzaro & Mearns, 1990; Big Five Personality, John & Srivastava, 1999; Impulsivity, Block & Kremen, 1996). The convergent and discriminant validity findings were reported for cognitive change (reappraisal) and response modulation (suppression). The results indicated that reappraisers cope with stress by using reinterpretation, have a well-developed capacity for negative mood repair, and show a sense of their capacity for negative mood regulation. By contrast, Suppressors were reported to cope with adversity by “battening the hatches,” and feel inauthentic, rather than venting their true feelings. Suppressors tend to evaluate their emotions in negative terms, and their lack of clarity about their emotions is associated with a lesser facility at mood repair, lower estimates of their own ability to regulate negative moods, and increased rumination. John and Gross (2007), in their research on links of emotion regulation strategies (using ERQ data; Gross & John, 2003) and global personality traits, reported that conscientiousness had negligible correlations with reappraisal and suppression, extraversion had zero-relation with reappraisal but a negative correlation with suppression, neuroticism had a zero-relation with suppression and a negative correlation with reappraisal, openness had a positive correlation with reappraisal and negative correlation with suppression and agreeableness had zero-relations with reappraisal and suppression.

2.7.5 Emotion Regulation and Work Performance

In the domain of work performance, most attention has focused on the emotional labor required by customer service interactions. Here, emotion regulation has been considered primarily through the lens of deep and surface acting. Surface acting is the faking of emotion display to conform to contextual display rules. Deep acting involves modifying inner feelings. Grandey (2000) draws on Gross’s process model of emotion regulation to consider emotional labour as a subset of emotion regulation and equates antecedent focused and response focused regulation with deep and surface acting respectively. In a study of front-line service workers, Grandey found antecedent-focused emotion regulation to be associated with greater effectiveness in relating to customers in a warm friendly manner whereas response focused emotion regulation was associated with emotional exhaustion and greater tendency to ‘break character’ by revealing negative emotions in a service encounter (Grandey, 2003).

2.7.6 Affect Optimization and Affect Differentiation

While Gross’ model of emotion regulation focuses primarily on the regulation process, others such as Labouvie-Vief (2003) have focused on the goals of emotion regulation; distinguishing between the goal of maintaining positive hedonic tone on the one hand, and the ability to tolerate tension and negativity in the interests of maintaining objective representations. Labouvie-Vief’s (2003; Labouvie-Vief & Medler, 2002; Labouvie-Vief et al., 2007) research into emotion regulation has found stable individual differences in emotion regulation. She has identified two different regulatory strategies,
which are particularly relevant to decision making biases. The first method of emotion regulation, referred to as affect optimization, involves the maintenance of positive hedonic tone through the amplification of positive affect and dampening of negative affect. The second method of emotion regulation referred to as cognitive affective complexity (affect complexity for short) is the ability to coordinate positive and negative affect into flexible and differentiated structures (Labouvie-Vief & Medler, 2002, p. 571). This second method focuses on objectivity, personal growth, individuation, and emotional and conceptual complexity (Labouvie-Vief et al. 2007, p 738).

Labouvie-Vief et al. (2007) argue that the two strategies coordinate dynamically so that momentary decreases in complexity are compensated by increases in optimization and vice versa. However, Labouvie-Vief (2003) also contends that there is a curvilinear relationship between the level of arousal and the ability to integrate complex emotions. Labouvie-Vief & González (2004 p 248 - 247) state “when levels of emotional activation-arousal are low, complex and well-integrated thinking, planning, and remembering are possible… when arousal rises to extremely high levels, it tends to render complex, cool cognitions and behaviour dysfunctional and poorly integrated.” So the method of emotion regulation adopted by an individual can depend on the situational constraints, age of person and also on individual differences in emotion regulation strategies (Labouvie-Vief et al. 2007).

As optimization and complexity methods of emotion regulation methods occur concurrently, trait based individual differences are not whether they adopt one or the other but the extent to which a person is high or low in both. Labouvie-Vief (2003) compiled a matrix of emotion regulation strategies to illustrate and label the individual (Figure 2.11). The vertical axis of the matrix distinguishes between people who are high in affect complexity (top) and low in affect complexity (bottom). The horizontal axis distinguishes between those who are high in optimisation (right) and low in optimization (left).

![Figure 2.11 – Four emotion regulation styles resulting from combinations of optimization and differentiation (Source: Labouvie-Vief, 2003; p. 204)](image-url)
Labouvie-Vief’s (2003) framework conceptualises some of the key aspects of emotion regulation, which relate to decision making biases. Affect optimization based emotion regulation is centred around a damping of negative affect and an avoidance of negative self image similar to the better than average effect (Glaser & Weber, 2007). Also with its focus on the maintenance of positive hedonic tone this emotion regulation method can be related to mental accounting (Thaler, 1999) and the disposition effect (Shefrin & Statman, 1985). Affect differentiation as a method of emotion regulation indicates a willingness to integrated negative affect to achieve objective views of the self and the situation. Thus it would encourage the cognition required to overcome these biases.

2.7.7 An Alternative Approach to Emotion Regulation

As a critique of emotion-generative process model, Koole (2009) pointed, “…when emotion-regulation strategies are merely classified by their targeted emotion-generation system, this results in rather heterogeneous groupings”. Gross and Thompson make clear (2007, p.16) this model of emotions, and their regulation, unfolding as a linear process is something of a simplification. Emotion regulation occurs in ‘the context of an ongoing stream of emotional regulation and responding’, which is substantially iterative in nature and may involve the deployment of multiple regulation processes.

Koole (2009) noted that much of the research on emotion regulation has focused on need-oriented emotion regulation. One such need-oriented function of emotion regulation is defensive processes or defensive emotion-regulation. Koole (2009) has noted that defensive processes such as making self-serving attributions, engaging in downward social comparison etc., are mutually substitutable (Tesser, 2000), which is consistent with the notion that they serve the purpose of emotion regulation. The emotion regulation function of defensive bias is further supported by findings that affirming positive views of the self, down-regulates negative emotion. Further, defensive bias is not associated with activation in brain regions that support effortful self-regulation, even though such regions are implicated in goal-oriented emotion-regulation strategies (Ochsner & Gross, 2008). Extreme and rigid forms of defensive bias have been reported to undermine psychological adjustment (Colvin & Block, 1994). Also, defensive bias has been linked to the repressive coping style (Derakshan et al., 2007), which in turn is associated with poor health outcomes (Myers, 2000). However, more moderate and flexible forms of defensive bias are positively associated with mental health (Baumeister, 1989).

Koole (2009) presented an alternative approach to emotion regulation by arguing in favour of functions of emotion regulation, rather than their generation process. He pointed that emotions are regulated in order to achieve certain psychological outcomes or functions. He argued that functions of emotion regulation represent a basic category for characterizing different emotion strategies that is independent of which emotion-generating system is targeted. It is a general assumption that emotion-regulation is aimed at hedonic needs of promoting pleasure and reducing pain (Westen, 1994). However, emotions are also regulated due to social reasons (the need to be calm and composed in social interactions) as well as other goals, which may increase the utility of hedonically aversive states (Tamir et al., 2007). Hence, in addition to being hedonically oriented, some forms of emotion regulation are oriented towards the priorities that are set by specific norms, goals, or tasks. Thus, emotion regulation may serve important goal-oriented functions, in addition to serving need-oriented functions (Koole, 2009).

Emotion regulation can also be used to serve multiple functions, including hedonic needs, goal-oriented functions, optimal personality functioning (person-oriented functions) and at times, a combination of these. It is also argued that at times these functions (need-oriented, goal oriented and person-oriented) can be conflicting. However, little work has been done on how these conflicts are
resolved. Koole (2009) has opined that conceivable, people alternate between functions or there might be individual differences in the preferential use of each function. In summary of classifying emotion-regulation strategies, Koole (2009; p.16) states, “A consensual, empirically validated taxonomy that spans all known emotion-regulation strategies has yet to be developed. Nevertheless, the literature has yielded several higher-order categories that seem useful in classifying emotion-regulation strategies. The most viable higher-order categories to this end are the emotion-generating system that is targeted and the psychological functions that are served by emotion regulation”.

2.7.8 Emotional Regulation in Financial Decision Making

There is also some evidence on emotion regulation and financial decision-making. In their study of investors, Seo and Barret (2007) found that investors who were better able to identify and distinguish among their current feelings achieved superior decision-making performance. This, they argued, was mediated by improved regulation of the influence of feelings on their decision-making. However, they made no direct measurement of emotion regulation and did not consider the relative contribution of antecedent and response focused emotion regulation.

In their work on traders Fenton O’Creevy et al (2008) go beyond the study of emotion regulation in the context of work performance, which depends primarily on social interaction. In contrast to emotional labour studies, which focus on the context of interpersonal interaction, most trading nowadays is conducted electronically via computer or through highly abbreviated and formalised electronic exchanges with counterparties. Rather than depending on appropriate emotion display in the context of customer interaction or negotiating with counterparties, trader performance depends on selecting optimal trading strategies in the face of complex cognitive demands and the need to process significant amounts of information with uncertain relevance (Cetina and Bruegger 2002). Fenton O’Creevy et al (2008) explicitly examine the different approaches to emotion regulation between novice traders and both high and low performing experienced traders. They investigate the relationship between traders’ emotion regulation strategies and their performance and found effective emotion regulation to be a critical success factor in trading. Their findings suggest that the strategies for emotion regulation adopted by expert, higher performing traders are qualitatively different to those of lower performing traders. In particular, higher performers are more inclined to regulate emotions through attentional deployment and cognitive change and may display a willingness to cope with negative feelings in the interests of maintaining objectivity and pursuing longer-term goals. In contrast, less expert traders engage either in avoidant behaviors (such as walking away from the desk) or invest significant cognitive effort in modulating their emotional responses. These findings also suggest that willingness to endure negative feelings in pursuit of long term goals may be more adaptive than purely defensive strategies aimed at maintaining positive feelings (Labouvie-Vief, 2003; Tamir, 2005).

The study undertaken by Fenton O’Creevy et al (2008) also provides some evidence that more effective emotion regulation strategies can be learned in a financial decision-making context. While an individual’s preferred approach to emotion regulation is likely to be influenced by personality traits, neuroticism and extroversion in particular (Gross & John, 2003), the interviews with traders and their managers (Fenton O’Creevy et al, 2008) also point to the importance of traders’ learned strategies for emotion regulation. The study, importantly, suggests that defensive emotion regulation strategies, which focus on avoidance or response suppression may be problematic because they reduce opportunities to exercise expert intuition.
2.7.9 Measures of Emotion Regulation

Garnefski (et al., 2001) pointed a gap in the literature, as there existed no valid measure of emotion regulation. Recent research has yielded some reliable and valid measures of emotion regulation, which are discussed below.

2.7.9.1 Emotion regulation questionnaire (Gross & John, 2003)

Gross and John (2003) began their research with the premise that specific emotion regulation strategies can be differentiated along the timeline of the unfolding emotional response (Gross, 2001). Underlying this model was the conception of the emotion-generative process found in the work of a number of prior emotion theorists (eg. Gross, 1998a). This conception implies that an emotion begins with an evaluation of emotion cues, when attended to and evaluated in certain ways, emotion cues trigger a coordinated set of response tendencies that involve experiential, behavioral, and physiological systems. Once these response tendencies arise, they may be modulated in various ways. Because emotion unfolds over time, emotion regulation strategies can be distinguished in terms of when they have their primary impact on the emotion-generative process.

At the broadest level, Gross and John (2003) distinguished between antecedent-focused and response-focused emotion regulation strategies. They cited Gross’s (2001) process model of emotion regulation (as discussed above). According to this model, emotion may be regulated at five points in the emotion generative process: (1) selection of the situation, (2) modification of the situation, (3) deployment of attention, (4) change of cognitions, and (5) modulation of experiential, behavioral, or physiological responses. The first four of these processes are antecedent-focused, whereas the fifth is response-focused strategy.

For the purpose of their research, Gross and John (2003) decided to focus on certain well-defined strategies. In order to select strategies for study, they considered several criteria. First, the strategies should be ones that people use commonly in everyday life. Second, they should be strategies they could manipulate in the laboratory and define in terms of individual differences. Third, because they found distinction between antecedent-focused and response-focused strategies so central, they wanted to include one exemplar of each in our studies. Two specific strategies met these criteria: cognitive reappraisal and expressive suppression.

Reviewing the existing literature and their earlier work, Gross and John (2003) reported that reappraisal was a more effective strategy, whereas suppression was cognitively more taxing. Reporting results of an experiment, Gross (1998a) noted that participants who suppressed showed much less expressive behaviour, however they experienced as much negative emotion as participants who did not suppress. By contrast, reappraisal decreased both the experience and the behavioural expression of negative emotion. An asymmetry has been noted, whereas suppressing negative emotions left intact the experience of negative emotion, suppressing positive emotions decreased the experience of these emotions (eg. Gross & Levenson, 1997; Strack, et al., 1988). The cognitive demands of suppression have been demonstrated in studies of social while either reappraising or suppressing (Richards & Gross, 2000). Suppression, but not reappraisal, led to memory impairment for social information presented while the individual was regulating emotions. This replicated finding suggests that using suppression as a regulation strategy is cognitively taxing in a way that reappraisal is not. Gross and John (2003) noted that these findings suggested that by disrupting the give and take of emotional communication, suppression has the potential to undermine social functioning to a much greater extent than reappraisal.

Reviewing the existing measures, Gross and John (2003) noted that methodologies used by researchers had been successful in using a manipulation approach to measure emotion regulation,
however, they suffered from a limitation that they tested effects fairly immediately and short-term consequences could not be extrapolated to longer-term. In order to overcome such a limitation, the approach taken by Gross and John (2003) relied on measuring individual differences in the use of reappraisal and suppression, and analyzing the longer term consequences that accumulate as individuals used these emotion regulation strategies day-in and day-out. Their studies examined the real-life and longer term outcomes associated with these regulatory processes. On the basis of their model and experimental work, Gross and John (2003) derived the ERQ items rationally, indicating clearly in each item the emotion regulatory process it was intended to measure. In addition to the general-emotion items, the Reappraisal scale and the Suppression scale both included at least one item asking about regulating negative emotion and one item about regulating positive emotion. Moreover, item content was limited to the intended emotion regulatory strategy, and avoided any potential confounding by mentioning any positive or negative consequences for affect, social functioning, or well-being. The 10-item scale was comprised of 6 items for reappraisal and 4-items for suppression.

**Emotion Regulation Questionnaire (ERQ)**

*Gross & John*

9/03

The Emotion Regulation Questionnaire is designed to assess individual differences in the habitual use of two emotion regulation strategies: cognitive reappraisal and expressive suppression.

**Instructions and Items**

We would like to ask you some questions about your emotional life, in particular, how you control (that is, regulate and manage) your emotions. The questions below involve two distinct aspects of your emotional life. One is your *emotional experience*, or what you feel like inside. The other is your *emotional expression*, or how you show your emotions in the way you talk, gesture, or behave. Although some of the following questions may seem similar to one another, they differ in important ways. For each item, please answer using the following scale:

1. strongly disagree
2. neutral
3. strongly agree

1. ____ When I want to feel more positive emotion (such as joy or amusement), I change what I’m thinking about.
2. ____ I keep my emotions to myself.
3. ____ When I want to feel less negative emotion (such as sadness or anger), I change what I’m thinking about.
4. ____ When I am feeling positive emotions, I am careful not to express them.
5. ____ When I’m faced with a stressful situation, I make myself think about it in a way that helps me stay calm.
6. ____ I control my emotions by not expressing them.
7. ____ When I want to feel more positive emotion, I change the way I’m thinking about the situation.
8. ____ I control my emotions by changing the way I think about the situation I’m in.
9. ____ When I am feeling negative emotions, I make sure not to express them.
10. ____ When I want to feel less negative emotion, I change the way I’m thinking about the situation.

**Note**

Do not change item order, as items 1 and 3 at the beginning of the questionnaire define the terms “positive emotion” and “negative emotion”.

**Scoring (no reversals)**

Reappraisal Items: 1, 3, 5, 7, 8, 10; Suppression Items: 2, 4, 6, 9.
After a series of confirmatory analyses, Gross and John (2003) reported that the six-item Reappraisal and the four-item Suppression scales were independent in each sample used for the study, which meant that individuals who frequently use reappraisal were no more (or less) likely to use suppression than individuals who use reappraisal infrequently. A series of confirmatory factor analyses were used to test these conclusions and reported alpha, which averaged 0.79 for Reappraisal and 0.73 for Suppression. Test–retest reliability across 3 months was .69 for both scales.

Results on gender differences using suppression scale revealed that men scored higher than women. Gross and John (2003) also reported that ethnic minority status was associated with greater use of suppression to regulate emotion, however, there were no ethnic differences in Reappraisal.

2.7.9.2 Cognitive emotion regulation questionnaire (Garnefski et al., 2001; 2002)

Garnefski et al (2001) identified cognitive and behavioural styles of emotion regulation and coping. They noted that cognitive style of emotion regulation has been associated with human life (eg. Garnefski et al, 2001) and better control over emotions (eg. Gross, 2002). Cognitive emotion regulation refers to the conscious, cognitive way of handling the intake of emotionally arousing information (Thompson, 1991). They noted that the concept of conscious, cognitive, emotion regulation (which includes purely cognitive styles) is narrowly related to the concept of cognitive coping (which includes components components of both, problem-focussed and emotion-focussed coping (Garnefski et al, 2001).

Due to the lack of any measures to measure cognitive components of emotion regulation, Garnefski et al (2001) developed the Cognitive Emotion Regulation Questionnaire (CERQ). CERQ included nine cognitive emotion regulation strategies, based on existing research and empirical evidence. These dimensions were defined either by taking out or reformulating the cognitive dimensions of existing coping, “transforming” noncognitive coping strategies into cognitive dimensions or adding new strategies on theoretical grounds. The concepts were taken from field of coping (eg. Carver et al, 1989) and other fields such as rumination (Nolen-Hoeksema, 2000) and catastrophising (Sullivan et al., 1995). The 9 concepts included: a) Self-blame (thoughts of putting the blame for what you have experienced on yourself), b) Other-blame (thoughts of putting the blame for what you have experienced on the environment or another person, c) Rumination or focus on thought (thinking about the feelings and thoughts associated with the negative event, d) Catastrophizing (thoughts of explicitly emphasizing the terror of what you have experienced), e) Putting into perspective (thoughts of brushing aside the seriousness of the event/emphasizing the relativity when comparing it to other events, f) Positive refocusing (thinking about joyful and pleasant issues instead of thinking about the actual event), g) Positive reappraisal refers to thoughts of creating a positive meaning to the event in terms of personal growth, h) Acceptance refers to thoughts of accepting what you have experienced and resigning yourself to what has happened and i) Refocus on planning (thinking about what steps to take and how to handle the negative event).

The CERQ is a 36-item questionnaire consisting of the nine conceptually distinct subscales, each consisting of four items and each referring to what the respondent thinks after the experience of threatening or stressful life events (Table 2.5). The responses were recorded on a 5-point Likert scale (1, almost never to 5, almost always). (Garnefski et al., 2002) used CERQ for their analyses and collected data over two time periods, at time 1 and time 2 (a year from time 1). They reported good internal consistencies all subscales ranging from .68 to .83, with most cronbach alphas over 0.80.

<table>
<thead>
<tr>
<th>Scale name and items</th>
<th>Time 1</th>
<th>Time 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self-blame</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(Source: Gross & John, 2003)
I feel that I am the one to blame for it | .70 | .70
I feel that I am the one who is responsible for what has happened | .71 | .70
I think about the mistakes I have made in this matter | .55 | .57
I think that basically the cause must lie within myself | .80 | .77

Acceptance
I think that I have to accept that this has happened | .73 | .77
I think that I have to accept the situation | .70 | .71
I think that I cannot change anything about it | .66 | .65
I think that I must learn to live with it | .69 | .61

Focus on thought/rumination
I often think about how I feel about what I have experienced | .75 | .66
I am preoccupied with what I think and feel about what I have experienced | .77 | .74
I want to understand why I feel the way I do about what I have experienced | .66 | .69
I dwell upon the feelings the situation has evoked in me | .68 | .77

Positive refocusing
I think of nicer things than what I have experienced | .76 | .79
I think of pleasant things that have nothing to do with it | .85 | .87
I think of something nice instead of what has happened | .83 | .80
I think about pleasant experiences | .67 | .74

Refocus on planning
I think of what I can do best | .69 | .81
I think about how I can best cope with the situation | .75 | .80
I think about how to change the situation | .74 | .71
I think about a plan of what I can do best | .78 | .77

Positive reappraisal
I think I can learn something from the situation | .67 | .72
I think that I can become a stronger person as a result of what has happened | .59 | .59
I think that the situation also has its positive sides | .64 | .52
I look for the positive sides to the matter | .73 | .70

Putting into perspective
I think that it all could have been much worse | .62 | .60
I think that other people go through much worse experiences | .77 | .79
I think that it hasn’t been too bad compared to other things | .68 | .79
I tell myself that there are worse things in life | .70 | .80

Catastrophizing
I often think that what I have experienced is much worse than what others have experienced | .75 | .34
I keep thinking about how terrible it is what I have experienced | .64 | .75
I often think that what I have experienced is the worst that can happen to a person | .70 | .80
I continually think how horrible the situation has been | .59 | .78

Blaming others
I feel that others are to blame for it | .75 | .71
I feel that others are responsible for what has happened | .82 | .79
I think about the mistakes others have made in this matter | .72 | .72
I feel that basically the cause lies with others | .83 | .81

Table 2.5 – Factor structure of the Cognitive Emotion Regulation Questionnaire (CERQ) at first measurement (Time 1) and follow-up (Time 2); items listed by a priori assignment to subscales (Source: Garnefski & Kraijj, 2007)
2.8 Heart Rate Variability

Unlike the clock ticking in the tin man’s chest from Oz, the beating rhythm of a healthy heart is not regular. There is variation in the amount of time from one normal beat to the next, a biological trait often referred to as heart rate variability (HRV). HRV occurs due to the dynamic control of the cardiovascular system by the central autonomic network (CAN) via the autonomic nervous system (ANS). Because of this, HRV is increasingly being used as a predictor of many conditions in psychophysiological research. Individual differences in HRV have been associated with coping strategies (Fabes & Eisenberg, 1997), attentional control (Thayer et al, 2009), anxiety (Pop-Jordanova, 2009), depression (O’Connor, Allen, & Kaszniak, 2002), stress (Pauls & Stemmler, 2003), and emotion regulation (Appelhans & Luecken, 2006). This subsection introduces:

- What causes HRV (subsection 2.8.1)
- Two theoretical backgrounds behind HRV (subsection 2.8.2)
- How HRV is measured (subsection 2.8.3)
- A review of research involving HRV (subsection 2.8.4)

2.8.1 What Causes HRV

The heartbeat rhythm is primarily dictated by an internal pacemaker called the sinoatrial node (sometimes called the sinus node) is located in the right atrium of the heart (refer to Figure 2.12 below). The sinoatrial node is linked by the autonomic nervous system (ANS) to the central autonomic network (CAN) so it can regulate the beats of the heart. However, the ANS has two methods of regulating heart rhythm; the inhibitory parasympathetic nervous system (PNS) which operates via the vagus nerve and the excitatory sympathetic nervous system (SNS) which operates via the cardiac nerves.

The SNS is responsible for arousing organs in relation to environmental influences such as the ‘flight or fight’ instinct, so the sympathetic influence on the heart is to increase the heart rate. The PNS has a calming effect which is sometimes called ‘rest and digest’. Therefore, the PNS has an inhibitory influence on the sinoatrial node decreasing heart rate (refer to Figure 2.13 for an overview of the sympathetic and parasympathetic nervous systems). The PNS and SNS work antagonistically to influence cardiac activity. As Appelhans & Luecken (2006, p. 203) state “an increase in heart rate could arise from either increased sympathetic activity or decreased parasympathetic inhibition (vagal withdrawal). Although both autonomic branches exert a constant influence on heart rate, parasympathetic influence is predominant at rest and serves to maintain resting heart rate well below the intrinsic firing rate of the sinoatrial node (Berntson et al., 1997)”.
There are two features of the ANS which cause HRV. The first is called respiratory sinus arrhythmia (RSA; for review see (Bernardi, Porta, Gabutti, Spicuzza, & Sleight, 2001)) and this occurs during resting periods when the PNS has the most control over the heart rate. Breathing air in temporarily stops the influence of parasympathetic influence on the sinoatrial node, causing a rise in heart rate. Breathing air out reinstates the parasympathetic influence on the sinoatrial node, resulting in a decrease in heart rate and thus creating HRV (Appelhans & Luecken, 2006). RSA is also referred to as tonic HRV, baseline HRV or resting HRV.
The other feature of the central nervous system which causes HRV is the amount of time the SNS and the PNS take to influence heart rate. The SNS is slower, with the peak effect being observed after 4s and a return to baseline after 20 s. The PNS is faster with peak effect occurring at about 0.5 s and a return to baseline after 1 s (Appelhans & Luecken, 2006). The difference in influence time of these two systems creates HRV because arousal by the SNS can be quickly curtailed by the PNS. As the sympathetic is activated in stressful situations, high HRV will indicate attempted control of heart rate by the PNS and low HRV will indicate lack control by the PNS with the heart rate being dictated primarily by SNS (Moses, Luecken, & Eason, 2007).

2.8.2 Two Theoretical Backgrounds Behind HRV

2.8.2.1 Neurovisceral integration theory

One interest of HRV to xDelia is that it can be used as a measure of emotion regulation (Appelhans & Luecken, 2006). There are two theoretical perspectives which give background to why HRV is associated with emotion regulation; the Polyvagal Theory (Porges, 2007) and Neurovisceral Integration Theory (Thayer, Hansen, Saus-Rose, & Johnsen, 2009). The basis of Neurovisceral Integration Theory is that autonomic influences on heart rate are regulated by the network of brain areas composing of the CAN. The CAN is responsible for global self regulative tendencies, but within this, there is a subset of support for self regulated emotion responding (Thayer & Brosschot, 2005). Thus, the CAN adjusts physiological arousal in accordance with changing situational demands (Appelhans & Luecken, 2006). Thayer et al. (2009) propose that the CAN is inherently related to Damasio’s (1998) emotion circuit and that there is a central functional network recognised by different researchers from diverse approaches. Furthermore they describe a model of this central network which shows the process by which areas of the CAN influences heart rate (refer to Figure 2.14 below).
2.8.2.2 Polyvagal theory

Polyvagal Theory comes from an evolutionary perspective “which understands aspects of human functioning in terms of acquired, genetically based characteristics that are presumed to have aided in survival and/or reproduction throughout human phylogenetic history” (Appelhans & Luecken, 2006, p. 233). It poses that the human ANS evolved in three stages; first developed was the dorsal vagus nerve which is slow responding and helps freeze in response to threats; second was the capacity for flight or fight responses through SNS and lastly the ventral vagus which supports PNS based regulation. The last development is most important for emotion regulation as the ventral vagus physically connects with facial muscles, voice production and other socially important behaviours, which creates a physical connection between the heart and emotion expression.

The similarities between the two models are summarised by Appelhans and Luecken (2006, p. 234) who state “both theories presented are similar in that they (a) specify a critical role for parasympathetically mediated inhibition of autonomic arousal in emotional expression and regulation and (b) maintain that HRV measures are informative about individuals’ capacity for this aspect of regulated emotional responding.”
2.8.3 How HRV is Measured

2.8.3.1 Length of time between heart beats

HRV is measured by the usual means of measuring heart rate, electrocardiography (ECG). The electrodes are attached to the right arm, left leg and a ground and the data should be sampled at a rate rapid enough to provide a high resolution signal (500 – 1,000 Hz (Berntson et al., 1997)). ECG recording provides several waveforms for a single heart beat, however, HRV is measured by the distance between R spikes (refer to Figure 2.15 below).

![R-R interval](image)

*Figure 2.15 – An example of an electrocardiograph*

The distance from R to R spikes is representative of the distance from normal to normal beats (NN) and is the basis of many different measurements for HRV. Each of the many NN based statistics are summarised using acronyms and a non-exhaustive list of these acronyms is as follows:

- **NN** - Normal to Normal
- **SDNN** - Standard deviation of NN
- **SDANN** - Standard deviation of average NN
- **MSSD** - Mean squared difference of successive NN intervals
- **RMSSD** - Square root of mean squared differences successive NN intervals
- **NN50** - The number of pairs of NN intervals differing by more than 50 ms
- **pNN50** - The proportion derived by dividing NN50 by the total number of NN intervals

Please note that SDNN reflects overall HRV where as SDANN reflects HRV occurring at cycles longer than 5min.

2.8.3.2 Frequency based power spectral analysis

The other method of measuring HRV is to use the frequency-based technique of power spectral analysis. The power spectrum of heart beats is separated into two bands the high frequency (HF) between .15-.40 Hz and low frequency (LF) between .04-.15 Hz (please refer to Figure 2.16 below for an example of HRV power spectrum graph). The HF primarily reflects cardiac parasympathetic influence due to RSA. The LF is reflects both SNS and PNS activity (Task Force 1996) so researchers often report the ratio of LF to HF power as an index of ‘sympathovagal balance’ (Appelhans & Luecken, 2006). Other researchers use just the HF based statistics (Geisler & Kubiak, 2009). Finally it is important to note that whilst some researchers have used HF, others have disputed that HF measurements reflect solely vagal tone (Pyetan & Akselrod, 2003).
2.8.4 Literature Review of Research Involving HRV

Below a non-exhaustive review of literature on HRV is provided in table Table 2.6 below.

- Column 1 outlines the author(s) and year of publication
- Column 2 briefly states their main findings in regard to HRV
- Column 3 outlines the method measuring HRV in respect to the two techniques mentioned above (power or length of intervals)

As it is important in WP2 to understand the emotion regulation of traders surrounding an emotional trading event, it is important to understand whether HRV can be used when participants are active or resting and how long a measurement will take. So:

- Column 4 indicates whether the HRV measurement was taken when participants were resting or involved in a task
- Column 5 indicates how long the participant’s heart rate was measured to get an HRV reading
<table>
<thead>
<tr>
<th>Authors</th>
<th>Findings</th>
<th>Method of measuring HRV</th>
<th>Participants Resting or active</th>
<th>Time HRV is measured over</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Segerstrom &amp; Nes, 2007)</td>
<td>Using the ‘carrot vs. cookie’ followed by anagrams task, this research showed that HRV is elevated during self regulation. They also found that Baseline HRV could predict self regulatory ability at 5% accuracy.</td>
<td>RMSSD</td>
<td>Not clear, appears to be active.</td>
<td>30-s Epochs</td>
</tr>
<tr>
<td>(Gyurak &amp; Ayduk, 2008)</td>
<td>Found that individuals who were high rejection-sensitive reported less emotion control and more hostility in conflicts only if they were also low in RSA.</td>
<td>Power analysis of HF</td>
<td>Resting</td>
<td>5 minutes continuous</td>
</tr>
<tr>
<td>(Moses et al., 2007)</td>
<td>Found that HRV decreases whilst doing stressful tasks. During an attention task both LF and HF decreased.</td>
<td>Power analysis of HF and LF</td>
<td>Active</td>
<td>5 minute window</td>
</tr>
<tr>
<td>(Geisler &amp; Kubiak, 2009)</td>
<td>That higher tonic HRV ratings are correlated with pre and post actional phase in goal pursuit after failure.</td>
<td>Power analysis of HF</td>
<td>Resting</td>
<td>6 minute measurements</td>
</tr>
<tr>
<td>(Hansen, Johnsen, &amp; Thayer, 2009)</td>
<td>High HRV participants showed superior performance on cognitive tasks in non threat and threat conditions. Low HRV patients dramatically improved performance on cognitive tasks in threat conditions.</td>
<td>Power analysis of HF</td>
<td>Resting</td>
<td>Not stated</td>
</tr>
<tr>
<td>(Pop-Jordanova, 2009)</td>
<td>That biofeedback training can help children with anxiety disorders and OCD improve HRV.</td>
<td>Power analysis of LF and HF</td>
<td>Active</td>
<td>Not stated</td>
</tr>
<tr>
<td>(Utsey &amp; Hook, 2007)</td>
<td>That HRV moderated the relationship between institutional race-related stress and psychological distress for men, but not women.</td>
<td>Mean RR &amp; RMSSD</td>
<td>Resting</td>
<td>Not stated</td>
</tr>
<tr>
<td>(Fabes &amp; Eisenberg, 1997)</td>
<td>That individuals high in vagal tone were relatively unlikely to experience high levels of negative emotional arousal in response to stressors and that under conditions of moderate to high stress, individuals high in vagal tone were likely to constructively cope with stressors.</td>
<td>Frequency of heart beats per 500ms</td>
<td>Resting</td>
<td>100 seconds</td>
</tr>
<tr>
<td>(O’Connor, Allen, &amp; Kaszniai, 2002)</td>
<td>Levels of depression in a group of bereaved people (n=10) correlated negatively with HRV.</td>
<td>Power analysis of HF (band0.12-0.4)</td>
<td>Resting-pre and post interview</td>
<td>5 min</td>
</tr>
<tr>
<td>Reference</td>
<td>Summary</td>
<td>Measures</td>
<td>Duration</td>
<td></td>
</tr>
<tr>
<td>-----------</td>
<td>---------</td>
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<td></td>
</tr>
<tr>
<td>(Sgoifo et al., 2003)</td>
<td>Individuals with higher levels of sympathetic dominance were characterized by higher scores of submissive behaviour, larger cortisol increments, and higher perception of psychophysiological arousal.</td>
<td>RR, SDRR, RMSSD</td>
<td>Resting Active and recovery</td>
<td>5 min</td>
</tr>
<tr>
<td>(Pauls &amp; Stemmler, 2003)</td>
<td>During an induced fear state, defensive coping was negatively related to a HRV.</td>
<td>RMSSD</td>
<td>Resting, active fear, active anger</td>
<td>3 measures of 1 min</td>
</tr>
<tr>
<td>(Cohen et al., 2003)</td>
<td>Bipolar patients at rest are characterized by low HRV</td>
<td>SDNN &amp; Power analysis of VLF, LF and HF</td>
<td>Resting</td>
<td>Not stated</td>
</tr>
</tbody>
</table>

*Table 2.6 – Summary of literature on HRV*
2.9 Practice Based Learning

In their research on informal learning methods, Cheetham and Chivers (2005) aimed at developing a taxonomy of informal professional learning methods. Their research was based on personal interviews of 80 professionals and survey data collected data from 700 professionals, across 20 professions. Both, interview and survey respondents were asked to rate each of ten common styles of informal learning. After analysis, in order of rated importance, these were:

a. on the job learning;
b. working alongside more experienced colleagues;
c. working as a part of a team;
d. self analysis or reflection;
e. learning from clients/customers/patients;
f. networking with others doing a similar job;
g. learning through training/training others;
h. support from a mentor of some kind;
i. use of a role model;
j. pre-entry experience.

In order to arrive at the taxonomy, Cheetham and Chivers (2005) drew on both interviews and surveys. All the respondents were asked to describe their formative experiences in detail. Interviewees were questioned in much greater detail, including open-ended questions. Using detailed content analysis, the taxonomy was reported with 12 general learning processes.

2.9.1 Practice and Repetition

This was reported as a beneficial tool in becoming proficient at a job. Certain respondents highlighted the importance of doing things over to learn something (iteration). However, some respondents reported reaching a plateau and some even reported a regression in effectiveness. Further, respondents reflected on the benefits of rehearsing before particular activities such as interviews, meetings and presentations. Preparation was considered to be highly important, with respondents divided in favour of over-preparation (reportedly gave them assurance) and against it (over-preparation made them more self-conscious). It was observed that preparation and rehearsal was important across the board, however, the more experienced prepared in outline, whereas, the less experienced in detail. Other researchers have reported similar results (eg. Fitts, 1986).

Previous research in psychology has noted over-learning to have negative effects (eg. Drever, 1964). However, in their research, Cheetham and Chivers (2005) reported over-learning (learning/training well beyond the minimum levels required for competent performance) to have positive results. The respondents highlighted that over-learning, whether sought, accidental or enforced, helped embed, desired behaviour, overcome weaknesses and help react automatically in difficult situations. Significant number of respondents offered examples where simulation had helped develop their skills. However, a small number reflected on possible negative effects of simulations, where low-fidelity simulations can develop bad and inappropriate behaviours, leading to loss of confidence in real situations. Cheetham and Chivers (2005) concluded that high-fidelity simulation can be beneficial (also reported by Short, 1989), whereas low-fidelity simulations could have potential negative effects (also, Reason, 1979).
2.9.2 Reflection

Although, only a small number of respondents indicated that reflection was beneficial in formative stages, considerable numbers found reflection to be of vital importance in continued development (e.g. to improve day-to-day performance). Several respondents stressed the importance of reflecting jointly, especially within an agreed framework of ground rules. Some examples of systematic forms of reflection were: a) debriefing (including self-debriefing); b) team based reflection; c) keeping reflective journals and d) reflection linked to peer review or practice audit. Cheetham and Chivers (2005) noted that reflection as a discrete tool might be limited but plays a vital element in other learning technique in turning experience into learning.

Respondents highlighted the importance of self-knowledge and self-appraisal as it helped in recognising one’s strengths, weaknesses and being realistic in one’s aims. Further, reflection included reflection before, during and after action (event or activity), reflection on how others do things and learning from failure.

2.9.3 Observation and Copying

Many respondents highlighted the importance of observation as observing colleagues’ behaviour had helped them improve their own personal skills, amongst them, a few stressed that observation needed to be close and purposeful, rather than casual. Several pointed at the need of having some structure or framework, in order to observe acutely or critically. Other researchers have stressed role of observation (e.g. Bandura, 1986).

A part of observation and copying is the function of role models. Some respondents dismissed the importance of role models in favour of a strong ‘self’, however, others found role models extremely influential. Analysing the responses, Cheetham and Chivers (2005) identified 3 levels of role modelling: a) synthesising (absorbing elements from number of people, more or less unconsciously), b) emulating (conscious effort to act like a particular individual when performing certain tasks) and c) actualising (actually feeling like one’s role model). Emulating and Actualising are reportedly similar to Imitation and Identification suggested by Bandura (1986). Respondents differentiated between positive role models and negative role models, where they followed the actions of positive role models, they avoided the actions of a negative role model.

2.9.4 Feedback

Respondents reported the importance feedback from superiors, mentors, colleagues, clients and patients. Further, they stressed the roles of actively seeking feedback and indirect feedback during interaction. A small number highlighted the importance of formal appraisal to identify their current performance and also, future avenues of growth. Several interviewees spoke about the ability to take criticism and turning it into a source of learning. Similar point was made about complaints, which formed a rich source of feedback and self-knowledge. Respondents noted that while they were happy to receive constructive criticism (at times actively seeking it), they were against destructive criticism, which could potentially damage their confidence and competence, especially if it came from their superiors. Significant proportion of respondents stressed on the importance of listening skills and identified clients, patients or customers as rich sources of learning. Similar feedback from additional sources, such as peers, evaluation exercises, 360o appraisals, reading body language, was reported to be beneficial.
2.9.5 Extra-Occupational Transfer

Respondents reflected on the importance of ‘out of work’ activities, relevant to their profession, and noted that it helped them develop their skills. Eraut et al. (1998) have reported similar findings in their research on learning from ‘life outside work’. Cheetham and Chivers (2005) pointed that pre-entry experience (experience gained from previous activities and assignments), learning transferred from formal education and out of work learning (e.g. hobby, voluntary work etc.) were important aspects of extra-occupational transfer.

2.9.6 Stretching Activities

A number of respondents described an opportunity to operate at a higher level than their normal grade in their formative experience as highly beneficial. It gave respondents a chance to view things from a strategic perspective and confidence to operate at a higher level. In addition, being faced with complex or multi-faceted problems early in their career had been an excellent learning opportunity as it helped them draw from a range of areas covered in their training. Certain experiences that were even traumatic were reported to be formative. Also, respondents stressed that undertaking pioneering or innovative work were valuable sources of learning.

Such stretching experiences during formative time offer a more holistic learning opportunity. However, without proper support such experiences can prove to be overwhelming and have a negative impact.

2.9.7 Perspective Changing / Switching

Significant number of respondents in Cheetham and Chivers’s (2005) research pointed that being forced to change perspective (e.g. when a doctor is admitted as a patient and is forced to view things from a patient’s perspective) had given them a chance to view a situation or their profession itself from a different standpoint. Others reported that change of perspective had resulted in improved empathy with clients or patients. Some of the respondents pointed at benefits of shadowing their superiors, which helped them see things from a broader/strategic perspective. Some actively viewed things from a client’s or patient’s standpoint. Several respondents said that working with people from other disciplines helped their professional development and helped them approach things differently.

A number of respondents reported to have formative benefits from working in a different culture, e.g. working abroad. They noted that such a experience enabled them to adapt themselves, imbibe good practices and also become more self-reliant, having worked with lesser support than their native culture.

2.9.8 Mentor / Coach Interaction

Only a small proportion of interviewees reported to have a mentor, though a significant number identified individuals who served as unofficial mentors. Some formal mentoring arrangements worked well and in a few cases resulted in ongoing relationships even after training was over. However, some formal mentoring arrangements were reported to be disappointing. Of those who identified mentoring as an important contributor, several reported that individual concerned was not their formal mentor but someone with whom they had developed a unofficial mentoring relationship.
Mentors were also reported from other professions, eg. a life mentor who had guided a respondent towards their chosen career. Others were functional mentors, eg. someone from a related occupation who helped them develop ancillary skills. Hence, mentors were reported to be formal but also self-selected, rather than imposed. The key to success of mentoring was reported to depend as much on compatibility as on coaching skills of the mentor.

2.9.9 Unconscious Absorption or Osmosis

Many interview respondents reported to have found working alongside experienced colleagues a rich source of learning where they recounted an absorbing skills and other behaviours on a nearly unconscious level. This seemed to have happened without particularly close observation or without a conscious effort to copy. Some noted such a process to be extremely effective in learning more tacit forms of knowledge. This kind of learning is very similar to apprenticeship. Some researchers have named this process as learning by osmosis (eg. Eraut et al., 1998).

A similar form of effective learning was reported by networking with fellow professionals particularly from different organisations or specialisations. Some even reported planned networking arrangements to share experiences, however, networking was primarily random and informal. Further, no specific advantage was reported by formal networking arrangements.

2.9.10 Use of Psychological / Neurological Devices or Techniques

A number of respondents described the process they followed to understand difficult concepts or to prepare for challenging tasks. They reported of benefits of breaking down complex situations or ideas into simpler stages, use of conceptual models or mind maps. Number of respondents reported to use techniques associated with lateral thinking. The use of mental tricks or imagery to help others learn was also reported. Some respondents pointed at importance of an appropriate mind-set, while others noted inner speech to induce a positive frame of mind.

Some respondents reported learning by routinely linking their existing knowledge with new concepts, while others reported use of mind-set changes. Cheetham and Chivers (2005) noted that learning experiences were a gradual and iterative process with a series of surges, triggered by formative experiences.

2.9.11 Articulation

A number of interviewees reported that being forced to articulate their work either orally or in writing was a great source of learning. A similar beneficial source of learning was through teaching others, where teaching, training or mentoring new entrants had helped their self-development.

2.9.12 Collaboration / Liaison

Many respondents identified and stressed learning benefits derived from working in teams and other collaborative techniques. Team working was reported to be especially effective when new or challenging work was undertaken. Such collaborative efforts were reported to have better results than individual efforts and also had beneficial effects on morale and confidence of those involved. Several
benefits such as improvement in communication skills, empathy and even relieving of stress, were reported from working in a team. An equally important point was diversity in teams, where people added and benefited from different styles and approaches. Another such learning technique was working with people from different disciplines and also with para-professionals (someone in a related profession with less status but more experience).

Cheetham and Chivers (2005) presented this taxonomy as a simplified version and reported that “…if desired it can be extended to give sub-divisions of learning experiences” (p. 205). The taxonomy provides a checklist of possible learning opportunities and approaches.

2.10 References


3 SoA on Serious Games (WP4)

3.1 Introduction

The term ‘serious game’ has given rise to widespread controversy and has spawned a wealth of attempts to capture the essence of games-based learning in a single definition. To make matters even more confusing, there exist numerous synonyms and proxy terms – game-based learning, games for health, persuasive games, meaningful games – that essentially describe the same concept. One of the key motivations behind the term is that learning through game play ought to be an enjoyable experience that stimulate or encourage players to more intensely engage with the educational content (Ritterfeld et al., 2009).

In xDelia, we need not be concerned with these definitional struggles. For us, games serve a broad range of purposes, not just traditional learning where a particular body of declarative knowledge needs to be mastered, but also cognitive and emotional skills development, and behaviour change. Moreover, as we have described in the description of work (DOW), games are also used as a research tool to gather psychological and behavioural data and, possibly, as a diagnostic component in a larger set of tools to support learning.

Perhaps unsurprisingly then, serious games show a considerable diversity in terms of pedagogical principles deployed, educational strategies and content drawn on, and learner profiles targeted. Ratan and Ritterfeld (2009) for example have examined a dataset of 600 serious games and found that only 5% of the games for instance targeted adult players. This raises the question of course whether there exist particular barriers our project – where we intend to reach a young adult population – has to be mindful of. The same authors found that games with academic content are by far the most common genre (63%), followed by games for social change with 14% share, and finally health and occupational oriented games with 8% and 9% respectively. Finally, games for military training have a share of 5% and games for marketing have less than 1%. Ratan and Ritterfeld find that the games they surveyed fall into just a few categories in terms of the different types of learning outcome they pursue:

- **Practical skills** (48%) – characterised by repeating tasks and activities, and relatively limited information
- **Cognitive problem solving** (24%) – e.g. puzzles and games with complex task patterns
- **Knowledge gain through exploration** (21%) – declarative knowledge is only of secondary nature in this kind of games. Players instead focus on exploring problem spaces and learning by doing
- **Social problem solving** (7%) – here players collaborate in teams to acquire social, emotional, and decision making skills to prevent problem behaviour

3.1.1 A Sketch of a Game Design Model

Abstracting from practical and also from many conceptual and methodological considerations, a game can be visualised as layers of increasing external complexity and salience (Figure 3.1). Located at the innermost layer we find the game play, that is, the sum of experiences including fun, challenge, curiosity, and so on that act upon and engage the player with the game. Game play is at the heart of game design. Although we can create designs that seek specific game play experiences, we cannot actually predict what exact experiential effects it has in individuals since the latter play a fundamental role in shaping the game experience. The next layer consists of the logical game systems and elements...
The logical game system is often independent of the implementation of the game and can thus be translated to a variety of different media. Key constituents of the logical system are:

- Rules or game mechanics
- Game objects (can be active or passive)
- Game space (the space where the game take place)
- Game system (orchestrate the elements)

Finally, the game media layer consists of the components and artefacts that imbue game play, game mechanics, and the game system with life. These include 2D and 3D graphics, animations, video, audio, costumes, lightning and so on.

Considerations around game play design flow into the design of the logical game system, which in turn affects decisions on the kind of game media to be used. As a concluding remark, games are embedded in contextual surrounding that can instrumentally affect the game experience (Lindley and Sennersten, 2007).

### 3.1.2 Game Development in xDelia

Leaning on Figure 3.2 for the purpose of illustration, the approach taken in WP4, in starkly simplified terms, is the following. The design of games in WP4 is informed by other research activities in the project, in particular those around the trader and investor case and the financial capability case. When the game is played, we assume that some kind of learning takes place and the player acquires knowledge and skills that result, say, in a repertoire of adaptive emotion- or self-regulation strategies, or that lead to improved cognitive skills. While learning outcomes such as newly obtained knowledge, skills, and strategies can be leveraged by players to their advantage within the game world, and while this might be all that is needed in an entertainment game, serious games have to go further. Serious games have to enable players, or learners, to actually apply learned knowledge and skills in the real world, or, more technically, learning has to transfer to the real world. There exist many strategies that facilitate this process, and game design needs to leverage these strategies. But the big question is how do we know if the design results in the desired outcome, e.g. what and how should we evaluate the game. In conclusion we have to, within xDelia, know what learning is. We have to discover how
game design relates to learning activities and learning outcome. We have to explore what learning outcomes can be expected. We have to study how transfer can take place, and we have to look into what should be evaluated and how we can accomplish it. The five key concepts in the chain (game design, learning, learning outcome, transfer and evaluation) are reflected in the five subsections in this section.

![Figure 3.2 – Overview of WP4 perspective](image)

### 3.1.3 Section Overview

After this brief and admittedly highly selective and stylised introduction, we will introduce key aspects of serious games most of which find less or no consideration in discussions on entertainment games: (1) learning models, both general and serious game specific, (2) learning objectives, or more specifically, learning outcomes, (3) selected aspects of game design, (4) skill and knowledge transfer, and (5) evaluation. Except for game design, these aspects are rather specific to the concern of serious games with knowledge and skill development, and, in our case, also with behaviour change. Figure 3.2 illustrates the different aspects of game design, implementation and evaluation that work package WP4 incorporates into a fully participatory and iterative development approach. Thus, where learning is the key objective with games developed in xDelia – psychological experiments and diagnostics are the two other use cases – games have to be designed in a way that the learning which takes place during game play has the desired effect or outcome, e.g. a newly acquired skill or a positive change in a particular behavioural pattern, and that evaluation of design, learning, transfer, and outcome should receive due consideration.

Section 3.2 ‘Learning Models’ discusses learning models, both general learning models and game-based learning models which are geared towards games.

Section 3.3 ‘Learning outcome’ presents two approaches of classifying learning outcomes from a game-based learning perspective.

Section 3.4 ‘Game design’ describes some approaches that help bridge game design and games-based learning e.g. what game characteristics to consider when developing serious games that are meant to produce a desired learning outcome.

Section 3.5 ‘Transfer’ discusses aspects and qualities of games that facilitate the transfer from the game to the real world application domains.

Section 3.6 ‘Evaluation’ discusses a variety of aspects related to the evaluation of serious games. It presents several evaluation frameworks and approaches from the area of serious games and from the health sciences.
3.2 Learning Models

There exists a range of different frameworks to use as a foundation for how to design for and evaluate aspects of game-based learning. For example between 1956, when Bloom (Bloom, 1956) first introduced his famous learning model taxonomy, and the revision of the classification at the start of the 21st century, a total of 19 alternative taxonomies have been put forward (Anderson, 2005). We will present four of these frameworks (or models for learning) here: Bloom’s taxonomy revised (Anderson, 2005), Kolb’s experimental learning cycle (Kolb et al., 2001), Gagné’s taxonomy (Gagné, 1984) and Baker and Mayer’s CRESST learning model (Baker and Mayer, 1999). Through our literature review, we have found that these models often act as basis for game-based learning approaches. In addition, we will describe two learning models that have been designed specifically with game-based learning and training in mind: the experimental gaming model and the input-process-outcome game model. These two are also often referred to in scientific papers.

3.2.1 Broader Learning Models

The learning models presented in this section are models that are intended to apply generally to most learning types and situations. The models are all used in literature as a basis for discussions of game-based learning. The game-based learning models discussed below in section 3.3.2 all use one or more of the learning models as a starting point. These models provide us with a shared and more complete understanding of what learning is.

3.2.1.1 Bloom’s taxonomy revised

Although bloom’s taxonomy (Bloom, 1956) is the oldest of the learning models, we would like to present the revised version of the taxonomy described in (Anderson, 2005) since this version corresponds well to the original taxonomy, preserving its original intent. The revised version differs from the old one by better reflecting the current view of learning where the learner is an active learner.

The cognitive process dimension in the new taxonomy (Figure 3.3) corresponds to Bloom’s taxonomy. Bloom (Bloom, 1956) has six levels of learning: knowledge, comprehension, application, analysis, synthesis and evaluation. To get to the top of the learning hierarchy the learner has to manage the lower levels first. In the new version Bloom’s six classes appear in the cognitive process dimension, but they have been replaced by their verb form to visualize active learning. The new concepts are: remember, understand, apply, analyse and evaluate. The different types of learning are organized from less comprehensive to more complex and abstract learning, while synthesis and evaluation (represented by analyse and evaluate) have changed places. In the new version the learner does not necessarily have to manage the lower levels to reach one of the higher levels. An example would be for instance a student who can put into practice a knowledge or skill before he or she understands it completely (Anderson, 2005).
The taxonomy described in (Anderson, 2005) adds another dimension to Bloom’s taxonomy. Instead of focusing on content as Bloom does, the knowledge dimension (Figure 3.3), which represents types of learning, makes the revised version more generic (Anderson, 2005). First, the most concrete knowledge type is factual knowledge which consists of knowing for example a particular terminology or the details of a subject matter. Second, there is the conceptual knowledge which is knowledge of classifications, theories and models and so on. Third, procedural knowledge means that an individual knows how to do things by applying methods, techniques and skills. Fourth, there is meta-cognitive knowledge which is knowledge of cognition in a broad-spectrum comprising strategic knowledge, task knowledge, and self-knowledge (Anderson, 2005). The intention with the taxonomy is to be able to categorise a particular learning activity or process according to the two axes.

**Relevance for xDelia**

Bloom’s revised taxonomy may be of assistance in xDelia by framing what type of learning outcome we want to achieve with a specific game. By starting on this question we can share a basic view of what the game should be about. The game development process in xDelia can be seen as an iterative process that starts with the learning objectives inspiring the creation of a game idea. The game idea leads to a game concept and the concept in turn forms the basis of the implementation of the game.
When a prototype is implemented the game is tested and evaluated. The results from one phase are
form the input to the next, although there is an equally important flow into the opposite direction
(Figure 3.4). In summary, Bloom’s revised taxonomy can be used to formulate the question: “What
type of learning or learning outcome should be the result of playing the game?” (Figure 3.4) The
question should preferably be raised in the phase of idea creation, since it will influence the rest of
the process.

3.2.1.2 The experimental learning cycle

In Kolb’s experimental learning cycle and basic learning styles as described in (Kolb et al., 2001) the
learning process is conceptualised as a sequence of continues shifts between different kinds of
learning. The model emphasises the importance of direct experience and reflection in the learning
process. The four stages in the learning cycle are (Figure 3.5):

1. concrete experience (feeling),
2. reflective observation (watching),
3. abstract conceptualization (thinking) and
4. active experimentation (doing).

Concrete experience acts as a basis for observations. The observations lead to reflection. The
reflections are refined and result in abstract concepts. The concepts have implications of what actions
can be taken and, importantly, the concepts can be actively tested through experimentation. Kolb and
colleagues also state that learning involves capabilities of opposite type, e.g. the learner continuously
has to choose what abilities to use in a specific learning situation. For example the learner has to
choose (more or less consciously) how he or she should take in a specific learning situation. One
example is that it is impossible to drive a car at the same time as studying the car's user manual (Kolb
et al., 2001). The conflict between the different ways of learning, that is, between concrete and
abstract, active and reflective, is resolved by the learner’s learning style. Kolbs et al. (2001) talk about
first-, second- and third-order learning styles depending on how the different learning types just
mentioned are combined. The first-order learning styles consists of:

1. **Diverging learning style** where the learner preferably combines concrete experience and
   reflective observation (a dialog between feel and watch).
2. **Assimilating learning style** that merges abstract conceptualization and reflective observation
   (watch and think).
3. **Converging learning style** that is a combination of abstract conceptualization and active experimentation (think and do).
4. **Accommodating learning style** means that the learner uses both concrete experience and active experimentation (feel and do).

**Relevance for xDelia**

The experimental learning cycle and learning styles is also about fundamental learning principles and should be a good base for discussion about how, with the games we develop in xDelia, players are supposed to learn. How the player learns may influence the game idea as well as the game concept (Figure 3.6). Thus, if we want for example to support the accommodating learning style, our game concept must implement active experimentation and concrete experiences.

![Figure 3.6 – The game development process and the use of the experimental learning cycle and learning styles in xDelia](image)

**3.2.1.3 Gagné’s learning taxonomy**

Gagné proposed first in 1972 his learning taxonomy, which he subsequently refined in an article from 1984 (Gagné, 1984). The taxonomy has five different categories with unique properties:

1. Intellectual skills
2. Verbal information
3. Cognitive strategies
4. Motor skills
5. Attitudes

Intellectual skills embrace concepts, rules and procedures and determine whether and to what extent a person can apply a sequence of concepts and actions in unfamiliar situations (Gagné, 1984). Verbal information is similar to factual (declarative) knowledge. The learning of verbal information is accomplished when a person can recall a presentation or text almost word by word or recreate the main ideas from the presentation without a comprehensive understanding. Cognitive strategies resemble meta-cognitive knowledge (see 3.2.1.1) in that the learner is able to choose appropriate intellectual skills and declarative knowledge when learning, remembering and solving problems. Motor skills are present when the quality of the skill is dependent on repetition of a trained movement (Gagné, 1984). Attitude is a new category of learning in comparison to the learning models presented in the subsection above. Attitude is motivated as a category of learning by the fact that individuals’ attitudes are influenced by the learning activities, and, depending on the
circumstances, a change in a particular attitude will influence the learner’s behaviour in some way or another.

**Relevance for xDelia**

Gagné’s taxonomy is of interest for xDelia in so far as it adds attitudes as a learning outcome and can be easily associated with learning in games, although it is on a rather high level and we would have to concretize the categories to be more detailed in terms of game-based learning. There is for example Kraiger et al.’s and indirectly Wouters et al.’s classification (section 3.3), both of which build on Gagné’s taxonomy and which is geared towards training. These classifications are likely to be more adequate for our purposes. Having said this, the description of Gagné’s taxonomy can nevertheless function as a basis for understanding where the learning outcome originates.

### 3.2.1.4 The CRESST model of learning

Baker and Mayer (1999) explore in the article “Computer-based assessment of problem solving” assessment of learner understanding with a focus on open-ended problem-solving. The authors’ learning model (Baker and Mayer, 1999) defines five families of cognitive demands, the CRESST model of learning (Figure 3.7). Each family represents a cognitive demand that is required for learning. The families of cognitive demand are the problem-solving task itself, self-regulation, communication, collaboration and content understanding. The families of demands can be used as base for creating assignments and tests, for example the family of “content understanding” (Figure 3.7) contains “explanation” which can guide creation of instructions to the students. The families of demands can also guide the creation of core attributes of a domain that can be used for testing or evaluation.

![Figure 3.7 – CRESST model of learning (Baker and Mayer, 1999)](image)

**Relevance for xDelia**

The CRESST model of learning could be used to create assignments for example, that stipulate what it is that has to be learned. It can be used within xDelia to form a discussion of what content to put into the game. We can go through the families of demand and discuss each family and consider what we want the player to learn about, say, self-regulation and then continue with how we can realize it in the game. Similarly, the CRESST model, as any other of the learning models discussed here, can be used to systematically analyse existing games as to their learning content. The question relates to the creation of game ideas as well as, or perhaps principally so, to creating the game concept, for the discussion can focus on rather concrete mechanisms in the game (Figure 3.8).
3.2.2 Game-Based Learning Models

In the models discussed up to this point, learning is viewed more or less in isolation from the delivery mode and medium. In the models presented in this section, learning is viewed in the context of games, with elements of game experience and gameplay added to the conceptualization of learning.

3.2.2.1 Experimental gaming model

Kiili (2005) discusses a framework of flow where a player’s skills and the challenges in the game are related to each other in a way such as to create a flow in the game experience. Flow is when a person is totally engaged with and immersed in an activity and could be described as the optimal experience (Kiili, 2005). Flow has a motivating positive effect on learning. What is influencing the experience of flow is the task that should be completed, the use of artefact and the individual differences of the person performing the task (Figure 3.9). According to Kiili (2005) flow is also influenced by different factors in the activity. Skill, feedback, control and playfulness are all determinants for flow independent of whether it is in interaction with the computer or while performing the task. In addition usability is important in the interaction with the computer, while clear goals and focused attention are factors that affect the flow experience in the activity to perform the task (Figure 3.9).

The experience of flow is a balance of the challenge and the person’s skill. If the challenge is too difficult and the skill is too low the person gets anxious or frustrated but if the challenge is too easy compared to the skill the person gets bored. The two factors have to be balanced.
Kiili’s experimental gaming model (Figure 3.10) builds on Kolb’s experimental learning cycle (Kolb et al., 2001). Kiili states that Kolb’s model (section 3.2.1.2) emphasises the continuous nature of learning and the necessity of proper feedback to guide the learning process by goal-directed action. Kiili’s experimental gaming model links gameplay with experimental learning in such a way that it provides for a satisfactory flow experience. The model incorporates learning as both cognitive and behavioural. The author defines learning as “a construction of cognitive structures through action or practice in the game world.” (Kiili, 2005, p. 18). What is not taken into account in the model is social interaction.
The experimental gaming model contains an iteration loop, an experience loop and a bank of challenges. The challenges are based on the learning objectives and are at the heart of the gaming model (Figure 3.10). To overcome the challenges the player (1) generates ideas in the preinventive idea generation loop to face the challenge. This process can be described as unstructured and chaotic and without constraints. In the next step (2), the player develops his or her ideas taking the constraints of the game into account. Then the player tests different solutions in the experience loop and (3) starts to explore what might work and what not. The game should provide clear goals, useful feedback and usability in other aspects than feedback to guarantee the necessary flow. The next step in the model is (4) reflective observation of the feedback that may lead to construction of schemata (5) that in turn can lead to new improved solutions. Then a new challenge is presented and a new loop starts. If the challenges support different types of solutions the player can develop more and deeper levels of skill and control over the game, which in turn contributes to the flow experience.

Relevance for xDelia

The experimental gaming model takes into account both flow, the gameplay process and how learning takes place. The result is that the model can be used as base for discussion in xDelia of how to design gameplay in the intended game. The question how to design gameplay can be related to the game concept as it generates implication of how to design the game (Figure 3.11).

3.2.2.2 Input-process-outcome game model

Garris et al.'s input-process-outcome game model (Garris et al., 2002) also builds on the experimental learning tradition here represented by Kolb et al. (2001). As pointed out in section 3.2.2.1 flow leads to motivation and motivation leads to better learning outcome. In the input-process-output model (Figure 3.12) instructional content together with game characteristics act as input to the game cycle. The process in the game cycle consists of an iteration of user judgements, user behaviour and system feedback. To achieve a successful game the activities in the game cycle must therefore produce flow and motivation.
User judgement takes place at the moment when the player starts to play the game and experiences it as fun or boring. User judgement is based on interest, enjoyment, and task involvement and how well the game provides opportunities to train to play the game for the player to gain confidence (Garris et al., 2002).

The affective judgments have an effect on the user behaviour either positively or negatively. The players that form positive attitudes towards the game are more intensively engaged in the game and more focused on the task (Garris et al., 2002).

System feedback is very important to performance and motivation. The feedback is also influencing the user judgement since if the feedback indicates too often that the player’s performance is below standard the game is likely to be perceived as too difficult. Too little feedback is similarly problematic.

The different stages in the game cycle are intervened and influence each other. In this way they work together to promote motivation.

**Relevance for xDelia**

In our project, this model can provide a shared understanding of the gaming process and point out the relationship between input and outcome in the process and how the gameplay itself creates, facilitates or enables these relationships. The model is located on a high level of abstraction and hence does not provide any concrete input to the game development process.

### 3.3 Learning Outcome

Learning objective, learning process and learning outcome are set in a successive order. The taxonomies presented in this section build on the general learning models, but focus on learning outcome rather than learning process.

#### 3.3.1 Kraiger et al.’s Classification of Learning Outcome

One important problem when discussing learning process and learning outcome is that learning differs between individuals and that it is hard to observe and measure in a tangible manner. Kraiger et al. (1993) suggest a model consisting of different categories of learning that are able to differentiate
between different types of learning. The resulting classification scheme of learning outcome builds on Bloom’s (1956) and Gagné’s (1984) taxonomies. Kraiger and colleagues divide the learning outcome into three main categories with several subcategories (Figure 3.13). The categories (subcategories) are: cognitive outcomes (verbal knowledge, knowledge organization, cognitive strategies), skill-based outcomes (compilation, automaticity) and affective outcomes (attitudinal, motivational) (Figure 3.13).

![Figure 3.13 – Classification if learning outcomes (Kraiger et al., 1993)](image)

**Cognitive outcomes** are related to the type and quantity of knowledge, and how elements of knowledge are connected. Cognitive outcomes consist of verbal knowledge (see 3.2.1.3 Gagné’s learning taxonomy) and knowledge organization. Knowledge organization is when the learner starts to develop meaningful structures from procedural knowledge e.g. how things are done. Knowledge organization can be seen as creating mental models. Mental models can be used to describe, observe and explain tasks as well as foresee or predict future requirements concerning the task. Cognitive strategies are a continuation of knowledge organization. When knowledge and procedures are further compiled a more comprehensive task strategy is emerging.

The next category is **skill-based outcomes** and involves technical motor skills. Typical for this type of learning is that it is goal oriented and the behaviour is organised in a sequence. When individuals just start to train they are fairly slow, but eventually they get better and the compilation phase emerge. Compilation consists of two kind of simultaneous activities; proceduralization and composition. Proceduralization means the trainee builds small discrete domain-specific behaviours and at the same time the composition starts and the different parts begin to fit together. Another subcategory to skill-based outcome is automaticity which means that the trainees behaviour changes from a controlled activity to routine task.

The third category is **affective outcomes**. Gagné (1984) motivates this category with the fact that attitudes can have an impact on behaviour or performance. The subcategories are attitudinal and motivational outcomes. Examples of attitudinal outcomes are group norms, tolerance for diversity and recognition of what is important to learn (Kraiger et al., 1993). Subcategories of motivational learning outcomes are motivational disposition, e.g. if the learner is performance or mastery oriented in his goal setting, self-efficacy, e.g. how the learner perceive his or her capabilities to carry out a specific task, and goal setting. Goal setting makes learners perform better and more persistent in behaviour implementation.
Relevance for xDelia

Kraiger et al.’s classification of learning contains a category of affective outcomes that resonates with concerns in xDelia about behaviour implementation or psychological determinants of behaviour and behaviour implementation for instance. For example attitudinal and motivational learning outcomes can play an important role in behaviour change. Moreover, the classification can be used within xDelia to pin point what outcome to evaluate. The question “what to evaluate?” can guide us not only on the kind of learning outcome that is to be evaluated, but also assist us in deciding how to evaluate the specific outcome of a game. The question is naturally associated with the evaluation phase in the game development process, but also to game testing as the method to evaluate the game may influence how the testing is done, what tasks to perform in the game for example (Figure 3.14).

![Figure 3.14 – The use of Kraiger et al.’s classification of learning outcome in xDelia](image)

### 3.3.2 Wouters et al.’s Taxonomy of Learning Outcome

Wouters et al.’s taxonomy of learning outcomes (Wouters et al., 2009) builds on the CRESST model of learning (Baker and Mayer, 1999) and Kraiger et al.’s classification scheme (Kraiger et al., 1993). Wouters and colleagues further extend these models with subclasses: cognitive learning outcomes (knowledge, skills), motor skills (acquisition, compilation), affective learning outcomes (attitude, motivation), and communicative learning outcomes (communicate, cooperate, negotiate) (Figure 3.15).
Cognitive learning outcomes are divided into knowledge and cognitive skills (Wouters et al., 2009). Knowledge refers to encoded knowledge reflecting both text-oriented, such as remembering the lyrics to a track, and non-text oriented knowledge, such as remembering a smell or the melody of a song. Encoded knowledge is divided into declarative knowledge (such as semantic or episodic knowledge) and non-declarative knowledge (such as procedural knowledge). A cognitive skill pertains to more complex cognitive processes. In problem solving, for example, learners have to apply knowledge and rules to solve new problems (Wouters et al., 2009). In complex and dynamic situations people are sometimes forced to make decisions under time-pressure. Such decision making skills require situational awareness, that is, the ability to attend to and perceive the relevant information in a situation, comprehend this information and predict how the situation may develop (O’Brien & O’Hare, 2007).

Motor skills are according to Wouters et al. (2009) learned in several stages. First from declarative knowledge to procedural knowledge. After that the motor behaviour is being automated and refined independent of verbal rehearsal.

Affective learning outcomes are divided into two subtypes. The first one, the attitude of the learner, can be either positive or negative, and is directed towards the attitudinal object which can be a person, a situation, an activity and so on (Wouters et al., 2009). Learning can try to change a negative attitude into a positive one (e.g. considering thrift as a positive quality). The other subtype, motivation, is crucial for learning since without it the learner will not pay attention to the material or the activities and may refuse to allocate sufficient cognitive resources for learning to be possible.

Communicative learning outcomes are those that consist of social and communication skills, building social relationship, group cohesion and shared mental models through this (Wouters et al., 2009). In many cases this can be the principal outcome of learning, such as in a military unit’s collaboration or sports teams.

Relevance for xDelia
The taxonomy presented in this subsection is rather similar to the Kraiger et al. classification of learning outcomes. Wouters and colleagues added a category (communicative learning outcome), but to xDelia it is mainly category one and three (cognitive and affective learning outcome) that are of interest. In the category of cognitive outcome there are some interesting differences compared to Kraiger's classification. Wouters et al. have added non-textual outcomes that refer to learning outcome that is related to the five senses, which could be important in view of things such as attitudes or emotion regulation. The environment and context influences the learner as well as the game. A smell for example might be a complement to the game to create a positive attitude towards a specific goal. But the most interesting learning outcome in the taxonomy is the skills-like problem solving, decision-making and situational awareness that is directly applicable to work package 2 and the study of traders and investors. Making application in this context should involve evaluation of all three learning outcomes. In conclusion Wouters et al.’s taxonomy can help us in deciding what to evaluate just like Kraiger et al.’s approach does (Figure 3.14). Moreover, both learning outcome classifications can guide the creation of evaluation questions when evaluating intervention activities in Work package 6.

3.4 Game design

There exists a mapping between learning and learning outcome, but it is not a simple 1-1 relation. Many factors influence the learning and the learning outcome and in this section we present an attempt to address this mapping. Specifically, we are interested in the question of what to consider when aiming for making serious games that result in desired learning outcome.

3.4.1 Motivation and Game Characteristics

Anything can be learned if the motivation and the inspiration to learn exist. In Gee (2003) the results of a study are presented where seven-year old children play the game Age of Mythology and subsequently engage in research about mythology, inside and outside of the game, and at their own pace. The children become motivated to learn more on their own, because the game inspired them.

“This is education at its best, and it is happening at home, outside of school.” (Gee, 2003, p. 2)

The idea is to design games that support knowledge and skill acquisition, while maintaining the games’ ability to present users with realistic and compelling challenges and thus capture the users’ concentration for long periods (Bellotti, 2009).

3.4.1.1 Game design patterns

Björk (2003) addresses the issue just mentioned by introducing a collection of Game design patterns. The patterns exemplify good practice to design good gameplay is more likely to that result in motivating, engaging and challenging games. The patterns can help us make design choices, analyse existing games or inspire new game ideas (Björk and Holopainen, 2004). Björk and Holopainen present ten categories of patterns to facilitate their use. The categories are Game design patterns for:

1. game elements,
2. resource management,
3. information, communication and presentation
4. actions and events,
5. narrative structures, predictability, and immersion,
6. social interaction,
7. goals, game design patterns for goal structures,
8. game sessions,
9. game mastery and balancing and
10. meta games, replayability, and learning curves.

Relevance for xDelia

Björk and Holopainen's approach can be of use to xDelia when analysing existing games to compare and understand how they are designed, for example to analyse different games for financial capability or social network based games. Game design patterns could also be of assistance when comparing different games since the game design patterns can also here be used as a foundation for the analysis. Together with the CRESST model (section 3.2.1.4) game design patterns can provide concrete inspiration to game concept design. It might also be interesting to try to map game design patterns to specific learning outcomes so that deliberate choices can be made when designing for a given learning outcome.

3.4.1.2 Six game attributes to promote motivation

Garris et al. (2002) describes six different game dimensions, e.g. fantasy, rules/goals, sensory stimuli, challenge, mystery and control, that is fed into the game cycle (see 3.2.2.2) and in the end contribute to the desired learning outcome. The selection of game dimensions is based on a literature review. Together with the instructional content the game characteristics influence the game cycle and the game cycle in itself promotes motivation when the instructional content is merged with the game characteristics in the game world.

- Fantasy is a characteristic that is easily associated with games as it can simulate things that do not exist outside the fictional game world. Fantasies let the player experience things different from her usual experiences, although positive and negative consequences are often felt in a similar way than in the outside world, but without the danger this carries for the integrity of the person. Endogenous fantasies that are intervened with the learning objectives are more motivating than when the fantasy world is separated from the learning objectives.
- The rules in a game concretize the goal. The goals in a game have been found to be one of the most important factors for good player performance (Garris et al., 2002). This resonates with similar findings in the real world, where an individuals behaviour intentions can be brought closer to realisation by adequate goal setting.
- Sensory stimuli appeal to the players’ senses and positive stimuli can transport the player into a positive mood.
- Challenge has been discussed above and is one of the most essential factors to promote motivation.
- Mystery is a motivating factor since curiosity is one of the driving factors of learning. Garris et al. (2002) differentiate between curiosity and mystery as curiosity is something inhabited within the player and mystery is an attribute of the game. Having said that, mystery invokes curiosity which makes mystery a good motivator.
- Control refers to the learner control over different elements in the game. More control leads to better flow and better motivation and better learning.

Relevance for xDelia

The six game attributes presented in this subsection could be used to guide the design process when creating game concepts within xDelia.
3.4.1.3 Biofeedback

One characteristic of flow is focused attention (Kiiil, 2005). According to Malone and Lepper (1987) attention can be gained by providing unusual sensory stimuli. In addition, the importance of feedback is also emphasised in several models presented in this section. An unusual feedback, which alternatively can be used as an input to the game, is biofeedback, which is something that will be explored within xDelia, both in terms of motivation, adaptation, and performance.

Put simply, biofeedback is feedback of physiological data that enable the individual to monitor and control physiological activity. The Association for Applied Psychophysiology and Biofeedback (AAPB), the Biofeedback Certification Institution of America (BCIA) and the International Society for Neurofeedback and Research (ISNR) have agreed on the following definition of biofeedback:

“Biofeedback is a process that enables an individual to learn how to change physiological activity for the purposes of improving health and performance. Precise instruments measure physiological activity such as brainwaves, heart function, breathing, muscle activity, and skin temperature. These instruments rapidly and accurately "feed back" information to the user. The presentation of this information — often in conjunction with changes in thinking, emotions, and behavior — supports desired physiological changes. Over time, these changes can endure without continued use of an instrument.” (AAPB, http://www.aapb.org/)

A literature search on ‘biofeedback’ at ISI Web of Science resulted in 4524 articles and the search showed that the greatest share of biofeedback articles was located in the field of psychology (42%). We found that only 0,4% articles discussed biofeedback in the context of education and 1% discussed it in conjunction with games. The plan is to explore the biofeedback state-of-art in the context of computer applications and games in much more detail in the second year of xDelia.

3.4.2 Learning and Game Characteristics

Section 3.4.1 discussed learning and game design from the view point of motivation. This section takes instead a game design and game play perspective to discuss learning and learning outcome.

3.4.2.1 Seven game characteristics to promote effective learning

Wilson et al. (2009) explore the game characteristics that influence the learning outcome. Different game attributes can be chosen to implement or incorporate the cognitive principles and these attributes will affect the learning outcome. Scholars and practitioners have suggested different subsets of game attributes that they believe are important for learning. Thus, Wilson et al. (2009) focus on

- fantasy – brings to mind images of objects or situations that do not exist in the real world,
- representation – accuracy of reproduction, that is, the extent to which game play and game features resemble the real world experience in terms of, say, psychological, physiological, or physical characteristics
- sensory stimuli – audio, visual or tactile effects,
- challenge – not to difficult and not to easy,
- mystery – gap between the known and the unknown,
- assessment – indicators of how to play the game, and
- control – the ability for players to control the environment.

Matching the game attributes with desired learning outcomes is challenging, but Wilson et al. (2009) have made an attempt to link the attributes and outcome. The authors provide indications of the
effects that different game attributes such as fantasy, mystery or challenge has on motivation. Or that representation and control may increase psychomotor skill learning.

Wilson et al. (2009) also point out that there is more research needed. For example there is a need to explore the true impact of the different game attributes. In the games the authors studied, they found a mix of different attributes, and it was not clear if it is the attributes in separation that have most impact on learning or if it is the combination of attributes that are more important. The authors also found it hard to determine whether the levels of game attributes (more or less of the attribute) affect the learning outcome. Another issue important to investigate is the relationship between tasks and game attributes. Specific game attributes may be better suited for specific tasks.

Relevance for xDelia

Wilson et al.’s approach differs from Garris et al.’s in that not only motivation but also the mapping between learning outcomes is problematised. The selection of game characteristics can be used in xDelia in the same ways as the ones presented by Garris et al., when for instance creating game concepts. It is also important to be aware of the fact that it isn’t quite clear whether the attributes themselves or a combination of different attributes lead to a specific outcome. Nevertheless it would be interesting to try to elucidate what combinations could be successful in different situations and for given learning outcomes.

3.4.2.2 Immersion to promote motivation

In the article “Good games and good learning” Gee (2005) talks about 16 different elements that a “good serious game” should consists of to promote learning. Although Gee’s focus lies mainly within the realm of children’s education and with the purpose of increasing the immersion of the game and thus the audience’s focus, many of his ideas are generalizable and thus applicable to other contexts of learning. Gee’s game characteristics are viewed from a game play experience perspective which differs from Wilson’s perspective, which can be seen as more game design focused.

The 16 characteristics are as follows:

1. **Identity**
   Good video games capture players through identity. That is, the player makes a commitment to see the world through the avatar’s eyes. Gee (2005) argues that no deep learning takes place unless the learner takes on a similar commitment.

2. **Interaction**
   Interaction might be one of the biggest differences between learning from games versus learning, say, from text books. In computer games, we have a back-and-forth communication path of learning where players obtain directed feedback from actions and decisions.

3. **Production**
   In computer games, players are producers as well as consumers, which provides for an additional means of control. In multiplayer games, people’s actions typically influence the game state for other players.

4. **Risk taking**
   Normally in school, students are allowed very little space for failure, trial and error and learning from mistakes. In computer games however, failure is often a great way to learn. A good game encourages risk taking and minimizes the consequences of failure so that players can explore different options before making assumptions about the best solution.

5. **Customization**
   A good computer game allows room for customization, to make it fit better with players’ individual play and learning styles. Most games have different difficulty levels and good games allow players to solve problems in different ways.
6. **Agency**

By allowing the player the amount of control and free choice in a way good computer games usual do, the player often gets a feeling of ownership and involvement on a much deeper level than is normal in classic learning scenarios.

7. **Well-ordered problems**

Good computer games have a well structured set of problems to solve. Early in the game, players are typically faced with relatively easy problems which allow them to form hypotheses that can then be used to solve more difficult problems later on.

8. **Challenge and consolidation**

Challenge is often what drives us to become better. Good games offer challenges for the player which must then be solved several times until almost a state of routine is acquired. Then the game offers a new challenge which forces the player to adapt and learn new methods which is then integrated with the possibly automated abilities acquired earlier on.

9. **“Just in time” and “On demand”**

In good games the player gets the necessary information “just in time” of when he or she needs it. Secondly, in interactive media such as games, information is also available “on demand”, that is when the player needs it.

10. **Situated meanings**

Gee (2005) points out that people really only learn new things when they can be related to an experience. Games situate the meaning of words and terms of the action, image and dialogues they relate to in a particular context and hence make it much easier for individuals to learn them.

11. **Pleasantly frustrating**

Good games stay within, but at the outer range of a player’s “regime of competence”. This means that the challenges a player is presented with are hard but nevertheless feel doable. This is, according to Gee (2005) a highly motivating state for learners.

12. **System thinking**

In games, players must often think in several steps ahead of the current state. A choice now might greatly affect the outcome of events to come. Choices made in the game may not only affect the player herself or himself but might also affect players around her or him.

13. **Explore, Think laterally, Rethink goals**

Games often allow and even encourage lateral thinking. Going towards the main goal as fast as possible may not always be the best solution. Instead it might be better to explore different possibilities and rethink their goals from time to time.

14. **Smart tools and distributed knowledge**

Many of the characters the player controls in different games possess specific knowledge that the player doesn’t always have himself. Formations between military squads are often automated and it then becomes the player’s responsibility to decide when and where to attack. The knowledge it takes to play the game is thus distributed between the player and the virtual characters.

15. **Cross-functional teams**

In most modern multiplayer games the roles in which different players partake often vary substantially. In order to overcome most challenges however, the players are forced to work together in teams where their goal is very similar, namely to overcome the given obstacle. To be able to work well together and coordinate the team, the players must have a basic knowledge of each other’s abilities and skills. This is called cross-functional understanding and is something that is widely promoted in workplaces nowadays.

16. **Performance over competence**

Good games encourage performance before competence, meaning that they do not force you to obtain a qualification before you can participate in an activity. By creating games which help and support new players, people are able to use the game successfully without having to do a lot of study beforehand. By easing players into the game, and gradually increasing difficulty and complexity, players can enjoy the game instantly without having to be an expert at the outset.
Relevance for xDelia

The list of attributes in good games can act as a checklist in xDelia when evaluating the game design before and after the game testing. This can be done to, from a learner’s perspective, try to ensure the game has potential to succeed.

3.4.2.3 Game object model II

Amory (2007) presents a game object model intended to be of assistance when creating educational games. Amory also claims that the model may be of use when evaluating video games in educational situations. This theoretical framework analyzes the development of games with regard to several different aspects: authentic learning, narrative, gender, social collaboration and challenge-puzzles-quests. These subcategories are then further divided into different sections, namely theoretical constructs and arguments, and core concepts derived from the theoretical discussions that are used to develop the game object model.

In his framework, Amory uses metaphors from software engineering like encapsulation, inheritance and polymorphism and thus uses terms like abstract and concrete interfaces. He also talks about spaces such as ‘Problem space’ and ‘Visualization space’, where different game objects (elements) are placed so that their coherence can be explained and visualized. ‘Spaces’ can also contain other spaces; sub spaces, which contain correlated game objects.

In the ‘Visualization space’, for example, lays the ‘Elements space’ and the ‘Problem space’. The ‘Problem space’ contains objects like challenges, communication, motor etc. In Game object model version 2, Amory also includes the Social space where computer mediated communication and social network analysis is placed to better represent game objects such as dialogue, social capital and democracy.

Relevance for xDelia

By using the categories presented in Amory’s framework, xDelia can evaluate games in regards to learning from very different aspects. It is also possible to use it as a checklist for each evaluated game to find important elements for learning.

3.4.3 Cognitive Perspectives on Game Play

The two approaches presented in this section differ in some ways from the approaches discussed previously in that they take a somewhat more direct cognitive perspective on gameplay and game design.

3.4.3.1 Cognitive principles

Greitzer et al. (2007) state that there exists a relationship between active or passive learning and engagement. The learner achieves better results if he or she can take active part in the learning activity. To realise an active learning environment there are some cognitive principles that should be followed. According to Greitzer and colleagues, five cognitive principles ought to guide active instructional design such as serious game design:

- Stimulate semantic knowledge. The materials should connect to the learner’s existing knowledge in order to facilitate learning and help remembering.
- Manage the learner’s **cognitive load**. Start out with small, simple organized chunks with information and then use them to build up the complex scene, which are going to be learned.
- **Immersive problem solving** activities. The learner should get opportunities to work with realistic tasks. The tasks should also meaningful and it should be possible to do them directly.
- Emphasize **interactive experiences**. Create an experience that forces the learner to manipulate objects and explore the relationships between them to create a deeper understanding.
- Engage the learner. Make sure that the learner doesn’t have a too easy or too hard experience to keep motivation and rewards balanced.

**Relevance for xDelia**

Greizer et al. (2007) use the cognitive principles as guidelines when designing active e-learning activities. In xDelia we could use them in the same way, that is, as guidelines when we create the learning environment or the game concept.

### 3.4.3.2 Game play schemas

Lindley and Sennersten (2006) state that the relationship between the game designer’s intention, the player’s experience and the mechanisms learned by players to assist the play are not comprehensively studied. This relationship gets even more essential in terms of game-based learning since serious games are designed with the intention of gaining a specific learning outcome. Lindley and Sennersten propose that an explanation of the relationships can be obtained by the cognitive schemas underlying gameplay, referred to as game play schemas. Schemas are structures that connect factual and procedural knowledge with cognitive resources into patterns. These patterns assist when making decisions of what actions to take in a specific context. Or in other words “… game play schema can be understood as a cognitive structure for orchestrating the various cognitive resources required to generate motor outputs of game play in response to the ongoing perception of an unfolding game” (Lindley and Sennersten, 2006, p.6). Individuals play according to game play schemas and designers also design according to schemas, but in the cognitive systems of the designer. Lindley and Sennersten state that shared schemas between designers and players can make game design more effective. The authors also suggest that a schema-based theory can be developed from observations of gameplay schemas and schemas of learning processes. The theory could then be used as a base for developing game play design principles.

**Relevance for xDelia**

This is in line with one of the tasks in xDelia (Task T4.3). In this task we must develop a cognitive framework for gameplay in serious games.

### 3.4.4 Target Groups

There exist substantial differences in game design depending on the field of application. Designing learning games for small children versus flight simulation games for military pilots does of course involve many different aspects. It is therefore crucial that the game designer is aware of possible individual difference criteria in any design.

Steiner (2009) points out that there is evidence on gender differences in computer games that are important to be known and understood when aiming in advancing them as a novel approach to learning that is likewise suitable for both groups of learners. While the number of computer game
players increases rapidly across the world, the majority of the players are still male (Ivory, 2006). Male players also generally play for longer periods of time than females (Bonanno, 2005).

So how do we design games with respect to different interests between genders? Steiner (2009) shows that there are several reasons why there is still a big gender gap in playing computer games. These are factors like violence, lack of social interaction and strong competitive elements in most games today. Gneezy et al. (2003) state that males in general are much more competitive and have a higher “need for achievement” than females normally do. These terms can be related to challenge. In contrast to most male players, female players instead prefer elements of social interaction, communication and human relationships. While the male crowd generally prefers violent action games, female gamers enjoy puzzle games, board games, role-playing and also educational games. Steiner (2009) shows that there are a few game types that overlap more across genders than others. These are adventure games, strategy and role-playing games.

Relevance for xDelia

It is our intention to search for such factors among all relevant target groups, not just gender-related, in order to create the best and most suitable games for each target group. In Work package 4 it is important to take target groups into account since we create games for both genders and most students on campus are male which leads to that the participants in different tests, evaluations and experiments are likely to be male and this needs to be controlled for.

3.5 Transfer

Decades of research show that even though people might learn specific knowledge or skills that allow them to pass a test, this is no guarantee that they can actually apply the knowledge or skills in the real world (Gee, 2005). The issue of transfer is important here. Transfer refers to the effective application of knowledge and skills acquired during training in the target environment, typically outside the game world. Transfer can be positive, negative or null. Positive transfer is when the skills learned in the game are contributing to the actual task, and negative transfer is when the skills learned are not only not effective in the target environment, but actually lower the performance.

Garris et al. (2002) claim that ‘debriefing’ is a major contributor to successful transfer of learning. Debriefing supports or ensures that game experience obtains a certain salience in the real world. Debriefing can consist of describing the game event, analysing what happened and discussing mistakes committed and how the situation could have been handled better. Garris et al. (2001) also emphasize the importance of adequate learner support, which is essential in experimental learning.

Debriefing is a strategy that might be considered in xDelia, especially in web based social games. There is a raft of other strategies that could increase the likelihood of transfer such as linking games explicitly to aspects of the player’s life and real world environment.

Alexander et al. (2005) suggest that there are four major factors in serious games that influence transfer: fidelity, immersion, presence and acceptance.

- **Fidelity** can be divided into several subcategories.
  - Physical fidelity refers to the extent that the virtual world mimics the physical experiences of the real world, e.g. the five senses. This is in line with the encoding specificity principle (Tulving, 1983) that states it should be easier to acquire transfer the more the two situations remind of each other. That is; the more alike the situations are, the more will be remembered.
  - Functional fidelity is whether the simulation works and responds in the same way as the real thing does. An example of this is a study where military trainees were to play
World of Warcraft with each other, but with the instruction to use appropriate military commands when communicating, which had a positive impact on their learning (Weil et al., 2005). A related view is offered by Lehman, Lempert and Nisbett (1988), they conclude that it is possible to transfer from formal training to every-day problems as long as the underlying structure are the same. They show this through graduate training in medicine, psychology, chemistry and law on problems such as statistical reasoning, methodological reasoning, confounding variables and conditional reasoning. For example medical and psychology training had effects on statistical and methodological reasoning while chemistry had no effect on any of the studied reasoning types.

- **Psychological fidelity** is to what extent the user is in the same state of mind (stressed, relaxed, angry etc.) as when doing the real task.

- **Immersion** - Immersion is to what degree the user feels absorbed by or engrossed in a particular experience. Many activities are immersive such as reading a book, having a conversation or playing a game of monopoly, and, of course, computer based games. There are factors inducing immersion such as level of control, ease of interaction, action-response timing and more. Immersion is measured over multiple continuous dimensions and are based on what extent the technology supports (Slater & Wilbur, 1997):
  - inclusive (the extent of the physical reality is shut out),
  - extensive (the range of sensory modalities accommodated),
  - surrounding (the size of the field of view, surround sound etc.) and
  - vivid (the resolution, richness and quality).

- **Presence** - Heeter (1992) has proposed three types of presence (sometimes referred to as situated immersion) in simulated environments:
  - **Environmental presence** is determined by how much the environment is affected by the users existence and actions in it.
  - **Social presence** assumes an interactive multi-player environment; greater interaction and presence of others will lead to higher engagement of the individual with the game and the group. Social presence research indicates increases in the number of avatars interacting (through communication, acknowledgement of presence) within a virtual environment leads to corresponding increases in rated presence (Heeter, 1992). A study of an online gaming community known as Norrath, where social roles are defined through communication with other avatars and social relationships greatly help or hinder progress within the virtual world, found that 20% of users report a feeling of “living in” Norrath (Castronova, 2001).
  - **Personal presence** is the most global type of presence in that it describes the extent of, and the reasons for, a person’s feeling like he or she is “in” a virtual environment.

- **Acceptance** - Acceptance, what psychologists would refer to as face validity, is the amount of acceptance from the user. High acceptance occurs when the tasks that are assigned seems relevant to the users normal work, or whether the user finds it amusing to do it. This is the one of the constructs that seems to affect the training in a (linear) positive way, deliberate practice (Ericsson et al., 1993) can occur with high acceptance.

The four presented factors involve both game media, logical game system, gameplay (Figure 3.1) and learning outcome. Fidelity is directly related to game media and logical game system since fidelity is to which extent the virtual world emulates the real world, physical fidelity is taken care of by the game media and functional fidelity is a part of the logical game system. Immersion and presence is how the player experiences the gameplay here and now. The difference between immersion and presence is that immersion refers to the game in an objective manner, while presence is the subjective experience of actually existing in the virtual world, rather than in the physical one that the person really is in.

Acceptance is of cause also something that comes out of gameplay, but acceptance is a attitude created by the game and can therefore be classified as learning outcome. The relationship between acceptance and perceived usefulness, enjoyment, ease of use and intention to use is a complex one.
There are positive correlations between ease of use and usefulness and enjoyment, but a negative correlation between ease of use and intention to use. At the same time there are positive correlations between usefulness, enjoyment and intention to use (Chesney, 2006).

**Relevance for xDelia**

Depending on the type of games we develop in xDelia, acceptance is important. For example if we make a gadget to give biofeedback of traders emotions in work package 2 acceptance is of major importance as the traders must be motivated to use the devices. The other factors that facilitate transfer have of course also to be considered. The factors should be dealt with both when creating game concept and in the implementation phase (e.g. fidelity). The factors need to be made more salient for the particular uses that we want to put the games to (learning, diagnostics, experiments).

### 3.6 Evaluation

#### 3.6.1 Overview

Although the evaluation of serious games has received much closer attention recently, there have been very few attempts to assess the impact of, say, existing financial capability games on skill development and behaviour change. There exist a broad range of evaluation approaches used to assess the usability and playability of entertainment games – e.g. heuristics and expert evaluations, physiological evaluations, etc. – most of which can be applied to serious games to assess for instance the entertainment dimension. The purpose of the play element in serious games is to secure the intrinsic motivation people typically feel when they engage with entertainment games. In a similar vein, several authors (e.g. Gee, 2003; Malone, 1980; Prensky, 2001) maintain that game-based learning can be more enjoyable, more interesting, and, thus, more effective than traditional learning modes. In serious games, where specific learning or training outcomes are sought, we need to go beyond ‘merely’ assessing the entertainment-specific emotional potential of gameplay.

Serious games have a set of characteristics that differentiate them from entertainment games, and hence not only design but also evaluation activities have to tap into a distinct set of strategies. While the challenge in entertainment games is broadly to ascertain the extent of immersion into game play, player fun, and game challenge in a fantasy world, serious games target people’s knowledge, skills, behaviours, or attitudes and hence pose additional needs in terms of evaluation targets and methods. Learning outcomes as well as knowledge and skill transfer into real world contexts are of secondary nature in entertainment games, but are central in the context of serious games. And this aspect of evaluating serious games is not so different from evaluating, say, consumer finance education or a smoking cessation therapy, although game specific factors such as motivation or balance between fun and learning pose additional challenges to the evaluation task.

Clearly, specific approaches to evaluation depend very much on the domain of practice and the target of a particular learning intervention. A game to teach specific mathematical concepts requires a different evaluation strategy than a behaviour modification game targeting sedentary lifestyle. While in the former case knowledge and understanding of the concept can be tested using a quiz or an exercise, evaluating a behaviour modification game needs to go beyond knowledge testing and determine to what extent and under what conditions the game has caused change in behaviour, and whether the new behaviour in fact transfers to a real world context. In the context of, say, financial education or of health promotion and prevention, policy makers and educators need to have some assurance that learning interventions are capable of bringing about a change in attitudes or behaviours that has a lasting effect. As it turns out, a key issue that financial capability is grappling...
with today is just this, that educational initiatives seem to have only a limited effect on consumer saving, spending or credit behaviour.

Frameworks that have been put forward to evaluate serious games are often located on a higher level of abstraction. This is because most are based on general concerns around learning. Only recently have there been efforts to develop such frameworks specifically for serious games. Since serious games as a field of inquiry is still in its infancy, it is hardly surprising that the literature on concrete empirical evaluation methods is rather sparse. There are however exceptions, and the next sections discuss some of them. Several empirical studies that evaluate the impact of the use of electronic games within disciplines such as mathematics, science, language, geography, and computer science, have shown positive outcomes in terms of student motivation and learning effectiveness in relation to curricular objectives (e.g. Klawe, 1999; Papastergiou, 2009; Rosas et al., 2003; Virvou, Katsionis, & Manos, 2005). This is some indication that electronic games could be used within the framework of HE and PE programs to improve the health and physical status of young people. However, this assertion needs to be further supported by relevant theory, application experiences and, above all, by empirical evidence.

While on a more concrete level, the game literature provides us with some guidance of how to evaluate motivation, fun, or interactivity, the dependence of important aspects of serious games on the actual domain of application has it that much less concrete advice is available on how to evaluate, say, games that aim at improving self-regulatory strategies, reducing procrastination, or changing maladaptive behaviour. To fill this gap in the serious games evaluation literature, we propose to also look at existing empirical studies and evaluation methods in health promotion and prevention and, more broadly, in the behavioural sciences for guidance and inspiration.

The following sections provide an overview of the broad evaluation approaches proposed by the game literature and also several approaches that are widely used in other fields, and in particular in health promotion and prevention, and in the behavioural sciences. Selected literature for each of the evaluation approaches and the target of the evaluations are discussed.

### 3.6.2 Evaluation of Serious Games

#### 3.6.2.1 The Connolly framework

Connolly et al. (2009) discusses a framework for framing the different aspects of game-based learning that are to be assessed for evaluation when looking at effective game-based learning. These categories are: learner performance, learner/instructor preferences, learner/instructor perceptions, game environment, learner/instructor motivation, learner/instructor attitudes, and collaboration (which is an optional category depending on the game).

*Learner performance* considers what the player actually learns; it could be declarative knowledge, metacognitive strategies, improvement in the formation of skills etc. Learner does not necessarily have to be a learner in an academic setting but really in any setting at all.

*Learner/instructor motivation* is primarily concerned with the motivations of the learner for using the intervention, participating over a period of time, what is interesting in the game. Is it from free will the learner participates? Are there distractors? Also the instructor’s (if there is one) motivations have to be evaluated since this can affect the learner’s performance.

*A Learner/instructor perception encompasses* the fidelity of the game and how the player perceives it, with respects such as time in the game, how holistic it is when it represents something (NPC,
organisations, physics etc.). Regarding on how much involvement the instructor has in choosing the material for the game this could be more or less important for him/her since if very much engaged more fine tuning with the context can occur.

**Learner/instructor attitudes** is concerned with the learner and instructor’s attitudes towards various elements that may alter the effectiveness of the game intervention. Elements that are included, but not exclusive, are learner attitudes about the subject, learner attitudes towards games, instructor attitude towards using games, learner preferences regarding game elements such as interface, sounds, feedback.

**Learner/instructor preferences** consider the preferences for learning styles, material used, game features, competitive modes etc.

**Collaboration** looks at the interaction between the participants; comments, log files, achievements of common goals, but it may also be that collaboration does not require any evaluation.

**Game environment** is a vast and complex category. It consists of everything that potentially could be analyzed about the game environment and have the sub-categories virtual environment, scaffolding, usability, level of social presence and deployment. The virtual environment could be things such as the virtual agents expressiveness, general game difficulty, characters, background etc. Scaffolding is the advice, tips, hints and resources within the game that supports learning. It can be evaluated through looking at the feedback to the player, the learner's understanding of the advice, and utilisation of the resources. Usability is evaluated with the help of conversation analysis, correlation of the learner demographics to the susceptibility of that is to be overcome by the game intervention. Initial and long term playing can be analysed in order to see what is mastered and what is hard to understand. Social presence is analysed by looking at how the player reacts to characters in the game (attitude, mood statements, politeness). Deployment is which method of presenting and using the game would be most effective in order to fit into the learning and the context of use.

**Relevance for xDelia**

This can be used in xDELIA as a framework for what is to be assessed when looking at the games, but not how it should be done, although Connolly et al. refer to some examples of how studies have been carried out. A criticism against this framework is that the categories are not distinct from each other but rather one item could be in two or more of the categories. There is also no way of covering all aspects of Connolly et al.’s framework since they themselves have no clear definition of the categories but only exemplars of things that could be in a category.

### 3.6.2.2 De Freitas & Oliver

De Freitas & Oliver (2006) suggest a framework with four dimensions specifically for evaluating games. This framework is intended as a touchstone rather than to be a compulsory method for working.

The first dimension, the context, focuses on the surrounding factors. It can be on micro-level such as what kind of computer and Internet access is available but also at macro-level such as the political situation, historical factors.

The second dimension, the learner or learner group, focuses on the specific learner; it can be age, previous experience, and preferences for learning styles.

The third dimension is the diégèse, or internal representation of the game. That is the interaction, levels of fidelity and immersion, and mode of presentation.
The fourth dimension is the *processes of learning*. It promotes the reflection of the practitioner upon methods, tools, theories, and frameworks.

The framework also comes with a checklist (Table 3.1) when choosing which game to use.

<table>
<thead>
<tr>
<th>1: Context</th>
<th>2: Learner specification</th>
<th>3: Pedagogic considerations</th>
<th>4: Mode of representation (tools for use)</th>
</tr>
</thead>
<tbody>
<tr>
<td>What is the context for learning? (e.g.: school, university, home, a</td>
<td>Who is the learner?</td>
<td>Which pedagogic models and approaches are being used?</td>
<td>Which software tools or content would best support the learning</td>
</tr>
<tr>
<td>combination of several)</td>
<td>What is their background and learning history?</td>
<td>Which pedagogic models and approaches might be the most effective</td>
<td>activities?</td>
</tr>
<tr>
<td>Does the context affect learning? (e.g.: level of resources, accessibility,</td>
<td>What are the learning styles/preferences?</td>
<td>What are the curricula objectives? (list them)</td>
<td>What level of fidelity needs to be used to support learning</td>
</tr>
<tr>
<td>technical support)</td>
<td>Who is the learner group?</td>
<td>What are the learning outcomes?</td>
<td>activities and outcomes?</td>
</tr>
<tr>
<td>How can links be made between context and practice?</td>
<td>How can the learner or learner group be best supported?</td>
<td>How are the learning activities?</td>
<td>What level of immersion is needed to support learning outcomes?</td>
</tr>
<tr>
<td></td>
<td>In what ways are the groups working together (e.g.: singly,</td>
<td>How can the learning activities and outcomes be achieved through</td>
<td>How level of realism is needed to achieve learning objectives?</td>
</tr>
<tr>
<td></td>
<td>partially in groups) and what collaborative approaches could</td>
<td>existing games or simulations?</td>
<td>How can links be made between the world of the game/simulation</td>
</tr>
<tr>
<td></td>
<td>support this?</td>
<td></td>
<td>and reflection upon learning?</td>
</tr>
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<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

*Table 3.1 - Checklist for de Freitas & Oliver's (2006) framework for evaluating games*

Relevance for xDelia

This framework was intended for helping instructors choosing games that support learning. However it can just as easily be used in xDelia when designing games. One problem as it seems is that de Freitas & Oliver (2006) take the standpoint of single-loop learning instead of double-loop learning (Argyris & Schön, 1974). In other words, they try to fit the games into an already defined situation without changing any governing variables. This would mean that they could find a game that fits into the current situation nicely, but they will not look at a situation from a new point of view (the game point of view). In xDelia we will introduce games into new situations where there currently does not exist good teaching forms and from that point of view this framework seems like a step backwards.
3.6.2.3  Kirkpatrick (1996)

Kirkpatrick’s four levels of evaluation:

- **Reaction**: How the participants react to the training, their emotions regarding it, but also about the instructor (game), the setting etc.
- **Learning**: Measures what knowledge has been acquired, attitude change, tacit knowledge gained.
- **Behavior**: Transfer of training, to what degree the things learned during the training programme is used in a real situation later.
- **Result**: To what degree the wanted outcome for the company are achieved, higher sales, lower turnover etc.

**Relevance for xDelia**

Kirkpatrick’s four levels are widely used in organizations but also by game evaluators (de Freitas 2009). In xDelia it is possible to use this framework but since the project specifies that it will try to achieve behavioural changes in people we already know where to focus in this framework (although the result section is important as well, when interpreted as total impact of the person’s economy).

3.6.2.4  O’Neil et al. (2005)

O’Neil et al. (2005) compared Kirkpatrick’s four level model and the CRESST (see more under learning) model for evaluating learning outcomes. They found a method for classifying material (19 articles) into both of the models and also augmented the CRESST model with affective learning. They drew the conclusion that both models are good for showing improvements with respect to games-based learning. In Kirkpatrick’s model five studies reviewed Level 1 (reaction) and Level 2 (learning), eleven studies were conducted only in Level 2 and two searched for changes in Level 3 (behavioural change), only one study were conducted on Level 4 (results).

When the studies were analyzed with respect to the CRESST model 16 of the studies measured problem solving, seven tested for content understanding, and one measured communication. None of the studies measured self-regulation.

**Relevance for xDelia**

For xDelia’s part this means that these two complementary frameworks can be used in order to capture different aspects of learning and can also provide a clear focus in evaluation and work methods. E.g. if we want people to stop using credit cards when they are not sure of how much money they have on the bank, then the focus is on behavioural change (Kirkpatrick Level 3) and the CRESST model requires a focus on how it should be achieved, say through training on motivation.

3.6.2.5  Kraiger et al. (1993)

Kraiger et al. (1993) suggested a framework for learning and evaluation (see more details under learning). The context is omitted from Kraiger et al. and instead more precise constructs within the person are discussed. However, this does not mean that the context is unimportant, Kraiger et al. (1993) is just taking the approach to look from within the learner and not from outside and the context she finds herself in. Kraiger et al. think that there are two good arguments for having a constructor-based approach to learning. The first one is that the researcher (and/or instructor) to state clearly what the learning outcomes may be and which ones that are preferable. The other argument is that validation of the training methods can potentially be assessed.
A classification scheme of the different categories, learning constructs, focus of measurements and also potential training evaluation methods (Table 3.2).

<table>
<thead>
<tr>
<th>Category</th>
<th>Learning construct(s)</th>
<th>Focus of measurement</th>
<th>Potential training evaluation methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cognitive outcomes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Verbal knowledge</td>
<td>Declarative knowledge</td>
<td>Amount of knowledge</td>
<td>Recognition and recall tests</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Accuracy of recall</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Speed, accessibility of knowledge</td>
<td>Power tests</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Speed tests</td>
</tr>
<tr>
<td>Knowledge organization</td>
<td>Mental models</td>
<td>Similarity to ideal elements</td>
<td>Free sorts</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Interrelationships of elements</td>
<td>Structural assessment (e.g. Pathfinder)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hierarchical ordering</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Self-insight</td>
<td>Self-awareness</td>
<td>Probed protocol analysis</td>
</tr>
<tr>
<td></td>
<td>Metacognitive skills</td>
<td>Self-regulation</td>
<td>Self-report</td>
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<td></td>
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<td></td>
<td>Readiness for testing</td>
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<tr>
<td>Skill-based outcomes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Compilation</td>
<td>Composition</td>
<td>Speed of performance</td>
<td>Targeted behavioral observation</td>
</tr>
<tr>
<td></td>
<td>Proceduralization</td>
<td>Fluidity of performance</td>
<td>Hands-on testing</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Error rates</td>
<td>Structured situational interviews</td>
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<tr>
<td></td>
<td></td>
<td>Chinking</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Generalization</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Discrimination</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hierarchical ordering</td>
<td></td>
</tr>
<tr>
<td>Automaticity</td>
<td>Automatic processing</td>
<td>Attentional requirements</td>
<td>Secondary task performance</td>
</tr>
<tr>
<td></td>
<td>Tuning</td>
<td>Available cognitive resources</td>
<td>Interference problems</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Embedded measurement</td>
</tr>
<tr>
<td>Attitudinal</td>
<td>Targeted object (e.g.</td>
<td>Attitude direction</td>
<td>Self-report measures</td>
</tr>
<tr>
<td></td>
<td>safety awareness)</td>
<td>Attitude strength</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Attitude strength</td>
<td>Accessibility</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Centrality</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Conviction</td>
<td></td>
</tr>
<tr>
<td>Motivation</td>
<td>Motivational disposition</td>
<td>Mastery versus performance orientation</td>
<td>Self-report measures</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Appropriateness of orientation</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Perceived performance capability</td>
<td></td>
</tr>
<tr>
<td>Self-efficacy</td>
<td></td>
<td></td>
<td>Self-report measures</td>
</tr>
<tr>
<td>Goal setting</td>
<td>Level of goals</td>
<td>Level of goals</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Complexity of goal structures</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Goal commitment</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 3.2 - A classification scheme for learning outcomes for training evaluation (from Kraiger et al. 1993)

The model by Kraiger et al. (1993) has been used by Wilson et al. (2009) in an extensive meta-analysis in order to study the relationship between game attributes (see game design) and learning outcomes.
They chose the Kraiger et al. (1993) framework because of the fact that it is constructor-based, multi-dimensional. It also guides the methods and measurements of the evaluation criteria and because it is based on education, cognitive, social, and human factors research. They also state several interesting research questions, each related to different categories of learning in Kraiger’s model.

Relevance for xDelia

With relation to xDelia this model by Kraiger et al. (1993) seems like a good choice, especially when augmented with the research questions and game attributes found in Wilson et al. (2009). It is also well established (484 citations) and guides the process by requiring defining up learning outcomes before any game design is started, whereas the other models does not require input at this specific level. It also makes it easier to look at other people material and methods for comparing and producing ideas.

The work by Wouters et al. (2009) much resembles the work by Kraiger et al. (1993). It extends it and adds a category called communicative (see learning for details).

As stated previously the categories most interesting for xDelia are cognitive and affective learning, but the new division of cognitive outcomes is however interesting. That said, the work by Kraiger et al. (1993) consists of prescriptive measures for the categories while Wouters et al.’s (2009) model is more a descriptive one (although Kraiger’s work can of course be used in this one as well).

3.6.3 Evaluation of Impact in Health Promotion and Prevention

Studying the health and psychological literature on evaluation has three benefits for our project. First, and most directly related to evaluation itself, existing studies can serve as a blueprint for our own evaluation activities. For example, studying experimental designs as espoused in clinical trials is a valuable source for useful hints and indications as to a better study design for our own game evaluations. Another example is theory-based, expert evaluation that draws on established behaviour and behaviour change models to assess the extent to which, say, a behaviour modification game incorporates elements of, say, the health belief model or the Bandura’s social cognitive theory. To summarise, the evaluation-oriented health and psychological literature offers guidance on how to evaluate learning or behavioural outcomes of serious games. Second, evaluation sometimes targets unusual aspects of an intervention or does so in an unusual way. For instance, rather than assessing the effectiveness of an exercising game by actually observing study participants’ physical activity habits in a longitudinal study, changes in antecedents such as self-efficacy or perceived barriers to exercising can be surveyed using standard scales and linked to behaviour intention via the health behaviour model. This is a useful approach when observing whether the outcome one is interested in is costly or to what extent participants’ self-report of the outcome might be biased. Also, an empirically validated theory that supports the causal links between antecedents and outcome needs to be available. Third, evaluations can point to features of interventions that can be translated, via analogy, to our own interventions. Articles that describe evaluations of learning technology often also contain lessons learnt that can be usefully applied to our own learning and game design.

From a broad reading of the literature on evaluating health interventions which covered around 50 articles, a number of different evaluation approaches that are of interest for us here can be distinguished. Experimental and quasi-experimental evaluations typically investigate the effects of a learning intervention by comparing two or more participant groups with differing manipulated variables. In field trial type studies, population samples are 'naturally' (ie not induced by experimenter) exposed to particular conditions (e.g. players of a popular game such as the Sims or Sim City) the effect of which we would like to study in comparison to a control group. Meta-analyses are a useful tool to synthesise the results of various individual studies - often randomised controlled trials - and are widely used in the health sciences. Theory-driven evaluations draw on existing...
theoretical knowledge or widely accepted hypotheses of mechanisms or other links between explanatory variables and observed outcomes to assess an intervention a priori, based on the use of theoretical constructs in the content or interaction design, or to indirectly assess the outcome of interest by the variables linked to it via the theory. Psychophysiological evaluations of emotional dimensions of games such as fun and challenge have been developed as an alternative or complement to self-report studies and can be used for serious games. Sometimes evaluations require a consultation with experts to develop evaluation measures that are appropriate for the domain at which learning is targeted. Subjective ad hoc evaluations by players or learners are probably the most common and often also the least satisfactory mode of evaluating learning technologies, and we will not further consider this literature. Instead we will go into specific models that by guiding evaluation also guide implementation of the games and help specify what the learning outcome shall be. Experts in the respective fields are needed for specifying what is to be learned, and also how it can be measured on a very concrete level.


\[ health evaluation approaches \]

Many of the evaluation approaches used in the health sciences are standardised and form part of the study curriculum of psychologists, epidemiologists, and public health specialists, to name just a few. However, game developers and computer scientists are less likely to be familiar with experimental or field studies, we will very briefly summarise here some of the key concepts and comment on the possible use of each of the approaches for the project. In the following sections we discuss the a number of evaluation approaches of health education and behaviour change: meta-analyses, experiments and quasi-experiments, theory-driven evaluation, and psychophysiological evaluation. We also make some suggestions as to how these approaches can help us in the evaluation of xDelia interventions.

3.6.3.1 Meta-analyses

What is a Meta-Analysis?

A meta-analysis examines, combines, and synthesises results from individual studies using statistical methods and other systematic techniques. The individual studies typically share a common topic or set of hypotheses and the meta-analysis tries to establish common outcome measures and possible relationships between the features of the studies and the findings (Bangert-Drowns and Rudner, 1991). In fields such as health or education where empirical studies on the same subject often abound, meta-analyses aim to account for differences in outcomes between the studies and to avoid systematic reviewer bias in less rigorous reviews or informal literature surveys. Hence, meta-analysis is a primary research approach, not unlike statistical analysis of numerical data sets.

What Can We Learn from Meta-Analyses for xDelia?

Meta-analysis as a method is less relevant for xDelia than the other approaches discussed here, mainly because there are not sufficient - or none at all - studies on game-supported learning interventions in the domains of application that we are concerned with here. (i.e. financial decision making). Rather, meta-analyses are a valuable source (1) of pointers to actual evaluation studies and (2) of assessments of evaluation findings in fields that bear some resemblance to our own interests. The meta-analysis on biofeedback for hypertension by Yucha and colleagues (2001) for instance provides us with combined evidence from a large pool of studies of the effectiveness of different types of feedback. The meta-analysis of video games for lifestyle behaviour change by Baranowski et al. (2008) points us to a set of video games that have been evaluated in 27 studies along a diverse range of outcome measures, including behaviour, physiological characteristics, or plain knowledge. Future work in this area could elaborate a set of criteria that would allow us to more systematically identify meta-studies for subsequent review and extract the most relevant research studies and findings from them for our project.
Examples of Meta-Analysis in Health Promotion and Prevention

Numerous meta-analytic studies exist that report on the effectiveness of technology-supported health promotion and prevention measures, and that are potentially of interest for the project. A few meta-analytic studies have looked at whether biofeedback might be effective as part of therapeutic interventions for some health-related problems (Nestorici and Martin, 2007; Yucha et al., 2001). Yucha and colleagues reviewed 88 articles of randomised clinical trials on techniques to reduce hypertension using biofeedback. The meta-analysis found that biofeedback resulted in significant reduction in blood pressure compared to alternative and to no treatment and suggests that biofeedback be considered as an additional therapeutic technique in individuals that suffer from hypertension. A number of meta-analyses have studied the effectiveness of technology support in self-help and self-care interventions (den Boer et al., 2004; Gellatly et al., 2007; Stefano et al., 2006; van't Hof et al., 2009). Wantland et al. (2004) analysed 22 studies with a total of 11,754 participants on the effect of web-based interventions on individual knowledge and behaviour change in a broad range of health domains including chronic illness, nutrition, physical activity and so forth. The authors found substantial evidence that web-based compared non-web based interventions leads to positive outcomes such as increased exercising, increased knowledge of health relevant topics, and more. Nine randomised controlled studies of a total of 2686 articles were included in a meta-analysis of self-help interventions for binge eating and bulimia nervosa (Stefano et al., 2006). Although the authors found support for self-help interventions compared to waiting list and cognitive behaviour therapy, the authors caution that the small number of studies included in the analysis is a limitation and that it is not clear exactly which elements of self-help contribute most to the effectiveness of this type of intervention. Further meta-analyses have looked at whether video games can promote and bring about positive health behaviours (Baranowski et al., 2008), the effectiveness of school-based cognitive behavioural therapy (CBT) for depression in youngsters (Kavanagh et al., 2009), whether problem drinking can be reduced by giving personalised feedback in single session interventions without professional support (Riper, 2009), what the features of an effective eating disorder prevention programme are (Stice and Shaw, 2004; Stice, 2007; Langmesser and Verscheure, 2009), whether communication tools are effective for remote delivery of therapist-guided psychotherapy (Penny et al., 2008), whether computer treatment, including computer-delivered CBT, of depression and anxiety is effective (Cavanagh and Shapiro, 2004; Spek et al., 2007; Reger and Gahm, 2009), whether CBT is effective in reducing problem gambling behaviour (Gooding and Tarrier, 2009), whether adjusting interventions to the cultural idiosyncrasies is a promising strategy (Griner and Smith, 2006), and how effective third-wave behavioural therapies such as mindfulness-based CBT are (Ost, 2008).

3.6.3.2 Experiments and quasi-experiments

What is an Experimental Study and What Types are There?

An experiment is an approach or paradigm that allows us to systematically investigate a scientific hypothesis or, more specifically, a causal relationship or mechanism and is conducted either under controlled or under naturally occurring conditions, in a laboratory or in the field. Experiments are well-established and systematised as a scientific method in many research fields, and especially in the natural, the health and the behavioural sciences. We are most interested in controlled experiments and in quasi-experiments (experiments without random assignment) here, although natural experiments are a feasible alternative in studies that drawn on very popular games with important existing player populations. A widely used experimental method to assess the effectiveness of traditional and technology-supported interventions in the education and health sectors is the randomised controlled trial (RCT). Also, meta-analyses of the effectiveness of health and education interventions typically require the underlying studies to adhere to RCT standards. Unlike quasi-experiments, RCTs assign individuals randomly to treatment and control groups in order to neutralise confounding factors between subjects in the sample. Depending on whether subjects,
researchers, and the intervention provider are ignorant of the treatment assignment, RCTs are called 'blind', 'double-blind', or 'triple-blind'.

**Of What Use are Experiments in xDelia?**

Unlike meta-analyses, experiments as well as field studies have always formed part of the planned activities in xDelia, as set out in the description of work (DOW). As of February 2010, most forms of experiments discussed above are planned or have been carried out in one work package or another. Experiments in both behavioural labs and game labs are under way to test the effects of emotion regulation strategies on financial decision making, and evaluate a range of interventions that are hypothesised to improve these strategies. A game-based behavioural experiment with a large household panel is also planned for later in 2010. A comparative experiment that involved different game-based implementations of the Iowa Gambling Task and had as an objective to explore the game feature dependency of outcomes has been conducted at BTH in February 2010. A number of experiments have also been carried out with sensor equipment although they have been more of an exploratory nature. This will however change in the systematic field studies projected throughout 2010. Some of these experiments are of an exploratory nature, while others in the project are quasi-experiments or fully-fledged experiments with random treatment assignment. Future work on experiments to evaluate learning interventions should pursue two aims. First, and similarly to what we have suggested in the case of meta-analyses, a more systematic overview of existing experimental evaluations of learning interventions with clear potential for xDelia should be conducted. Second, an approach for micro evaluations as discussed in the context of the WP6 evaluation framework should draw specifically on lessons learned from these (and of course other) types of evaluation studies and infer a set of guidelines and prescriptions.

**Examples of Experimental Studies in Health Promotion and Prevention**

There is virtually an infinity of experimental studies on topics that are potentially of some relevance to our project. In fact, the meta-analyses that we briefly discussed in the previous section encompass hundreds of studies that may contain important findings on which to base our own studies and from which we can infer practical game design prescriptions. Since all of the intervention targets covered in the discussion on meta-analyses draw on experimental studies, a small selection of such studies shall suffice to make our point here. A more detailed illustration of an experimental study is given in section 3.6.3.3 below. In a randomised controlled trial, Peng (2009) shows that a specifically-designed computer game to promote healthy eating is effective in young adults (see the next section for more details on this study). Stretcher and colleagues (2002) investigate in an RCT whether computer-tailored print material and telecounselling helps to reduce smoking, increase vegetable intake, and increase physical activity. Based on a cluster RCT, Aveyard et al. (2003) analyse whether an expert system incorporating stages of change (TTM) strategies is successful in reducing teenage smoking. The evaluation of a diabetes self-management program is at the centre of an RCT study at a large UK-based university (Steed et al., 2005). Williamson and colleagues (2006) report on a two-year RCT for weight loss, comparing the effectiveness of a web site that incorporates and promotes behaviour modification strategies with a site that doesn't. Finally, Avci and Gozum (2009) investigate how an educational video and a scale model demonstration might lead to differing beliefs and behaviours in breast cancer screening. There are also a number of quasi-experiments that have been reviewed for this section. Carmel et al. (1996) evaluate the effectiveness of health messages targeted at skin cancer prevention and pre/post changes in antecedents of protective behaviour amongst the elderly at a collective settlement in Israel. Makuch and Reschke (2001) present the results of a small study with children in which the authors compare different game-based approaches to oral health. Lastly, Yon et al. (2007) assess whether the use of personal digital assistants among a small group of overweight individuals increases self-monitoring compared to paper and pencil diaries.
3.6.3.3 Psychophysiological evaluation

What Does a Psychophysiological Study Involve?

Psychophysiological evaluation involves the measurement of physiological signals and mapping of the processed signals onto cognitive or emotional states or processes. The rationale behind this approach is that physiological data offer a more objective basis for measuring psychological constructs than self-reports by the individuals concerned. Thus, psychophysiological evaluations involve experiments with sensor equipment either in the lab or in the field, and they require a set of well-founded hypotheses or a theory that links the observed physiological signals to purported mental states. They are thus a hybrid of experiments and of theory-driven evaluation. There are a handful of physiological measures that are commonly used in research for the purpose of assessing the impact of technology on their human operators. Cardiovascular activity for instance may indicate arousal, stress, and heightened mental effort and can be measured using heart rate or heart rate variability. Arousal is also sometimes measured via skin conductivity, where electrodes are placed on parts of the body with a large concentration of sweat glands. Valence of emotions such as sadness/happiness can be assessed for instance by measuring tensions in specific facial muscles, a procedure called electromyograph which uses electrodes placed on the brow and the cheek to detect smiling. Eye tracking can be used to determine the locus of attention and EEG can provide data about attentional states of the player.

What Are Psychophysiological Studies Good for in xDelia?

Sensors for psychophysiological measurements take on a central role in xDelia, both in lab experiments and field studies, and as components of multimodal game interfaces. However, beyond these application areas, sensors can also play an important role in evaluating game usability, game play, and learning. Section 3.6.4 below discusses an example in more detail of how the psychophysiological measures approach has been used to complement or substitute evaluation of dimensions of game entertainment based on self-reports of emotions by game players.

3.6.3.4 Theory-driven evaluation

In most cases, experiments, meta-analyses, and psychophysiological measurements aim at evaluating a particular outcome of a learning intervention. In some cases, researchers may want to assess the design of a learning intervention by using well-established theories or sets of rigorous and well-founded criteria proposed by experts. In this case thus, the potential of an intervention to deliver the desired learning outcome is measured in terms of the presence of expert or theory-supported elements and strategies embedded in the learning content, the means of delivery, the mode of presentation, the way learners are motivated and so forth. Theory-driven evaluation is closely linked to design since it proposes that a given set of underlying theories and concepts may link specifically designed features of the intervention to desired learning outcomes. Section 3.6.4 illustrates this approach with an evaluation of physical activity web sites based on behaviour change theories commonly used in health communication, promotion, and prevention.

Use of Theory-Driven Evaluation in xDelia?

Theory-driven evaluations have two principal uses in xDelia: to evaluate game design proposals and to assess impact on skills or behaviours of serious game interventions. Similarly to heuristics-based evaluations of usability and playability, theories that can link specific game features to the effects they may have on player behaviour, in particular in the real world, can serve to determine the possible impact that a serious game might have on behaviour without resorting to experimental studies. There are several behaviour models used for instance in health, education, and advertisement that are well researched empirically and that we could adapt for the purpose of evaluating designs of serious games. In fact these theories can be useful in an iterative design process that tightly incorporates this
element of evaluation. A different way of using behaviour theories and models is as a provider of proxies for an empirical behaviour change measure where such this would only be difficult to obtain. For instance, taking as a basis the health belief model, it may be difficult to observe the effect an intervention has on actual behaviour, while it might be easier to do so with known antecedents of that behaviour. Thus, while we may not be able to follow large numbers of people in their daily lives to observe physical activity, we might be able to gather data on determining factors more easily and infer behaviour intention and behaviour from that data. A shortcoming here is that while in key areas of health prevention there is ample evidence that can feed such a strategy, much less is known about the determinants of particular financial behaviours, although the economic psychology literature points to some useful evidence.

3.6.4 Examples of Pertinent Health Evaluation Studies

3.6.4.1 1. Can mobile technology enhance self-monitoring?

Article: Yon et al. (2007)
Evaluation type: quasi-experiment (no random treatment assignment)
Evaluation target: self-monitoring frequency in a behavioural weight loss program
Evaluation rationale: obesity and the diseases caused by obesity pose an increasing threat to public health and hence increasing compliance with self-monitoring - an important antecedent of weight loss - is one way to address this problem

Background: It has been shown that success of behavioural weight loss programs depends to a large extent on the capacity of individuals to accurately record and monitor their daily physical activity and dietary habits. Hence, there is much value in developing resources and techniques that help increase compliance with keeping records and self-monitoring of food intake and exercise on a daily basis.

Objective: Investigate whether the use of PDAs increases the frequency of dietary self-monitoring compared to traditional pen and paper diaries. More specifically, the authors hypothesised that individuals who use PDAs to monitor their food intake would update their diaries on a more regular basis.

Potential interest for xDelia: (1) investigates effectiveness of electronic diaries for self-monitoring, (2) points to possible barriers for an effective use of electronic diaries, (3) highlights the importance of self-monitoring for behaviour intention implementation and goal achievement, (4) lists several other studies that have investigated the use of handheld computers.

Study design: Study participants for both the treatment and (on a previous occasion) the control group were recruited through newspaper advertisements. The treatment group consisted of 61 overweight and obese adults whereas the control group 115 subjects. Individuals in the treatment group were given an orientation course, a PDA with a diet management software, and physiological baseline data such as weight and height were gathered. They subsequently participated in a 6 month behavioural weight loss program. Conditions for subjects in the control were exactly the same except that they used pen and paper diaries instead of PDAs to keep their dietary records and submit on a weekly basis.

Experiment: Subjects in both the treatment and and the control group enrolled in a 6 month behavioural weight loss, where they were instructed in the use of self-regulatory and behavioural strategies to improve their dietary habits and increase physical activity. Participants were asked to reduce their overall calorie intake, to walk a certain aggregate distance each week and to engage in lifestyle exercises such as taking stairs instead of the elevator. Up to this point, the experimental
conditions for the treatment and the control group were the same. Individuals in both groups were instructed to record their food and calorie intake, as well as their physical activities. Both groups differed in the way records were taken and self-monitoring took place, as well as how the records were transferred to the program instructor. While individuals in the treatment group used a PDA and calorie calculation software for this task, those in the control group used paper-based diaries and a book with calorie listings of food stuff.

**Measures used:** Weight, height, and calorie intake (food frequency questionnaire), energy expenditure (Paffenbarger physical activity questionnaire), comfort and ability with computer technologies, group meeting attendance, compliance with calorie reduction, exercising, and self-monitoring.

**Study results:** The study found no significant difference in weight loss between those individuals of the control and the treatment group who completed the weight loss program, although the control group complied to a greater extent with their exercise goals than the treatment group. In line with previous findings, compliance with self-monitoring was strongly associated with a higher weight loss. A significant increase in physical activity and decrease in calorie intake was observed for both groups. Importantly, the comfort that participants felt in using computer technology was significantly related to the frequency of self-monitoring, even after individuals had a chance to get accustomed with the PDA and the calorie management software. Hence, technology turned out to be a considerable barrier to self-monitoring.

**Implications for xDelia:** Keeping track of one’s financial situation is a key dimension to financially capable behaviour. This study alerts us to the fact that although using mobile technology might improve data quality, it doesn’t necessarily raise compliance with record keeping. Also, effectiveness seems very much to depend on the specifics of context and application domain. Moreover, although the authors of the study haven’t said this explicitly, there is some indication that individuals in the treatment group, who felt less comfortable with computer technology than their generally better educated counterparts in the control group, were reluctant to use the handhelds for self-monitoring. The project needs to be sensitive to individual, social, and cultural differences when it comes to introduce technology as part of a learning intervention in specific segments of the population. On a more technical note, the use of standardised measurement scales here suggests that some care needs to go into constructing the dependent and independent variables used in empirical evaluations of serious games. Wherever possible, standard scales should be used, especially to measure common psychological constructs. Another interesting finding is that those who used the PDA on a regular basis "perceived that their friends, family and colleagues wouldn’t know that they were keeping a food diary since so many other people regularly used a PDA in public settings." So PDA use is a moderator of the effect of social norm (eg not wanting to judged by others) on behaviour (ie record keeping).

**Further comments:** (1) some of the limitations of handhelds and software that affected results at the time the study was conducted might not apply to the same extent anymore today, (1a) participants liked the convenience (34%) and portability (47%) of the PDA, and ease of looking up (65%) and entering (26%) data, (1b) 44% disliked, eg because it didn’t list some common food stuff and the display was hard to read, (2) applicability of results to xDelia is constrained by the fact that this was a guided intervention, where we are mainly concerned with interventions that are effective in a self-help context.

### 3.6.4.2 The use of behaviour change theories on physical activity web sites

**Article:** Doshi et al. (2003)

**Evaluation type:** theory-based
**Evaluation target:** use of behaviour change theories in educational strategy of physical activity web sites

**Evaluation rationale:** physical activity is a high priority goal of health promotion and theory-based interventions are thought to be an indicator of higher quality content

**Background:** Web-based health promotion and prevention presents us with an array of possibilities such as individually and stage tailored messages, increased potential for motivation and thus engagement with a healthy lifestyle, and so forth. However, the sheer amount of sometimes inappropriate information available on the Internet poses in itself a public health hazard that can put individuals at risk. Existing criteria targeting content, aesthetics, usability, or disclosure need to be complemented by criteria that can measure more reliably the likely effectiveness of the educational strategies deployed by such sites.

**Objective:** The study evaluates physical activity web sites for their use of five widely used behaviour change theories in health promotion and prevention: health belief model, theory of planned behaviour, social cognitive theory, transtheoretical model (stages of change), and the ecological model. An evaluation template to guide the study was designed and its reliability and validity determined by experts. The authors' underlying hypothesis is that theory-based interventions "may be an indicator of higher quality content".

**Potential interest for xDelia:** (1) Behaviour change is a key aspect of financial capability interventions considered in xDelia. This study points to a number of behaviour change theories that to date have garnered only little attention in consumer financial research and in financial education. (2) Behaviour change theories can provide a useful framework within which to conceptualise and evaluate the effect of serious games on behaviour. (3) The procedure by which the evaluation template is developed with the support of external experts could be considered for some applications in xDelia as well. (4) Most of evaluation categories and items proposed in the article are non-specific and can be almost directly applied to our domain. However, unlike in many important health areas, there is limited empirical evidence available (and specifically in the economic psychology and the consumer research literature) on the link between antecedents of behaviour intention and actual behaviour (intention) for the five domains of financially capable behaviour. (5) The behaviour change strategies proposed in the article provide us with a template for intervention design.

**Study design and implementation:** In this study, two independent expert reviewers use a custom developed evaluation template to rate and compare physical activity web sites on their use of strategies and constructs from four widely used behaviour change theories. A total of 24 web sites were included in the search. The raters evaluated the sites on the basis of the 118 criteria set out in the evaluation template (see next point) using two hypothetical user profiles. The profiles differed on socio-demographic, stage of change, and other characteristics, so that the variety of aspects problematised by the different behaviour change strategies would assume particular salience. Raters logged onto the different sites once for each hypothetical profile and evaluated the sites from the particular perspective of the assumed profile. The evaluation rated sites according to the presence of each of the behaviour change strategies and ability to adapt interventions to the characteristic stage of change for each profile.

**Evaluation criteria:** The evaluation template consisted of 118 items and was developed in an iterative process, in consultation with health promotion experts. Experts were asked to review the draft template designed by the authors and suggest changes or include additional criteria. This resulted in a set of 20 different intervention strategies (eg self-efficacy, realistic goal setting, and negative affect management) along five different dimensions: knowledge, cognitive strategies, behavioral strategies, emotion-focused strategies, and therapeutic interventions. Strategies were further assessed on five levels of interaction offered to users by the sites: pure information or guiding help, behavioural assessment or diagnosis, feedback on strategies used by individuals, non-individualised suggestions on how to apply behaviour change strategies, and individually tailored
assistance. In addition, a set of 18 idiosyncratic strategies (eg content validity, physical exercise and medical risk assessment, etc) unrelated to behaviour change theories were included in the evaluation.

**Study results:** Few of the sites reviewed by the authors incorporated constructs or strategies from any of the four commonly used theories in health communication, promotion, and prevention. Moreover, just one web site tailored the content to the stage of change (eg contemplators vs active individuals) of the hypothetical profiles used in the evaluation. Tailoring messages to the stages in which an individual finds herself with respect to behaviour change and adaptation is commonly thought to be necessary for the effectiveness of an intervention, although the evidence is mixed even for smoking cessation, the domain for which the concept of stages of change was originally developed for. Even worse, sites predominantly fell into the 'information and guiding help' category, with few offering assessment, feedback, or individually tailored help.

**Further comments:** (1) While financial education has primarily been concerned with improving literacy and numerical skills, elements of cognitive behavioural therapy curricula have been more or less successfully put to work in a range of school-based interventions eg to address depression in teenagers. The fact that much of the most severe and sustained criticism raised at the purportedly low effectiveness of financial education has come from behavioural economics quarters sheds some light on why many of the solutions proposed to the financial capability conundrum centre on the environment, and more specifically on adapting aspects of the choice architecture to what are seen inevitable flaws and biases of human judgment. (2) The text mentions other evaluation criteria: “Kim, Eng, Deering, and Maxfield reviewed published criteria for health-related Web sites and found that many authors agreed on key evaluation criteria, including (a) content; (b) design and aesthetics of the site; (c) disclosure of authors, sponsors, or developers; (d) currency of information; (e) authority of source; and (f) ease of use. In addition, an expert panel convened by the U.S. Department of Health and Human Services described high-quality health information as accurate, current, valid, appropriate, intelligible, and free of bias.”, (3) although much of the study is pertinent for our own work, we need to be conscious of the fact that the study has been conducted in 2000 and that criteria for instance related to the social nature of web interaction are missing.

**3.6.4.3 Psychophysiological measures of entertainment value of games**

**Article:** Mandryk et al. (2006)

**Evaluation type:** psychophysiological

**Evaluation target:** whether 'modelled emotions' as calculated by the authors' fuzzy logic, psychophysiological model is able capture differences in treatment conditions

**Evaluation rationale:** self-reports are notoriously unreliable as an indicator for entertainment value of games, including challenge, fun, and boredom

**Background:** Assessing the entertainment value of games is a challenging task since traditional objective performance measures that might apply to work-based information technologies cannot easily be translated to entertainment games. Motivation, challenge, and fun are characteristics commonly associated with successful games and point to the importance of emotion-laden experience in game play. While observational studies and self-reports go some way in uncovering the emotions at play in a particular game situation, the increasing availability of wearable sensors allows researchers to directly and continuously measure physiological correlates of play experience in real time.

**Objective:** The objective of the study was to evaluate an psychophysiological-based emotion model in an experimental setting, and in particular to determine whether and which of the modelled emotions could differentiate between the three treatment conditions (game adversary): co-located friend, co-located stranger, computer.
Potential interest for xDelia: (1) edutainment and serious games should also be evaluated on the entertainment dimension, and this study provides some clues of how to achieve this with psychophysiological measures; (2) Mandryk and colleagues propose a classification of evaluation methods along the subjective/objective and the qualitative/quantitative dimensions, which although quite abstract could be useful in discussions on evaluation methods.

Study design and implementation: Twenty-four individuals were recruited for the experiment. Participants differed in game play experience and the 'stranger' remained constant throughout the experiment. Subjects reported on their experience (challenge, boredom, excitement, frustration, and fun) using 5-point scales, and the following physiological data were gathered: galvanic skin response, heart rate, and electromyography. Values for the five emotion experiences were calculated based on arousal and valence derived from the psychophysiological measures using a fuzzy logic model. Data from half of the participants in the study was used to fit the fuzzy models while the other half was used to validate the model.

Study results: The findings showed that fun and excitement in the game were significantly related to play condition while challenge, boredom, and frustration weren't. Results for self-reports and physiological measures were correlated for fun and excitement, but not for boredom and frustration. Measurements of challenge were negatively correlated for subjective and physiological measures.

Implications for xDelia: The article suggests that the surprising results for 'challenge' may be reveal "a strategy to attempt to relax when challenged, in order to improve their performance [and that] how participants handle challenge in a game is an individual strategy and additional work is required before challenge can be modeled accurately." This is noteworthy insofar as we have a particular interest in emotion regulation (and to some extent also in self-regulation) in xDelia. Thus, emotion measures of challenge - and probably to a differing degree of the other entertainment dimensions as well - will be moderated through efforts by individuals to regulate their emotions. The authors suggest that psychophysiological measures of entertainment are well suited to be use in combination with more traditional approaches such as observational analysis or self-reports.

Further comments: While performance measures for entertainment games are indeed less (or not) applicable, serious games evaluation will have to incorporate whatever performance measures make sense in the domain of application and in view of the desired learning outcomes.

3.7 References


Bloom B. S et al. (1964). *Taxonomy of educational objectives: The classification of educational goals* (Longman Group Ltd.)


4 Technology Options (WP4)

4.1 Introduction

It is important to get an overview of available software tools, to be able to select suitable software for different situations and requirements. The range of prototypes within xDelia is expected to be wide, ranging from mobile phone games, small web application, and more complex games, to tools for awareness of emotions. In addition a participatory approach to game design is applied in xDelia. These conditions make it highly probable that different tools will be used dependent on the type of game created. It makes it even more important to get an overview of different kinds of tools available. The tools presented here is a selection of what is offered on the market.

The selection is based on the following interpretation of the current needs in xDelia.

- We will work in groups with a diversity of competencies where we would like everyone to be able to contribute to the game development directly, in a way that produces a running prototype fast.
- We will make more complex games where the developers’ control is important. For example to make a more sophisticated game world where the player can complete different task in an arbitrary order.
- We expect to make both 2D and 3D games.
- We think we will need to make some graphics of our own, even if it is possible to buy different kind of graphics.
- We expect to make mobile application, for example mobile games for learning financial issues and wearable tools connected to psychophysiological sensors to make the carrier aware of his or her emotions.

Based on this reasoning, the selection can be divided into four categories:
1. Tools for game development where we have tools which are expected to be suitable in a participatory design approach and game and graphic engines for development of more complex games.
2. Artist tools which allows you to make your own graphics.
3. Mobile hardware that can be used to make wearable devices.
4. IDE (Integrated Development Environment) which is tools that facilitate programming. In this case mobile phone programming.

The evaluation criteria are in nature different for the different categories. Starting with the game development the criteria are divided into groups since the tools can be viewed from different perspective. The tools can be evaluated based on how it supports different features for game play and for development. The artist tools differ from the development tools and therefore the evaluation criteria differs. The artist tools are often specialized in a specific area and this is reflected in the criteria, as it is interesting to explore what a tool support and when it is feasible to use it. The mobile hardware section is rather short as there are only two products reviewed (section 4.7 ). This is due to the fact that it is extremely important that the hardware is easy to use to be able to do some rapid prototyping, and the two reviewed hardware pieces fall into this category. In the area of mobile phone development there is a huge amount of different operating systems and development environments, each focusing on a limited set of mobile phones. We have decided to review IDEs used to develop applications for two of the current most popular operating systems, but also an IDEs that facilitate mobile phone development by making it possible to transfer an application to different types of phones. The evaluation criteria is presented and explained in section 4.3.
The evaluation was performed by collecting data from try outs of full versions of the tools, by reading the documentation, and by reviewing tutorials. Unity3D (section 4.4.7) and UDK (section 4.4.10) where evaluated based on the trial version, as Unity3D and UDK is a commercial product and we do not have a software license for these particular engines. Some of the partners have used some of the tools more extensively. This is the case of Director, Ogre 3D, Game Maker, DX Studio, Torque, 3ds Max and Photoshop.

As a comparison Fu et al. (2008) have made an evaluation of tools for development of training games where they have considered evaluation criteria which at a glance seams different from ours. But if you take a closer look there is significant similarities. For example Fu et al. have a criterion called ‘Native scenario authoring capabilities’ and it corresponds to what we define as “editors”, “native support for synchronized communication” we simply call “support for communication”, “interoperability” is similar to “platform support” and “languages”, and “modelled subject matter” is the same as “availability of models”. What we do not take into account is if the tool itself is able to capture the play session or you have to use an external tool, like Camtasia Studio¹ or Captivate², to achieve that. The evaluation in this chapter is motivated by the need in the xDelia project and therefore the evaluation is tuned at what we at this stage think might be useful to consider when choosing a particular tool. As mentioned previously we also expect to use different tools in different situations.

The rest of the chapter is organized as follows. First there is a section explaining different technical terms and thereafter the evaluation criteria are presented for the different categories of tools. Next the tools are presented and evaluated, sorted under each category, starting with game development tools, then artist tools, IDE for mobile phone development, and mobile hardware. Each section ends with a summary of the evaluation of the tools within the category. The chapter ends with a short conclusion where some initial recommendations are summarized.

### 4.2 Technical Terms

- **3D engine** - is the part of game engine that handles the computer game’s graphics.

- **Adobe Shockwave** – is a multimedia player program that allows Adobe Director applications to be published on the Internet and viewed in a web browser on any computer which has the Shockwave plug-in installed.

- **API** - Application Programming Interface is a set of rules of how software communicate with other software.

- **Artist 3D tool** - allows 3D game artists to create the art content for computer games.

- **DirectX** - 2D and 3D API from Microsoft

- **DLL** – Dynamic-Link Library. A DLL-file is a file with functionality that can be shared by different applications. DLLs are mostly used under Windows.

- **Event system** – is a system for using different events (keyboard, mouse etc.) to execute actions when those events occur.

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- **Exporter** – an exporter is an extra piece of software that can get 3D content out of an artist 3D tool software into the game.

- **Flash** – is a multimedia platform commonly used to create animation, advertisements, and games.

- **Game engine** – is a software designed for development of video games. A game engine has functionality for 2D or 3D graphics, collision detection and collision response, sound, animation, artificial intelligence and networking.

- **GUI** – Graphical User Interface is a type of user interface (the type users are use to nowadays) that allows interaction with a game or application.

- **IDE** - Integrated Development Environment, a tool to support programming, often consists of text editor, debugger and compiler, sometimes also support of creation graphical interfaces by drag-and-drop.

- **JIT compiler** – A compiler that converts program source code into native machine code just before the program is run.

- **Mesh** – Mesh is a collection of vertices, edges and faces that defines the shape of an object in 3D computer graphics. The faces usually consist of triangles.

- **OpenGL** – Open Graphics Library, 2D and 3D API

- **Open source** – software that is realized under a license that admit for a public collaborative development of the software.

- **Plug-in** – piece of software that is installed within another software and add functionality to the software.

- **QuickTime** – is an extensible proprietary multimedia framework developed by Apple, capable of handling various formats of digital video, 3D models, sound, text, animation, music, panoramic images, and interactivity.

- **Scripting** – see Scripting language.

- **Scripting language** – is a high-level programming language that is interpreted by another program at runtime and allows control of one or more software applications.

- **Shader** – software instructions for calculating rendering on the hardware

- **TCPLink** – is an object for direct internet communication.

- **Texture** – 2D-picture/pattern that is put on a surface.

- **UI** – User Interface is where interaction between humans and machines occurs.

- **Vector graphic** – is the use of geometrical primitives such as points, lines, curves, and shapes or polygon(s), which are all based on mathematical equations, to represent images in computer graphics.

- **Visual Studio** – widely used IDE from Microsoft
- **VoIP** – Voice Over Internet Protocol

- **Widgets** - is an element of a graphical user interface (GUI) that displays an information arrangement changeable by the user, such as a window or a text box.

- **WYSIWYG** – What You See Is What You Get

- **Xcode** – Xcode is a suite of tools for developing software on Mac OS X, developed by Apple.

- **XML** – is a definition of a standard way of encoding the structure of information in plain text format.

### 4.3 Evaluation Criteria

The evaluation criteria differ dependent on what categories of tools that are reviewed. To make the evaluation easier to follow and overview we have divided the evaluation of the development tools in three subgroups. As the main activities in the context of games are play and development and since we in xDelia will use the games in different ways in the research we have chosen to divide the evaluation criteria into criteria for play and criteria for development. The different criteria are described in the subsections below.

The criteria for artist tools, IDE and mobile hardware are specific for each category as the tools have totally different purposes.

There are also a few common criteria that are valid for all the categories and it is price, how open the tool is, how good the support is and if the university already have a license of the tool. The last criteria might appear a bit odd, since it is much related to the current situation, but since the evaluation is aimed for use within the xDelia project it is rather useful to know if the tool is already available.

#### 4.3.1 Common Criteria

This type of criteria, common criteria, does not have anything to do with the functionality of the tools. But the criteria are not less important in terms of how the tool fits into the organization. The price is always an issue, especially if you are just using the tool for a short period of time and for minor tasks. Therefore knowing if a license already exists can make a difference when deciding what tool to choose. Something you should not disregard is a well functional support forum and other types of support like well written documentation and books. It saves a lot of time if you get support to solve your problem. Another thing that might be seen as an ideological question is whether the tool is open source or not, but in the case of xDelia is it a matter of control. Open source makes it possible control almost anything and it may be desirable when experimenting with for example biofeedback.

In summary the common criteria are

- Price
- If license is availability at the university
- Support forums
- If the tool is open source
4.3.2 Criteria for Play

Gameplay is the core of game design (Lindley and Sennersten, 2007) and it is the players’ experience of the game play that is essential for the success of a game. As the gameplay and the logical game system differs dependent of what game we are discussing, we here focus on technology that support the game play experience such as what platform the tool supports. The experience and nature of the gameplay might be rather different dependent of which platform the game is played on. It makes a difference whether it is played on an iPhone, a PC, a Xbox or if the game is web based.

Something else that makes a big difference in the experience of gameplay is whether the game is a single or multi player game. In addition, the multi player mode is related to what communication channels the game supports. When playing together a text or voice chat puts another dimension to gameplay. Another type of features that often is seen as fundamental in a game, but never the less are meaningful to discuss, is whether the tool supports 2D or 3D lighting, and if audio and animation are supported. The appearance of the game will affect the feeling in the game.

In addition it is important to consider how the finished games can be distributed. Dissemination is an essential part of the project since the games has to be spread to make a difference. The game experience starts when the game is downloaded, as the attitude towards the game is influenced by a smooth or troublesome download.

In summary the criteria for play are
- Platform support
- Single or multi player
- Communication
- Animation support
- Audio support
- 2D or 3D
- Lighting support
- Distribution

4.3.3 Criteria for Development

In xDelia we will use a participatory design approach when developing the games. It means that people with no programming experience will cooperate with game developers. The set of tools needed will therefore depend on what kind of game is to be developed, e.g. is it a prototype to get to know the requirements or is it a more complex game where previous prototypes are made more sophisticated. The choice of tool will also depend on who is collaborating in a subproject. Therefore it is interesting to explore the tool’s suitability for participatory design as well as the learning curve for programmers since it will influence the choice of tool. Another issue that is related to participatory design is the occurrence of an easy to use editor. It is also interesting from a prototyping perspective as it is faster to create a working games with support of a good editor. Another issue that may be important for the learning curve of the developer is what programming language is used when the editor has reached its limits.

Almost every tool available require a preconstruction of models and creating models require art skills and time, therefore the availability of models that are compatible with the tool is essential. It is therefore important to know what files can be imported and parsed. It is also interesting to know if it is possible to import sensor data into a game e.g. can we present phycophysiological data as biofeedback in a game. Related to import is export, what data can be exported, what file formats are supported. This is interesting from an evaluation point of view, when evaluating the games.
It might be that the tool does not support import or export of data directly; instead you need to add some external code to achieve what you want to do. It is therefore interesting to explore the degree of extendibility.

Dependent of what kind of game you create there might be a need for physics or not. That should also be indicated in the evaluation to guide decisions.

A crucial question to ask when choosing what tool to use is what dependencies there are between the tool and for example a specific IDE or operating system. If not considering this from the beginning you can find yourself in a situation where you have to invest in peripheral software and equipment to be able to fully use the feature of the tool. Related to different dependencies is how the future of the tool looks like. Of course it is hard to say something certain of the future, but it important to take it into consideration. Even if the tool is free you will invest time to learn the tool and to master the different features.

In summary the criteria for development are
- Suitability for participatory design
- Learning curve for programmers
- Editor
- Language
- Availability of models
- Import and export
- Extendibility
- Physics
- Dependencies
- Future

4.3.4 Criteria for Artist Tools

Even though some of the development tools come with a set of models or sprites and it is possible to buy certain items, there might be occasions where there is a need for more specialized models, backgrounds, textures etc. Therefore we will review some tools that can be of use when creating artwork for the games. In the review we will assess whether it is possible to draw, paint, make textures (that is, make a 2D surface with a pattern), model in 3D, model details like pimple or wrinkles, and whether you can make animations.

The criteria is used in this part more to get an overview of what the tool can do than an evaluation as the tools often are very specialized. Some of the reviewed tools are similar and then it is other types of criteria that will influence the choice e.g. criteria presented in section 4.3.1.

In summary the criteria for artist tools are
- Support of drawing
- Support of painting
- Support of creation of textures
- Support of 3D modelling
- Support of detail modelling
- Support of animation
4.3.5 Criteria for Mobile Phone Development

Games for mobile games may be of interest in work package three, as this type of games can reach many people. To develop mobile games include a set of requirements that differs from other type of games. For example screen size, processor performance and capability, put restrictions of the graphics and the computation. In addition there are a lot of different operating systems and development standards to take into considerations. What types of mobile phones to develop for is a strategically, political or ideological issue.

We have decided to focus on mobile development by looking at some IDE that facilitate mobile development, namely Xcode for iPhone development, Eclipse for Android development and MoSync for porting code to different mobile phones.

The criteria for mobile development are language support since it important to know what programming skills are needed to get started. The platform support is related to what programming language to use, even if Java can be used on many platforms. It may also be interesting to know something of the perceived future for the IDE itself. A critical thing when it comes to mobile development is also how to distribute the games.

In summary the criteria for mobile development are
- Language support
- Platform support
- Future
- Distribution

4.3.6 Criteria for Mobile Hardware

Something that may be of interest for especially work package two is small mobile devices, for example to be able to measure and display psychophysiological data. In this case a small processor is needed and when it comes to mobile hardware the size is of importance as well as the computing capacity. Another issue to consider is how steep the learning curve are, as most of the participants in work package four have no or little experience in hardware creation. Once again the programming language is an issue, since it is faster to use a well known language than one designed for a specific setting. The documentation of well established languages is also often better. In the hardware area interfaces are of importance as it determines how easy it is to connect the processor with external equipment. The last criterion we look at and try to estimate is the future of the hardware.

In summary the criteria for mobile hardware are
- Size
- Computing capacity
- Learning curve
- Language
- Interfaces
- Future

4.4 Game Development Tools

The development tools presented below differs significantly. In terms of use they range from easy to use by non programmers to that it is rather compressive and hard to delve into the tool by even a
competent programmer. In terms of game appearance there are tools that are limited to simple 2D games as well as tools for creation of fully fledged commercial 3D games.

4.4.1 Game Maker 8

Game Maker allows very rapid prototyping by drag-n-drop primarily in 2D but also in 3D. Game Maker is easy to use and you do not need to be a programmer. You can create backgrounds, animations, and add sounds. There are possibilities to do some programming when the desired functionality exceeds what Game Maker provides. The tool also provides some freeware images. Game Maker also contains a game engine. Game Maker is distributed by YoYo games3 and the created games can be hosted at their web page for free.

The advantage with Game Maker is that it is extremely easy to use to make simple games. Creation process is well segmented so a wide variety of developers (programming, design, art, sound) can work on a game simultaneously.

The disadvantages are that it quickly becomes unwieldy. It neither allows for proper debugging. Game Maker is a purely event-based application which makes it quite hard to find tricky errors.


4.4.1.1 Common criteria

- **Price**
  - Basic version is free
  - Pro version is 25 $.
- **License is available at the university**
- **Support forums**
  - Big active forum with different kinds of free DLL-files, for example for physics.
- **The tool is not open source**

4.4.1.2 Support of play

- **Platform support**
  - The supported platforms are Windows and web
- **Single or multi player**
  - Game Maker 8 has network support and therefore supports multi player games.
- **Communication does not exist**
- **Animation support exists**
- **Audio support exists**
- **2D support**
- **Lighting support does not exist**
- **Distribution**
  - Games created with Game Maker 8 are distributed from user to user (UTU) and on YoYo games website

4.4.1.3 Support of development

- **Suitable for participatory design**
  - Game Maker is suitable for participatory design as it is simple to use and do not require any programming if you keep the game simple.

- **Learning curve for programmers**
  - Low

- **Editor**
  - There is an easy to use, built in editor.

- **Language**
  - Possible with own scripting language to extend the functionality.

- **Availability of models**
  - Models are not provided for.

- **Import and export**
  - Easy. Many formats supported.
  - The assets work like you would expect when you have imported them.

- **Extendibility**
  - Can run external code, ex. physics, through DLL-files from forum. Only available in the pro-version.

- **Physics**
  - Possible With DLL from forum.

- **Dependencies**
  - There are no dependencies except for the platform support.

- **Future**
  - Positive. Many people use it, lots of activity on the forum, easy to use in constant development.

4.4.2 DX Studio 3.2

DX Studio is an IDE for 3D graphics and can be used to create standalone applications and games as well as embed them into Visual Studio IDE applications (e.g. Microsoft Office applications). IDX Studio is a powerful tool that contains a suit of editing tools and also a real-time 3D game engine. The editors support both 2D and 3D and drag-and-drop is used to create game UI and 3D scenes, which makes it easy to use. DX Studio also offers special effects tools out of the box. There is also a built in support for databases. Some examples of games created in DX Studio can be found at: http://www.dxstudio.com/gallery.aspx

An advantage with DX Studio is that there is alot of tools facilitating game development.

A disadvantage with DX Studio is that the tool, up to now only supports Windows.

Link: http://www.dxstudio.com/
4.4.2.1 Common criteria

- **Price**
  - Academic and personal license - $100
  - Standard Edition - $250
  - Professional Edition - $500

- **License is not available at the university**

- **Support forums**
  - There is no direct support but an internet community and a wiki page.
  - Plenty of documentation on their wiki page.

- **The tool is not open source**

4.4.2.2 Support of play

- **Platform support**
  - The supported platform is Windows
  - Support for Linux and Android phones are announced for spring 2010.

- **Single or multi player**
  - DX Studio has network support and therefore supports multi player games.

- **Communication**
  - There is support for text chat, but not for voice chat.

- **Animation support exists**

- **Audio support exists**

- **3D support**

- **Lighting support exists**

- **Distribution**
  - Games created with DX Studio are distributed from user to user (UTU).

4.4.2.3 Support of development

- **Suitability for participatory design**
  - DX Studio is suitable for participatory design when making maps etc., but not in terms of creating the logic behind the game.

- **Learning curve for programmers**
  - The learning curve is medium high as there are a lot of syntaxes and functions to learn.

- **Editor**
  - There is a easy to use, built in editor.
  - A screen shot of the editor can be found at: [http://www.dxstudio.com/images/editor/editor1.jpg](http://www.dxstudio.com/images/editor/editor1.jpg)

- **Language**
  - The language used for the logic is java script.

- **Availability of models**
  - Good Built in asset library with free models, textures etc.

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• **Import and export**
  o DX Studio can import many different formats, such as models from Blender (section 4.5.5), Maya (section 4.5.4) and 3ds Max (section 4.5.3).

• **Extendibility**
  o In the Pro version it is possible to run external C++, C# and Visual Basic code from DLL-files, which means it is possible to have sensor equipments incorporated in the games.

• **Physics**
  o DX Studio has all types of physics most games need.

• **Dependencies**
  o There are no dependencies except for the platform support.

• **Future**
  o The future looks positive for DX Studio as it has a fully fledged editor and it appears popular judged on forum discussions.

### 4.4.3 Torque

Torque consists of a suit of engines e.g. Torque 2D, Torque 3D, iPhone and console. Torque is easy to use and comes with an editor that provides a set of different WYSIWG tools. The 2D and the 3D engines are built on the same architecture but the 2D engine is customized towards 2D and the other way around for the 3D engine and the other variants. Example of games created with Torque engines can be found at [http://www.torquepowered.com/best-of-torque/](http://www.torquepowered.com/best-of-torque/)

An advantage with Torque is an excellent support, since it is a commercial product. It has a powerful WYSIWG editor with scripts integration. Project deployment for PC, Wii, Xbox 360 and iPhone platform.

A disadvantage with Torque is that it requires additional licenses for Wii, Xbox 360 and iPhone deployment.

Link: [www.torquepowered.com/](http://www.torquepowered.com/)

#### 4.4.3.1 Common criteria

• **Price**
  o Torque 2D costs $250 with source code and $100 without
  o Torque 3D costs $1000 with source code and $100 without
  o iPhone license costs $2250 for commercial license and $750 for indie license

• **License is not available at the university**

• **Support forums**
  o Forum & paid custom support for $250 / hour.

• **The tool is not open source**

#### 4.4.3.2 Support of play

• **Platform support**
  o The supported platform is Windows
- Single or multi player
  - Torque has built in networking and therefore supports multi player games.

- Communication
  - There is support for text.
  - Speech is possible, but VoIP you have to implement yourself

- Animation support exists
- Audio support exists
- 2D and 3D support
- Lighting support exists
- Distribution
  - Games created with Torque are distributed from user to user (UTU) and through the AppStore
  - Executable files can be created

4.4.3.3 Support of development

- Suitable for participatory design
  - Torque is suitable for participatory design as it has a good editor.

- Learning curve for programmers
  - The learning curve is medium high as there are a lot of syntaxes and functions to learn.

- Editor
  - Easy fully fledged GUI editors (level, world and game editor).
  - A screenshot of the editor can be found at: http://farm3.static.flickr.com/2720/4116396542_f019e41bfd_o.png

- Language
  - Supports scripting in a "C++ like" scripting language called TorqueScript.

- Availability of models
  - Models are not provided for.

- Import and export
  - Easy. Supports many formats.

- Extendibility
  - With the pro version it is possible to extend the applications with sensor equipment.

- Physics
  - Supported. But requires a lot of programming.

- Dependencies
  - There are no dependencies except for the platform support.

- Future
  - Positive.
  - Wide platform support, some commercial games that use it, not exceedingly expensive (unlike other more professional engines).

4.4.4 HGE

HGE stands for Haaf's Game Engine. HGE is a 2D game engine that is easy to get started with developing a game. HGE supports all kinds of games, from puzzles to strategy and platform games.
HGE is hardware accelerated and fast. HGE also simplifies game programming as the engine provides for helper classes which help to reduce development time of things like sprites and animations, fonts, particle systems, resource management etc. HGE runs on simple video cards as, for example, built in video cards. Some examples of games created with HGE can be found at: http://hge.relishgames.com/games.php

An advantage with HGE is that it is easy to get started with.

A disadvantage with HGE is its limitation to Windows and there is no GUIs or editors to facilitate development.

Link: http://hge.relishgames.com/

4.4.4.1 Common criteria

- **Price**
  - The engine is free to use
- **License is availability at the university**
  - N/A
- **Support forums**
  - There is a working HGE forum at http://relishgames.com/forum/
- **The tool is open source**

4.4.4.2 Support of play

- **Platform support**
  - Can only be used on Windows as an executable.
- **Single or multi player**
  - It is possible to make multi player games with assistance of external DLL-files which can be recovered from the support forum.
- **Communication**
  - Theoretically possible by making your own DLL
- **Animation support exists**
- **Audio support exists**
- **2D support**
- **Lighting support exists**
- **Distribution**
  - Games created by using HGE are distributed from user to user (UTU)
  - Executable files can be created

4.4.4.3 Support of development

- **Suitability for participatory design**
  - The engine is not suitable for participatory design as it requires writing C++ code.
- **Learning curve for programmers**
  - The curve is low as it is a rather simple engine which makes the functions also rather simple.
- **Editor**
  - There is no editor. The code is written in Visual Studio or similar.

- **Language**
  - C++

- **Availability of models**
  - Models are not provided for

- **Import and export**
  - The engine has a rather good helper class that makes loading of common formats quite simple.

- **Extendibility**
  - Is done by writing C++ code and therefore it is possible to have sensor equipment in the games.

- **Physics**
  - There is no support for physics. You have to write it yourself.

- **Dependencies**
  - There are no dependencies except for the platform support.

- **Future**
  - The future does not seem too positive as HGE is limited to Windows and it does not involve any editor or GUI that makes the development easier.

### 4.4.5 SDL

SDL stands for Simple Direct Media Layer. SDL is a multi media library that provides for simple access to 2D graphics, audio, keyboard, mouse, joystick etc.. Different libraries are available at the SDL web site, for example libraries for sound, networking and 2D rendering, which makes it easy and fast to develop prototypes in 2D as well as in 3D. By combining SDL with OpenGL even 3D graphics are supported. SDL can be combined with several languages to make games. SDL is mature and used in commercial products as well as in smaller games.

An advantage with SDL is that it is lightweight, include only what you need. SDL can compile on every platform. It can be integrated with other technologies.

A disadvantage with SDL is that it is just a multimedia library without any tools, and requires a lot of programming to make a game.

Link: [http://www.libsdl.org/](http://www.libsdl.org/)

#### 4.4.5.1 Common criteria

- **Price**
  - Free

- **License** is at the university
  - N/A

- **Support forums**
  - There is a SDL forum available.

- **The tool** is open source
4.4.5.2 Support of play

- **Platform support**
  - Cross-platform with these supported systems: Linux, Windows, Windows CE, BeOS, MacOS, Mac OS X, FreeBSD, NetBSD, OpenBSD, BSD/OS, Solaris, IRIX, and QNX.
  - Un-official platform support includes iPhone and other Windows, Linux, Max, iPhone

- **Single or multi player**
  - Possible, but you need to implement it yourself.

- **Communication**
  - Possible, but you need to implement it yourself.

- **Animation support** exists

- **Audio support** exists

- **2D and 3D support**

- **Lighting support** exists

- **Distribution**
  - Games created by using SDL are distributed from user to user (UTU)
  - Executable files can be created

4.4.5.3 Support of development

- **Suitability for participatory design**
  - SDL is not suitable for participatory design as it requires programming.

- **Learning curve for programmers**
  - The learning curve is medium high as there are a lot of syntaxes and functions to learn.

- **Editor**
  - There is no editor.

- **Language**
  - No limitations in code.
  - You can do anything that is supported by the following languages: C++, Ada, C#, D, Eiffel, Erlang, Euphoria, Guile, Haskell, Java, Lisp, Lua, ML, Objective C, Pascal, Perl, PHP, Pike, Pliant, Python, Ruby, Smalltalk, and Tcl. C++.

- **Availability of models**
  - Models are not provided for.

- **Import and export**
  - Not very many formats are supported.

- **Extendibility**
  - SDL is only a library and as such extendable

- **Physics**
  - Possible with libraries from website or you have to implement it yourself.

- **Dependencies**
  - There are no dependencies except for the platform support, which is well provided for.

- **Future**
  - Negative. Very old and not a whole lot of changes over the years. There are definitely better alternatives.
4.4.6 Ogre3D

Ogre stands for **Object-oriented Graphics Rendering Engine**. Ogre is a rendering engine, that is a graphic engine and thus lacks features that a fully fledged game engine has, for example support for audio, network and collision detection. Ogre can be combined with external library to form a game engine. Ogre has a large number of source tools like mesh viewer, Xcode templates, exporters from Maya, Blender and 3ds Max (section 4.5.3). Ogre together with C++ has a good performance, better than Unity and Director below (section 4.4.6.1 and 4.4.7.1). Databases are supported through common C++ APIs.

An advantage with Ogre 3D is that it has a large active community. Ogre 3D is powerful, fast and has a lot of tools.

A disadvantage with Ogre 3D is that it is not a fully featured game engine. Programming in Ogre 3D is somewhat confusing by use of British English which is not standard.

Link: [http://www.ogre3d.org/](http://www.ogre3d.org/)

4.4.6.1 Common criteria

- **Price**
  - Free
- **License is at the university**
  - N/A
- **Support forums**
  - There are active and good support forums.
- The tool is open source

4.4.6.2 Support of play

- **Platform support**
  - Portable to platforms: Mac, Linux, PC, Web, iPhone Windows.
- **Single or multi player**
  - Ogre has multiplayer network support.
- **Communication**
  - Possible, but you need to implement it yourself.
- **Animation support** exists
- **Audio support** exists
- **3D support** exists
- **Lighting support** exists
- **Distribution**
  - Games created by using Ogre3D are distributed from user to user (UTU)
  - Executable files can be created

4.4.6.3 Support of development

- **Suitability for participatory design**
Ogre3D is not suitable for participatory design as it requires programming.

- **Learning curve for programmers**
  - Very high. Complicated architecture design, takes a long time to learn how to use it.

- **Editor**
  - Ogre has several free open source editors with support forums.
  - No official level editor is available. You need to use third party applications or design from modelling software.

- **Language**
  - Programming languages - C++, C# and F#.
  - Can also use the scripting languages Python and Lua.

- **Availability of models**
  - Models are not provided for

- **Import and export**
  - Hard. Has a 3ds Max exporter where the Ogre 3D engine is running inside a viewport in 3ds Max, which means you can see the result immediately without exporting the model and start the program once again. It means you can both model, program and test the game inside 3ds Max, which is very powerful.
  - Has a strange way of handling assets which is not that easy to understand at first.

- **Extendibility**
  - Sensor hardware interfaces - Ogre can be used with most hardware and sensors through C++.

- **Physics**
  - Nvidia PhysX

- **Dependencies**
  - There are no dependencies except for the platform support.

- **Future**
  - Negative. It is very hard to learn and poorly documented in many aspects. This limits new users from getting to learn it, so it is suspected that with time it will die out when the more polished engines get more attention.

### 4.4.7 Unity 3D

Unity 3D is designed for easy game development. All entries go through the editor's graphical interface. Unity is similar to Torque (section 4.4.3) in that the integrated graphical editor is the main method for development. Unity 3D can also be used for web games as Unity supports a web player plug-in. To run a Unity 3D game the unity web player has to be installed first. Unity 3D has a JIT compiler and performance is dependent of what programming language used. Some database support does also exist. Examples created in Unity 3D can be found here [http://unity3d.com/gallery/](http://unity3d.com/gallery/).

An advantage with Unity 3D is that it supports many different platforms and has a good editor.

A disadvantage with Unity 3D is that the Pro license is rather expensive in comparison with other alternatives.

Link: [http://unity3d.com/](http://unity3d.com/)
4.4.7.1 Common criteria

- **Price**
  - Unity Pro costs $1250
- **License is not availability at the university**
- **Support forums**
  - There exists a good Unity community with forum, wiki, chat etc.
  - There is also a paid support. The price is not available.
- **The tool is not open source**

4.4.7.2 Support of play

- **Platform support**
  - Unity supports Mac, PC, Web and iPhone development.
- **Single or multi player**
  - Unity has multiplayer support.
- **Communication**
  - There is no built in support, but it is possible to implement a text chat by yourself.
- **Animation support exists**
- **Audio support exists**
- **3D support**
- **Lighting support exists**
- **Distribution**
  - Games developed with Unity 3D are distributed from user to user.
  - If the game is an iPhone game it is distributed by AppStore and must follow the standard required to use the distribution channel.

4.4.7.3 Support of development

- **Suitability for participatory design**
  - Unity can be suitable for participatory design when it comes to making maps etc., but not for the logic.
- **Learning curve for programmers**
  - The curve is medium high since there is a lot of syntaxes and functions to learn.
- **Editor**
- **Language**
  - C#, JavaScript and Boo
- **Availability of models**
  - Models for commercial use are not provided for
- **Import and export**
  - Many supported formats for import.
  - Possible to drag-n-drop 3ds Max files (section 4.5.3).
- Export is not needed as the files not get embedded into the project as in Game Maker (section 4.4.1) for example.

**Extendibility**
- It is possible to, for example, extend the functionality to comprise external sensor equipments, but the Pro version is needed.

**Physics**
- The physics is rather good. Nvidia PhysX is used.

**Dependencies**
- There are no dependencies except for the platform support.

**Future**
- The future seems rather positive as Unity 3D supports rather a lot of platforms.
- Unity 3D appears to be generally well designed and modern.

### 4.4.8 Adobe Director 11.5

Director was from the beginning intended for creating sequences of animation, but by the introduction of the scripting language called Lingo it became possible to, for example, create interactive web content by assistance of an Adobe Shockwave plug-in. Both 2D and 3D multimedia and games can be created with Director. Director supports for example Flash animation files, vector graphic, embedded QuickTime movies. The performance of Director is a bit slower than for example Unity and Ogre due to the use of Lingo and Java. Director has a build in support of databases and no extra plug-ins are required to use databases.

An advantage with Director is that it supports many different platforms.

A disadvantage with Director is that it is very poorly supported.


#### 4.4.8.1 Common criteria

- **Price**
  - The price is $999, but it is possible to get a better price if the university already have a contract with Adobe for other software products.

- **License is availability at the university**

- **Support forums**
  - There is a quite big Director community on-line, but the community is not very active. You cannot expect to get any answers in this forum.

  *The tool is not open source*

#### 4.4.8.2 Support of play

- **Platform support**
  - Mac, PC and Web applications are supported.

- **Single or multi player**
  - Director has network support and plug-in applications (called Xtras) for multiplayer support.
4.4.8.3 Support of development

- **Communication**
  - Possible to make text but must be created by yourself
- **Animation support exists**
- **Audio support exists**
- **2D and 3D support**
  - 3D uses DirectX 9/10 and OpenGL
- **Lighting support exists**
- **Distribution**
  - Games created with Director are distributed from user to user (UTU)

4.4.9 Irrlicht

Irrlicht has an easier and more understandable API compared to, for example, Ogre3D (section 4.4.6). Irrlicht has simple collision detection and handling built into the engine and is very easy to use. The collision handling is sufficient for most games as long as it is not a physics game. The performance of Irrlicht should be comparable with the one of Ogre 3D. Irrlicht has a skinnable 2D GUI and users can add their own widgets at runtime. The event system provides events for handling mouse, keyboard, joystick and GUI events without using external libraries. As the engine is designed to load
and save current scene to an XML file, engine developers have created world editors for Irrlicht. This simplifies the world-creation process significantly.

An advantage with Irrlicht is that it has a simple API. Irrlicht is a powerful and fast game engine with events and collision handling. It has integration with 3rd party audio and physics library, it is a multi platform, has a world editor and has a large community.

A disadvantage with Irrlicht is that it is not a real game engine and requires programming to make a game. It doesn’t have a graphical editor like Unity and Torque.


### 4.4.9.1 Common criteria

- **Price**
  - Free

- **License is at the university**
  - N/A

- **Support forums**
  - There are a very active forum and community.
  - There are many easy tutorials,

- **The tool is open source**

### 4.4.9.2 Support of play

- **Platform support**
  - Portable to platforms: Windows 98 - Windows 7, Linux, OSX, Sun Solaris/SPARC, All platforms supported with SDL.

- **Single or multi player**
  - Multi player games are possible. There is a lot of plug-ins to choose from.

- **Communication**
  - Possible, but need to implement it yourself.

- **Animation exists**

- **Audio support**
  - Yes, there are external components to use.

- **3D support**

- **Lighting support exists**

- **Distribution**
  - Games created with Irrlicht are distributed from user to user (UTU)
  - Executable files can be created

### 4.4.9.3 Support of development

- **Suitability for participatory design**
  - Irrlicht is not suitable for participatory design as it requires programming.

- **Learning curve for programmers**
- The learning curve is medium high as there are a lot of syntaxes and functions to learn.
- Has complex scene management, but is easier to understand than Ogre3D.

**Editor**
- Easy. Has a simple external scene editor.
- The external scene editor is very basic, it seems to work for most parts, but definitely not the best one out there.

**Language**
- Programming languages – C++

**Availability of models**
- Models are not provided for

**Import and export**
- Medium. Built in XML parser. Supports many universal model formats (.obj, .3ds, .dae, .x and more).
- Has a somewhat decent handling of assets that could be simpler, but you probably will not find a better one for free engines.

**Extendibility**
- As the programming language is C++ it is possible to extend games to embrace sensor equipment

**Physics**
- Good. Irrlicht has basic support for collision handling and detection. It is good enough for most games.
- A lot of physics plug-ins to choose from if physics need to be implemented.

**Dependencies**
- There are no dependencies except for the platform support.

**Future**
- Negative. Similar to Ogre3D. Not as hard to learn but still a very large system with too little GUI-support to make it desirable in the long run.

4.4.10 ‘UDK – Unreal Development Kit’

The Unreal game engine is developed by Epic Games (http://www.epicgames.com/). UDK consist of a set of different tools to facilitate game development by providing for a fully integrated editing environment. The Unreal engine also provides tools to facilitate content creations for artists and designers. A module-based particle effects system makes it possible to preview visual effects in real-time, e.g. fog, fire, explosions and smoke. Most of the code is written in an internal scripting language, which make it possible to modify large parts of the gameplay without having to go deep into the engine. There is no database support integrated into the engine, but it can be arranged by TCPLink. The performance is slowed down by the use of a scripting language, but the performance should be sufficient since several high performance games have been created with Unreal.

An advantage with Unreal is there is a good support and documentation that is continuously updated and developed further.

A disadvantage with Unreal is the price of the non royalty license.

Link: http://www.udk.com/
4.4.10.1 Common criteria

- **Price**
  - For in-house development it costs $2,000 / year and development seat to work with UDK.
  - If one has commercial interests with the engine it costs $99 + 25% royalty fee for all profits above $5000.
  - For everyone else it is free to use, but before starting to use UDK you have to read the license agreements thoroughly as there is some complicated clauses that can restrict the work.

- **License is not availability at the university**

- **Support forums**
  - Unity has a very active community, many Epic Games employees reads the forum frequently.
  - The community is very active in making tutorials and is very helpful to questions.
  - Documentation – There is a book series currently being released for the UDK. Volume 3 came out in December 2009.

- **The tool is not open source**

4.4.10.2 Support of play

- **Platform support**
  - UDK supports Windows, Xbox and Playstation 3

- **Single or multi player**
  - There is built in support for 64 players

- **Communication**
  - Text chats is supported

- **Animation support exists**

- **Audio support exists**

- **3D support**
  - Uses DirectX 9/10

- **Lighting support exists**

- **Distribution**
  - Games created with UDK are distributed from user to user.

4.4.10.3 Support of development

- **Suitability for participatory design**
  - UDK is suitable for participatory design when it comes to maps etc, but not for logic.

- **Learning curve for programmers**
  - The curve is medium high as it uses UnrealScript which is not as documented as one would like at this point, but it is likely to be improved within time.

- **Editor**
  - UDK has a very mature and easy to use editor.
The editor is probably the best level editor on the market. Built in systems for everything that involves editing of the game. Such as creation of physics for models (including hinges), character animation, map building, AI path placement etc

- **Language**
  - UnrealScript

- **Availability of models**
  - UDK does not provide any models for commercial use.

- **Import and export**
  - Import and export is easy to handle
  - There is a built in GUI for asset management in the editor.
  - There is also plug-ins for most modeling software for exporting assets.

- **Extendibility**
  - There is a new feature called DLL-Link which allows you to create your own external DLLs. This could be used to handle for example sensor input.

- **Physics**
  - UDK has one of the best editor and physics handling. It can handle pretty much anything. It is powered by Nvidia PhysX.

- **Dependencies**
  - No dependencies except for the platform support.

- **Future**
  - Hundreds of commercial games have been created with UDK.
  - There is a lively forum with hundreds of independent projects that use the engine.
  - Epic Games is very keen on making UDK as attractive as possible, since their business plan basically says that if their users cannot get their games sold with UDK, then the company does not make any money so they are constantly updating and extending the engine to attract more people to use it.

### 4.4.11 Summary

In Table 4.1 the evaluation the different game engines are summarized.

Beneath the different criteria in the criteria column the grades of the criteria are specified, e.g. the criteria support is graded according to the scale good/ok/bad etc.

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5 [http://udk.com/licensing.html](http://udk.com/licensing.html)
<table>
<thead>
<tr>
<th>Criteria</th>
<th>Game Maker</th>
<th>DX Studio</th>
<th>Torque</th>
<th>HGE</th>
<th>SDL</th>
<th>Ogre</th>
<th>Unity</th>
<th>Adobe Director</th>
<th>Irrlicht</th>
<th>UDK</th>
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<tr>
<td>Price</td>
<td>$25</td>
<td>$250-$500</td>
<td>$100-$1750</td>
<td>Free</td>
<td>Free</td>
<td>Free</td>
<td>$1250</td>
<td>$999</td>
<td>Free</td>
<td>$2000/year</td>
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<td>No</td>
<td>No</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>No</td>
<td>Yes</td>
<td>N/A</td>
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<tr>
<td>Support (Good, OK, Bad)</td>
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<td>Ok</td>
<td>Ok</td>
<td>Ok</td>
<td>Ok</td>
<td>Good</td>
<td>Good</td>
<td>Bad</td>
<td>Good</td>
<td>Good</td>
</tr>
<tr>
<td>Open source (Yes, No)</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
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</tr>
<tr>
<td>Platforms</td>
<td>Windows, web</td>
<td>Window, Java</td>
<td>Web, Windows, Mac, iPhone</td>
<td>Windows</td>
<td>Windows, Linux, Mac, iPhone</td>
<td>Windows, Linux</td>
<td>iPhone, Web, PC, Mac</td>
<td>Web</td>
<td>Windows, Linux</td>
<td>Window, Xbox, PS3</td>
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<tr>
<td>Single or multi player (single, multi)</td>
<td>Single</td>
<td>Multi</td>
<td>Multi</td>
<td>Possible</td>
<td>Possible</td>
<td>Possible</td>
<td>Multi</td>
<td>Multi</td>
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</tr>
<tr>
<td>Communication (speech, text)</td>
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<td>Possible</td>
<td>Text</td>
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<tr>
<td>Animation</td>
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<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
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<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
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</tr>
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<td>Audio (Yes, No)</td>
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<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
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<td>2D or 3D</td>
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<td>3D</td>
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<td>Both</td>
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</tr>
<tr>
<td>Criteria for development</td>
<td>Lighting (Yes, No)</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
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</tr>
<tr>
<td>Distribution</td>
<td>UTU, YoYo games</td>
<td>UTU</td>
<td>UTU, AppStore</td>
<td>UTU</td>
<td>UTU</td>
<td>UTU, AppStore</td>
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<td>UTU</td>
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</tr>
<tr>
<td>Suitability for participatory design (Yes, No)</td>
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<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
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<td>No</td>
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<tr>
<td>Learning curve for programmers (High, Medium, Low)</td>
<td>Low</td>
<td>Medium</td>
<td>Medium</td>
<td>Low</td>
<td>Medium</td>
<td>High</td>
<td>Medium</td>
<td>High</td>
<td>medium</td>
<td>Medium</td>
</tr>
<tr>
<td>Editor (Hard, Medium, Easy to understand)</td>
<td>Easy</td>
<td>Easy</td>
<td>Easy</td>
<td>No editor</td>
<td>No Editor</td>
<td>Hard</td>
<td>Easy</td>
<td>No Editor</td>
<td>Easy</td>
<td>Easy</td>
</tr>
<tr>
<td>Language</td>
<td>Own</td>
<td>JavaScript</td>
<td>Torque-Script</td>
<td>C++</td>
<td>C++</td>
<td>C++</td>
<td>JavaScript, C#</td>
<td>Lingo</td>
<td>C++</td>
<td>Unreal-Script</td>
</tr>
<tr>
<td>Availability of models (very good, good, bad)</td>
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<td>Good</td>
<td>Bad</td>
<td>Bad</td>
<td>Bad</td>
<td>Bad</td>
<td>Bad</td>
<td>Bad</td>
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<td>Import and export (Hard, Medium, Easy, No)</td>
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<td>Easy</td>
<td>Easy</td>
<td>Easy</td>
<td>Medium</td>
<td>Hard</td>
<td>Easy</td>
<td>Medium</td>
<td>Medium</td>
<td>Easy</td>
</tr>
<tr>
<td>Extendibility (Yes, No)</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Physics (Good, OK, No)</td>
<td>Possible</td>
<td>Good</td>
<td>Ok</td>
<td>Possible</td>
<td>Possible</td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
<td>Good</td>
<td>Good+</td>
</tr>
<tr>
<td>Dependencies (Yes, No)</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
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</tr>
<tr>
<td>Future (positive, negative)</td>
<td>Positive</td>
<td>Positive</td>
<td>Positive</td>
<td>Negative</td>
<td>Negative</td>
<td>Negative</td>
<td>Negative</td>
<td>Positive</td>
<td>Negative</td>
<td>Negative</td>
</tr>
</tbody>
</table>

Table 4.1 – Summary of evaluation
4.5 Artist tools

Most artist 3D tools are specialized in different aspects of the creation of game graphics. Some tools are specialized in 2D graphic and others in 3D. Below follows a range of commonly used tools.

4.5.1 Adobe Photoshop

Photoshop is a graphics editing software that is the number one program used for drawing, painting and creation of textures. It is a professional tool and easy to use. It works very well for making or manipulating textures. A drawback is the limited aim towards 3D models.

Link: http://www.adobe.com/uk/products/photoshop/photoshop/

4.5.1.1 Common criteria

- **Price**
  - Adobe Photoshop CS4 $649
  - Adobe Photoshop CS4 Extended $999
- **License is availability at the university**
  - Only single user licenses are available
- **Support forums**
  - Adobe Photoshop has huge active user community since it is a standard artist tool.
  - It has direct support from Adobe on official forums as well as paid customer support
- **The tool is not open source**

4.5.1.2 Specific criteria for artist tools

- **Support of drawing**
- **Support of painting**
- **Support of creation of textures**
- **Support of animation**

4.5.2 Google SketchUp 7

SketchUp is used for making 3D models of, but not limited to, architectural designs. SketchUp can be used for almost anything that follows a blueprint. It is a very limited tool, but very streamlined and easy to use. Works well with exporting and importing to and from 3ds Max (section 4.5.3). In 3D Warehouse\(^6\) creators can search for models as well as contribute models.

Link: http://sketchup.google.com/

---

\(^6\) Google, ”Google 3D warehouse” <http://sketchup.google.com/3dwarehouse/> (retrieved 26 February 2010)
4.5.2.1 Common criteria

- **Price**
  - Free
- **License is availability at the university**
  - N/A
- **Support forums**
  - This tool is supported by Google experts on the official web.
  - It has a good and active user community.
- **The tool is not open source**

4.5.2.2 Specific criteria for artist tools

The only criteria, of the examined, supported by Sketch up are 3D modelling. The 3D modelling is restricted to buildings and other type of blueprint creations. Humans or other types of characters cannot be modelled in SketchUp.

4.5.3 Autodesk 3ds Max

Autodesk 3ds Max was previously called 3D Studio Max. 3ds Max is a package for modelling, animation and rendering. It is a powerful 3D modelling program. It is sometimes difficult to find proper exporters for this program. The GUI is rather intuitive and can be customized to suit different types of use. The latest version of the tool also includes advanced shader support. 3ds Max also provide for dynamic simulation, creation of particle systems, global illumination and its own scripting language.

Link: [http://usa.autodesk.com/adsk/servlet/index?siteID=123112&id=13567410](http://usa.autodesk.com/adsk/servlet/index?siteID=123112&id=13567410)

4.5.3.1 Common criteria

- **Price**
  - $3495
- **License is availability at the university**
- **Support forums**
  - 3dMax has huge user community since it is a standard 3D tool.
  - It has direct support from Autodesk on official forums as well as paid customer support
- **The tool is not open source**

4.5.3.2 Specific criteria for artist tools

The supported criteria are

- **Support of creation of textures**
- **Support of 3D modelling and**
- **Support of animation**
4.5.4 Autodesk Maya

Maya is used for modelling 3D objects, textures and animation. It is a powerful 3D modelling tool used for film, TV, and computer and video games. Maya has a simpler API than 3ds Max so it is more likely to find good exporters to Maya.

Link: http://usa.autodesk.com/adsk/servlet/pc/index?siteID=123112&id=13577897

4.5.4.1 Common criteria

- **Price**
  - $4090

- **License availability at the university**

- **Support forums**
  - Maya has huge active user community since it is a standard 3d tool.
  - It has direct support from Autodesk on official forums as well as paid customer support

- **The tool is not open source**

4.5.4.2 Specific criteria for artist tools

The supported criteria are

- **Support of creation of textures**
- **Support of 3D modelling**
- **Support of animation**

4.5.5 Blender 2.5

Blender is the free open source 3D content creation suite, e.g. 3D modelling. Blender is available for all major operating systems under the GNU General public Licence. It is the number one free 3D modelling tool on the market and Blender is comparable with 3ds Max and Maya and stands strong in the competition with Maya and 3ds Max as it is free and open source.

Link: http://www.blender.org/

4.5.5.1 Common criteria

- **Price**
  - Free

- **License availability at the university**
  - N/A

- **Support forums**
  - It has a good and active user/developer community since it is the biggest open source 3D tool.

- **The tool is open source**
4.5.5.2 Specific criteria for artist tools

The supported criteria are

- Support of creation of textures
- Support of 3D modelling
- Support of animation

4.5.6 Pixologic ZBrush

ZBrush is a tool for digital sculpting that combines 3D modelling, texturing and painting. In comparison with Maya, Blender and 3ds Max ZBrush is more like sculpting. ZBrush and Maya are well integrated. ZBrush is used for painting and modelling details. It is easy to create displacement maps (cause an effect where parts of the surface is raised by dispatching the geometric position of points) and other types of maps.

Link: [http://www.pixologic.com](http://www.pixologic.com)

4.5.6.1 Common criteria

- **Price**
  - $595
- **License** is availability at the university
- **Support forums**
  - It has a good user/developer community.
- The tool is **not** open source

4.5.6.2 Specific criteria for artist tools

The criteria supported by ZBrush are:

- Support of 3D modelling
- Support of detail modelling

4.5.7 Autodesk Mudbox 2010

Mudbox is designed for making modelling easier. Models are done by mud like sculpting, which usually is easier than working directly with vertices. Mudbox has a toolset of stencils and brushed that makes it possible to make realistic 3D characters, environments etc. Mudbox is similar to ZBrush and interoperable with 3ds Max, Maya and Photoshop.


4.5.7.1 Common criteria

- **Price**
  - €825
- **License** is availability at the university
4.5.7.2 Specific criteria for artist tools

The criteria supported by Mudbox are:

- **Support of 3D modelling**
- **Support of detail modelling**

4.5.8 Autodesk Motionbuilder

Motionbuilder is used for animation in games and works with Maya and 3ds Max. Motionbuilder can be used for motion capture or ordinary keyframe animation. Motionbuilder is used for making films, games and multimedia projects. The tool contains for example skeleton animation, facial animation, ragdoll physics, story timeline editing and the possibility to create scripts to allow for communication with Maya and 3ds Max.

4.5.8.1 Common criteria

- **Price**
  - $3995
- **License is availability at the university**
- **Support forums**
  - Motion builder has active user community.
  - It has direct support from Autodesk on official forums as well as paid customer support
- **The tool is not open source**

4.5.8.2 Specific criteria for artist tools

The only criterion supported by Motionbuilder is:

- **Support of animation**

4.5.9 Summary

There are a lot of Artist 3D tools that can be used in different situations. Maya, 3ds Max and Blender are comparable, which to use depends on taste, e.g. what you are used to and/or already have a license for. Another important issue to consider is if there are exporters available bridging the Artist3D tool and the game engine. Otherwise you have to make the exporter yourself. What is most important when choosing Artist 3D tool is to consider what you want to do and choose tool thereafter. In Table 4.2 the functionality of the different tools are summarized.
## 4.6 Mobile Phone Development

Games for mobile phones are one way to reach people that do not play computer games. The device’s mobility makes it feasible for users to play a small game while riding the bus to work etc. The playing context and the small screens put different requirements on the games compared to ordinary computer games. Together with the fact that there exist a lot of different mobile phones on the market, with different screen sizes and operating systems, makes mobile development difficult. But there are three feasible options dependent of what kind of mobile platform is chosen. You can choose to develop for iPhones and iPod Touch, Android based mobile phones or use a multi cross mobile environment like MoSync.

### 4.6.1 Xcode for iPhone Development

iPhone development has grown popular the last years due to the IDE and tools facilitating the development, but also the possibility to distribute and sell the applications via AppStore. Xcode is a suite of tools and used for developing applications for Mac OS X and iPhones. The IDE, also called Xcode, is often used in combination with a tool called Interface Builder, which makes graphical interfaces really easy to make. The Xcode suite supports a variety of languages, but the main language is Objective-C. The suit also supports a range of programming models like Cocoa, Carbon and Java. A screen shot of Xcode can be found here: [http://developer.apple.com/iphone/library/reference/library/GettingStarted/Creating_an_iPhone_App/Art/moveme_project.jpg](http://developer.apple.com/iphone/library/reference/library/GettingStarted/Creating_an_iPhone_App/Art/moveme_project.jpg)


### Table 4.2 – Summary of functionality in the reviewed artist tools

<table>
<thead>
<tr>
<th>FUNCTIONALITY</th>
<th>Photoshop</th>
<th>SketchUp</th>
<th>3ds Max</th>
<th>Maya</th>
<th>Blender</th>
<th>Z Brush</th>
<th>Mudbox</th>
<th>Motionbuilder</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drawing</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Painting</td>
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<td>X</td>
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<td>Detail modelling</td>
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<td>Animation</td>
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<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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4.6.1.1 **Common criteria**

- **Price**
  - free
- **License is availability at the university**
  - N/A
- **Support forums**
  - The support forum is very good with most common problems already answered.
- **The tool is not open source**

4.6.1.2 **Specific criteria for mobile phone development**

- **Language support**
  - Objective-C
- **Platform support**
  - iPhone
  - iPod Touch
- **Future**
  - The future looks positive as it is Apple's primary IDE and it is supported and updated continuously
- **Distribution**

4.6.2 **Eclipse for Android Development**

Android is Google's operating system (OS) for mobile phones. The OS is open source which makes it possible to modify the appearance of the interface to a higher degree than with other OS. To develop Android applications there is a plug-in for Android development, the Android Development Tool (ADT), for Eclipse, a standard IDE used broadly for Java development. Eclipse is well known and established IDE with a lot of plug-ins. To create Android applications you program in Java blended with XML to define the interfaces.


4.6.2.1 **Common criteria**

- **Price**
  - free
- **License is availability at the university**
  - N/A
- **Support forums**
  - Eclipse communities are widespread over the internet.
  - There are several very active forums for both Eclipse and Android.
  - The Android documentation is comprehensive and rather good.
- **The tool is open source**
4.6.2.2 Specific criteria for mobile phone development

- **Language support**
  - Eclipse support both language such as C/C++ and PHP, but is most famous as a Java IDE.
  - Android programming is done in Java and XML in the Android Development Tool.

- **Platform support**
  - Eclipse is a generic IDE where you can develop different kinds of applications. To support Android development a plug-in is required.
  - Eclipse support Java development which means you can also use Java ME (Java Micro Edition) for mobile phone development.

- **Future**
  - Eclipse is well established and is to be considered the best IDE for Java. Eclipse has a lot of developers developing plug-ins and it is likely to continue.

- **Distribution**
  - The games can be distributed from user to user but also by upload them to Android market.

4.6.3 MoSync

MoSync makes mobile cross-platform development available to all developers. MoSync is an IDE and a SDK (Software Development Kit) that simplifies mobile development and let you work in C/C++ and when a project is finished you can convert the code to run on different mobile phones. The problem with different types of phones, operation systems and operators’ offerings is facilitated by the MoSync IDE. MoSync is open source and is provided by Mobile Sorcery AB in Stockholm. A screen shot of the IDE interface can be found at [http://www.mosync.com/system/files/mosync-main-screen.png](http://www.mosync.com/system/files/mosync-main-screen.png).

Link: [http://www.mosync.com/](http://www.mosync.com/)

4.6.3.1 Common criteria

- **Price**
  - free

- **License is availability at the university**
  - N/A

- **Support forums**
  - MoSync is rather new, but during the last couple of years the number of users has increased substantially. The employees of Mobile Sorcery are also very active in answering questions.
  - The documentation has improved during the past years
  - Sample projects, guides and tutorials are available.

- The tool is open source

---

4.6.3.2 Specific criteria for mobile phone development

- **Price**
  - free

- **License is availability at the university**
  - N/A

- **Support forums**
  - MoSyne is rather new, but during the last couple of years the number of users has increased substantially. The employees of Mobile Sorcery are also very active in answering questions.
  - The documentation has improved during the past years
  - Sample projects, guides and tutorials are available.

- **The tool is open source**

4.7 Mobile Hardware

Interesting to the xDelia project is also easy to use, mobile hardware as we, in work package two, are likely to create some kind of portable devices and applications that collect and display sensor data. In the presentation bellow Hydra with Propeller chip and Arduino represent this category.

4.7.1 HYDRA with Propeller Chip

HYDRA with Propeller chip is an open system which lets you create console games in retro style. The propeller chip has eight 32-bits cores and supports standard NES (Nintendo Entertainment Controller) controllers as well as mouse and keyboard.


4.7.1.1 Common criteria

- **Price**
  - About €160

- **License is availability at the university**
  - N/A, BTH has a HYDRA starter kit.

- **Support forums**
  - The open source nature of the Propeller project has generated a lot of sample code for connecting different type of equipment to the propeller chip.
  - The HYDRA starter kit is shipped with a 800 page book about how to make games on the HYDRA

- **The tool is open source**

4.7.1.2 Criteria for mobile hardware

- **Size**
  - The board is 126x126 mm and the propeller chip is 53x17mm.
Computing capacity
- The Propeller chip contains eight 32-bit processors. Each processor has 2K of its own memory. Additionally there is 32K of shared RAM and 32K ROM.
- Clock speed 80MHz

Learning curve
- The curve may be medium or high dependent of previous experiences with one chip processors.

Language
- Propeller can be programmed in a C-like language called SPIN or in assembly.

Interfaces
- VGA port
- RCA video connector
- RCA audio connector
- Mini USB programming port
- PS/2 keyboard port
- PS/2 mouse port
- 2 Nintendo NES compatible game ports
- USB2 compatible programming port

Future
- The propeller chip has been around for a couple of years, and there is still an active community, accordingly the close future seems stable.

4.7.2 Arduino

Arduino is an open-source electronics prototyping platform based on flexible, easy-to-use hardware and software. Arduino is not geared towards games and has less computing power than the Hydra. There are several models of the Arduino board. The standard board are called Duamilanove. There is also a small board called the LilyPad that is intended for sewing into fabrics etc.


4.7.2.1 Common criteria

- Price
  - Duamilanove about €28.
  - LilyPad about €22.

- License is availability at the university
  - N/A, BTH has a couple of boards.

- Support forums
  - There is an Arduino forum as well as a user community. In addition there is a lot of sample code, tutorials and YouTube movies showing how to do different things with the Arduino boards.

- The tool is open source
4.7.2.2 Criteria for mobile hardware

- **Size**
  - 55x75mm

- **Computing capacity**
  - 16KB flash memory
  - 1KB SRAM
  - 512 bytes EEPROM
  - Clock speed 8MHz

- **Learning curve**
  - Arduino is very easy to start with and good tutorials are helpful.

- **Language**
  - The Arduino is programmed in an Arduino language based on C/C++

- **Interfaces**
  - 14 digital I/O pins (of which 6 provide PWM (Pulse-width modulation) output)
  - 6 analogue input pins.

- **Future**
  - Arduino has become very popular and new boards and accessories are provided for, accordingly the future seems stable.

4.8 Conclusion

Some initial suggestions of how and what to choose may be in place. For the category development tools there are three main issues to consider

1. Shall the tool be used in participatory design, where non-programmers take part in the implementation?
2. What kind of games shall be created? 2D or 3D?
3. How complex must the game be? Is it a rapid prototype or a full game?

Game Maker should be considered for use in participatory design activities, as it is very easy and uncomplicated to use. There is also an existing channel for distribution. The free version holds the functionality needed for participatory design activities. But if implementation is not a part of the participatory design approach, other 2D tools can be considered, for example if the participants take part in making maps etc. for the game, DX Studio, Unity or UDK may be suitable.

Also for rapid development of small games Game Maker would be preferable. However if developing more complex games one might consider one of the more expensive engines, and if you also perhaps want to be able to port the games to iPhone and the web, then Torque 2D with the iPhone license can be recommended.

Dependent on the game complexity the choice for making 3D games may be Unity 3D, Torque 3D or DX Studio, because these are a lot closer to being possible to use in participatory design activities and it takes less time to develop games with these engines compared to for example Ogre. With Ogre you have to put in enormous amount of time and energy into the initial structure. Then it is better to take advantage of existing engines that facilitates and speed up the game development.

If the game is intended as a complete and final product, UDK should be considered since many commercial games use the Unreal 3D engine. However the limitations in platform support are very apparent since it basically only works for Windows. For Xbox360 and Playstation 3 additional
development licenses are needed, but for now such development is not considered in xDelia. As there is a lot of, in detail regulated, license agreements associated with UDK the choices of license type should be thoroughly examined. Engines like Unity, Torque and DX Studio might be sufficient for a final xDelia game as well.

For artist tools three other issues should be considered. Artist tools should be based on following questions.

1. What kind of graphics is required in the games?
2. What tools the staff has experience in?
3. What licenses are already available at the university?

The choice of IDE for mobile development is dependent of what platform or platforms to develop for. Is a single platform targeted then a specific IDE for that platform should be used. But if several platforms are targeted, then MoSync should be considered as the same code can be ported to different mobile phones.

When it comes to hardware the size and capacity will be conclusive dependent of what shall be done.

### 4.9 References

5 SoA on Emotional State Monitoring (WP5)

5.1 Physiological Signals

5.1.1 Introduction

The purpose of this subsection is to provide an overview about physiological signals that are used to allow emotion recognition from sensor data. It contains a short description about the physiological signals itself followed by an overview about studies that have been conducted using these signals.

5.1.2 Skin Temperature

Skin temperature is the temperature that can be measured on the surface of the body. To measure skin temperature, a thermistor (a sensor whose resistance varies according to its temperature) is usually placed at the finger tip or the palm.

McFarland (1985) states that arousing, negative emotions lead to a decrease of skin temperature, whereas calm, positive emotions caused an increase of skin temperature. In contrast, Ekman et al. (1983) found that finger temperature increased more in anger than in happiness. In addition, a distinction between the negative emotions anger, fear and sadness was possible as sadness and fear caused lower changes in skin temperature than anger.

When skin temperature is measured, one has to take care that no heat accumulation takes place under the electrode. Moreover, the temperature of the environment should be constant, as it influences the skin temperature.

5.1.3 Heart Rate

Heart rate is recorded using electrocardiography. The recorded signal reflects the summed action potentials of the heart muscle. Electrocardiographic measures can be influenced by changes of skin potential which causes slow oscillation in the signal. In addition to that muscle potential artifacts can corrupt the signal if the electrodes are placed on muscles. Another problem is that heart rate also increases as a consequence of physical activity.

Instead of measuring heart rate directly, it can also be derived from blood volume. Blood volume refers to the amount of blood that is present in the peripheral blood vessels in a certain region at a given time. It is usually measured by photoplethysmography which is an optical technique that measures the amount of infrared light that is reflected by the skin. Compared to electrocardiographic electrodes, photoplethysmographic sensors are easier to apply and to wear and therefore more comfortable for a person.

When blood volume is measured, it is important to have a constant temperature as the temperature of the body influences the dilatation of blood vessels and therefore also the blood volume. Moreover,
the relative position to the heart should be kept constant because hydrostatic pressure also has an influence on the blood volume.

Anttonen and Surakka (2005) found that heart rate decelerated in response to emotional stimulation, especially in response to negative stimuli compared to responses to positive and neutral stimuli. Vrana et al. (1986) also reported a higher heart rate acceleration during fear imagery than neutral imagery and silent repetition of fearful or neutral sentences respectively. Moreover, Leng et al. (2007) verified that amusement produces a larger average and standard deviation heart rate of the heart rate than fear.

5.1.4 Respiration Rate

The respiration rate refers to the number of times a person inhales and exhales per time unit. Picard and Healey (1997) assume that it can also be useful to recognize a subject’s affective state. As heart rate and respiration are highly correlated, recordings of respiration rate can also be used to analyze which heart rate changes are affected by changes in respiration.

One main problem when measuring respiration is that humans are able to control their respiration and therefore influence the results voluntarily.

5.1.5 Muscle Activity

When a muscle is contracted, electrical potentials are generated by the muscle fibres. These electrical potentials can be measured by electromyography (EMG). Especially facial electromyography (fEMG) can provide a sensitive and objective measure for emotion studies as some facial muscles cannot be activated voluntarily (e.g. Ekman (1993); Ekman et al. (2003)).

Schwartz et al. (1976) found that positive thoughts come with a higher activity of zygomaticus major whereas unpleasant thoughts lead to an increase of the activity of corrugator supercili when self inducing different emotions. Cacioppo et al. (1986) corroborated this study when they found that corrugator supercili and orbicularis oculi regions varied in conjunction with valence and intensity of pictures: if subjects liked a scene, corrugator supercili and zygomaticus major activity was higher and orbicularis oculi activity was lower compared to neutral or unpleasant stimuli. More examples for research in emotion specific facial EMG activity can be found at Tassinary and Cacioppo (1992).

As the amplitude of facial EMG is quite weak, the signal can easily be affected by external interference. Additionally, movement artifacts can influence the signal. For example the movement of a muscle can deform the skin under the electrodes which would lead to a change of the skin-electrode impedance. It might also happen that electrodes change their position because of muscle contractions. It is also possible that crosstalk from adjacent muscles is recorded.

5.1.6 Skin Conductance

Skin conductance measures the electrical resistance of the skin which is influenced by the activity of the perspiratory glands. The more perspiratory glands are active the higher is the skin conductance. Skin conductance is usually measured at the hand or at the feet. As most emotions cause an increased activation of the human nervous system, skin conductance can be seen as a good indicator for the existence of an emotion although there is usually a latency of one to two seconds between stimulus and response. For example Winton et al. (1984) proved that skin conductivity response changes
linearly with emotional arousal. This view was supported by Ekman et al. (1983) who verified that fear and disgust lead to larger changes of skin conductance than happiness. Beyond that Ax (1953) used skin conductance to differentiate between anger and fear.

There are some things that have to be kept in mind when analyzing skin conductance. If the body temperature increases, skin conductance increases as well. Therefore, the temperature should be kept stable during the whole time signals are recorded. Moreover, respiration has an influence on the signal which can cause artifacts while a person is speaking. Skin irritation can also become a problem if the electrodes are attached to the skin with adhesive tape.

5.1.7 Electroencephalography (EEG)

Electroencephalography (EEG) provides information about the electrical activity of the human brain which results from post synaptic potentials of the cortical neurons. Compared to other methods for monitoring brain activity such as functional Magnetic Resonance Imaging (fMRI) or Positron Emission Tomography (PET), EEG has a high temporal resolution. However, as the origin of the signal can not be localized precisely, the spacial resolution of the EEG is worse than the spacial resolution of other methods.

Davidson (1992) states that left and right hemisphere of the brain are specialized to different classes of emotions. While the left anterior hemisphere is specialized on approach, the right anterior hemisphere is responsible for withdrawal. He explains the specialization of the left anterior hemisphere with the findings of Luria (1973) who described the left frontal region as an important center for intention, self-regulation and planning. Moreover, damage of left frontal region has been proved to cause apathetic behavior in combination with a loss of interest and pleasure in objects and people what can be seen as a deficit in approach. Evidence for the specialization of the right anterior region can be seen in findings that indicate a high activation of right frontal and anterior temporal regions during arousal of withdrawal-related emotional states (e.g. fear and disgust).

This theory supports the findings by Davidson et al. (1990) who detected less alpha power in right frontal regions for disgust than for happiness while happiness caused less alpha power in the left frontal region than disgust.

Additionally, in an EEG study about brain asymmetries during reward and punishment (which can be seen as a positive and a negative emotional stimulus), Sobotka et al. (1997) found that punishment was associated with less alpha power in right mid and lateral frontal regions of the brain (electrodes F4 and F8) whereas reward trials were associated with less alpha power in the left mid and lateral frontal regions (electrodes F3 and F7).

In an experiment where three emotions (fear, happiness and sadness) were induced with visual and auditory stimuli, Baumgartner et al. (2006) showed that alpha power over the left hemisphere increases in happy conditions compared to negative emotional conditions.

There are also several neuroimaging studies about brain activity during emotions. See Murphy et al. (2003) for more information about this topic.

As the amplitude of the EEG-signal is quite low, the signal can easily be influenced by artifacts - especially because of the high amplification, also small electrical interferences can have an impact on the signal. Trimmel (1990) differs between technical artifacts and artifacts with a biological origin. Technical artifacts can result from relative electrode movement on the skin which can for instance be caused by movements of the face. Moreover, movements of the electrode cables can cause capacity changes. Another source for artifacts is the noise of an amplifier, as well as interfering fields from
power supply voltage. Finally electrostatic voltages can affect the EEG-signal. Most of these artifacts can be delimited by a careful preparation such as insulation of the cables. Biological artifacts result from physiological activity of the body. For example eye blinks produce high amplitudes which occur especially at the frontal electrodes. Eye movements can also cause artifacts due to the electrical polarity of the eye.

5.2 Combined Measures for Emotion Recognition

Discrimination of different emotional states from physiological signals is a difficult task. In a study about emotion recognition from speech Scherer (1981) found that even humans are only able to distinguish among six emotions from speech signals with an accuracy of 60 percent. To improve recognition rates of affective system, different physiological measures can be combined.

In a user-independent study using skin temperature, electrodermal activity (skin conductance response) and heart rate as input signals, Kim et al. (2004) achieved a recognition rate of 78.43% for three emotion categories (sadness, anger and stress) and a recognition rate of 61.76% for four categories (sadness, anger, stress, surprise). For emotion elicitation, a multimodal approach which included visual, illumination, and auditory stimuli was used. The classification was done using a support vector machine.

Picard et al. (2001) conducted a study where electromyographic, blood pressure, skin conductance, and respiration information were collected from one single person over a period of some weeks. For eight emotion categories (no emotion, anger, hate, grief, platonic love, romantic love, joy and reverence) a recognition rate of 81% was achieved.

A combination of electromyography, electrodermal activity, skin temperature, blood volume pulse, electrocardiogram, and respiration was used in a study conducted by Haag et al. (2004) with a single person on different days. In the experiment emotional states of high and low arousal and high and low valence were elicited with a blockwise presentation of emotional pictures from the international affective picture system (IAPS). To classify the emotions, a neural network was used. For arousal a classification rate of 96.58% could be achieved whereas high and low valence could be distinguished with a correctness of 89.93%.

In a study with multiple subjects using electroencephalography, heart rate, and pulse were conducted by Takahashi and Tsukaguchi (2003), who tried to elicit positive and negative emotion by acoustic stimuli (music). For data analysis, a multi layer neural network was compared with a support vector machine. With the neural network classifier a recognition rate of 62.3% was achieved whereas the SVM classifier recognized 59.7%. Takahashi (2004) extended these results with a study where five emotions (joy, anger, sadness, fear, and relax) were induced by audio-video contents. For classification of the signals (electroencephalography, skin conductance, heart rate) a support vector machine was used and achieved a recognition rate of 41.7% (66.7% on three emotions).

5.3 References


6 SoA on Experimental Economics (WP2, WP5)

6.1 Introduction

The purpose of this section is to introduce the reader to the state of the art of research on emotions in experimental economics. The focus of this document will be on laboratory auctions because auctions are a simple model for the stock market mechanism and allow for isolating relevant decision situations. Thus studying behavior in laboratory auctions yields valuable information for understanding decision behavior of traders and investors.

Since xDelia is aiming at introducing sensor technology as a means of monitoring and changing behavior in decision making a new research methodology called physioeconomics is introduced.

6.2 Experimental Economics

6.2.1 Introduction

Experimental economics is a fast growing field of research. It is committed to the idea that economics, like all of the natural sciences, can be a laboratory science. Psychology and sociology have a long tradition of experimental research, and natural sciences have almost always relied on experiments. Opposed to that, experiments in economics were only sparsely used for a long time. With the introduction of economic experiments by Chamberlin (1948) and later by Smith (1962) first steps in this field were made, but until the 1980s not much was published.

Traditional economic models can only be tested with data from existing “natural” markets. This data often fails to allow “critical” tests. Hence, there is little practical possibility to observe evidence from naturally occurring markets. Additionally, economic models become more complex and the set of assumptions they rely on is huge. This makes it very hard to control for certain assumptions and to examine their contribution/influence to the decision making of an individual. For that matter, experiments can help to test for the validity of economic theory. While typically conducted under laboratory conditions, experimental economics can keep some factors constant and thus measure the effects of the relevant input. Additionally, with experiments it is possible to test the theoretical assumptions about preferences of economic agents; especially whether and how these preferences actually have an impact on economic decision making. Smith (1994) outlines seven reasons for experiments: to test theory, to explore why theory fails, to establish “stylized facts” as a basis for new theory, to compare environments, to compare institutions, to evaluate and to test-bed policy. Experimental economics is an inter-disciplinary science. Economists often work together with social scientists to determine the biological, social and psychological causes of an individuals’ behavior. The different topics of experimental economics can be loosely classified in: markets, games, decision-making, bargaining, auctions, coordination, social preferences, learning, matching, experimental finance, and field experiments.
6.2.2 How is it Done?

When conducting economic experiments, it is essential that this happens under controlled and replicable conditions. Replicability refers to the necessity that other researchers can reproduce the experiment, and thereby verify or falsify the results independently. Control is the capacity to manipulate laboratory conditions so that observed behavior can be used to evaluate alternative theories and policies. In order to obtain replicable results, the environment and the institution (“rules” of the game) have to be under control of the experimenter. When the experiment is under control, it can be replicated and hence produce evident results. Replicability and control are especially important when researchers from different laboratories conduct research on one topic. But the major advantage of laboratory experiments is that they yield the possibility to keep variables constant and only change the one variable you are interested in as a researcher. With this set up it is possible to draw causal conclusions between the manipulated variable and the observed effect.

To induce prespecified characteristics in experimental subjects, Smith (1976) introduced the Induced Value Theory. The Induced Value Theory states that subjects’ personal preferences are “neutralized” and the experimenter “induces” new preferences. Subjects’ actions should then be driven by the induced preferences. The conditions under which subjects perform according to this theory are monotonicity (subjects must prefer more of the reward medium to less and not become satiated), salience (the reward depends on subject’s actions), and dominance (changes in a subject’s utility from the experiment come predominantly from the money reward and the influence of all other motives is negligible).

6.2.3 Advantages and Limitations

A sceptical reader might ask what can be learned from simple laboratory experiments. As mentioned above; the chief advantages are the possibility to draw causal conclusions, replicability and control. While relevant data from “natural” markets is usually imprecise, expensive and cannot be controlled, experimental economics give the opportunity to get relatively inexpensive and reliable results. Hence, experimental economics can enrich economic theory with empiric evidence. One reservation against experiments in economics is that decision makers in the economy are more sophisticated than the usually chosen undergraduate students in laboratory studies. This problem can in part be solved by looking at different subject pools (e.g. experts vs. non-experts). Another criticism is that market economists are interested in the more complicated market reality than simple experiments. In this context it is important to mention that experimental economics is no panacea, it rather complements than substitutes other empirical techniques in economics. Thus results from experimental economics should never be “oversold” because results from experimental economics are only a piece of the puzzle to better understand human behavior in economic decision making.

6.3 Auctions

6.3.1 Why Study Auctions?

One branch of experimental economic research is that of auction research. One important reason for studying laboratory auctions in xDelia is that they serve as a useful platform for investigation deviations from rational choice theory under controlled circumstances. Under assumptions of rational choice an individual will decide for the course of action with maximum expected utility, a function of the probability and the magnitude of the expected payoff (Neumann & Morgenstern,
Auction experiments frequently reveal that participants’ choice behavior deviates from these theoretical predictions. These findings indicate that individuals decision behavior is guided by the intend to maximize the economist’s “expected value” but likewise influenced by “soft factors” like cognitive biases or emotional involvement. Before delivering an overview of emotional phenomena that can be observed in laboratory auctions all common auction types will be introduced. This listing serves to get a better overview of different auction formats.

Another reason for studying auctions is that the value and diversity of goods exchanged in the auction market each year is huge. Among the many goods exchanged in auctions are: antiques, collectibles, wines, real estate property, commodities, US Treasury bills, etc. Online auction companies have grown in number during the past years. Among them we find eBay, Amazon.com, Yahoo, etc. Therefore, the size of the auction market highlights the importance of studying them. For instance, the New York Stock Exchange (NYSE) trades everyday in a continuous time auction format. Specifically, buyers and sellers of a determined stock submit an offer price and asking price, respectively.

6.3.1.1 Common auction forms in alphabetical order

**Buy It Now**
With the BIN option the seller sets a fixed price for the good for sale. The bidders could either accept this price or not.

**Continuous double auction**
In a CDA the prices of sellers and buyers which they have in mind are continuously matched until they agree in opinion like on the stock exchange.

**Dutch auction**
DUA is a descending auction which begins at a high price level and is reduced by the auctioneer periodically. The bidder who first accepts the current price level wins the auction and has to pay their bid. (Cui et al., 2008; Ku, 2000, Ku et al. 2005)

**Dollar auction**
In a dollar auction there are small bid increments i.e. jump bidding is not permitted. The auction ends if no one bids for a predefined period of time (soft close). After the auction ended the highest bidder obtains the commodity and has to pay the amount of her bid. However, the second highest bidder also has to pay her bid, without obtaining the commodity. (Adam et al. (2009))

**English auction**
ENGA is an ascending auction which begins at the lowest acceptable price also known as Vickrey auction. The bids are increased by the auctioneer or called out by the bidder. The price will increase until no bidder is about to pay more. The bidder with the highest bid wins the auction and has to pay their last bid. (Cui et al., 2008; Ku, 2000, Ku et al. 2005)

**First price sealed bid auction**
1stSEALA is a combination of 1stA and SEAL auction. Bidders submit their bids secretly and at the end of the auction the highest bidder wins and has to pay his bid. (Cui et al., 2008; Ku, 2000, Ku et al. 2005)

**Group buying auction**
Consumers bundle their requirements in GROUBA. The more potential buyers are interested in the good for sale the higher are the effects of volume discount. (Cui et al., 2008)

**Invitation to tender**
The customer gives a description of the job that has to be done and companies bid on this job. Their bids show the price at which they accept to do the job.

**Japanese auction**
The seller increases the price level incrementally. The bidders are asked at every price stage if they accept the current price or not. The last remaining bidder wins the auction. (Ehrhart et al., 2008)

**Lowest unique auction**
LUNIA is an UNIA auction in which the bidder who submitted the lowest unique bid wins the auction.

**Name your own price auction**
A variant of the 1stSEALA where a bidder proposes a potential price for an item, and the seller can either accept or not. (Cui et al., 2008)

**N-price sealed bid auction**
N-SEALA is some kind of SEALA auction. Bidders submit their bids secretly and at the end of the auction a number of n highest bidders win the auction and have to pay the lowest bid of the n highest bidders.

**Proxy auction**
The participant with the highest bid wins the PROXA and has to pay the price of the second highest bidder plus an increment. (Bajari and Hortacsu, 2003)

**Reverse auction**
The REVA is an ASCA where service companies decrease their prices until the consumer accepts the price level. (Ding et al., 2005)

**Second price sealed bid auction**
2ndSEALA is a combination of 2ndA and SEALA. Bidders submit their bids secretly and at the end of the auction the highest bidder wins and has to pay the bid of the second highest bidder. (Cui et al., 2008; Ku, 2000, Ku et al. 2005)

### 6.3.2 Emotional Phenomena in Auctions

Research in experimental economics has shown that decision makers often do not decide in the way that is predicted by standard rational theory. The underlying mechanisms of these deviations from rationality are still subject to research.

Decision making can be influenced by cognitive aspects as well as emotional states of the decider. It is plausible to assume that deviations in behavior from standard rational theory are related to cognitive limitations as well as emotional influences. Thus far, research on “irrationality” in economic decision making has focused mainly on the cognitive aspects of decision biases such as limited computational ability and selective memory and perception (Kaufmann, 1999). Recent economic literature has pointed out the importance of emotions in financial decision making. Thaler (2000) predicted the “Homo Economicus will become more emotional”. Whereas other disciplines like psychology have already stressed the importance of emotions for decision making the relation between emotions and decision making in economic experiments has not been studied extensively, thus far.

As pointed out above, observing behavior in auctions yields the opportunity to analyze irrational behavior that is associated with different emotional influences. Only recently auction research has
started to systematically investigate how emotions interact with the bidding process. The following section gives a broad overview of different aspects of emotions in financial decision making.

Loewenstein (2000) made a distinction between immediate emotions as direct reaction to an emotional stimulus and anticipated emotions as the expected emotional processing to a salient future event. This distinction is very important when looking at emotions in financial decision making. Especially in a sequence of financial decisions the decider usually shows an immediate emotional reaction to the outcome of her decision but also anticipates these immediate emotions before making a subsequent decision. An example that clarifies this distinction is the one of a trader that realizes a painful monetary loss with a certain product. The next time before she will buy this product again, she will anticipate the feeling she had after the last loss and eventually refrain from buying this product again.

Besides immediate and anticipated emotions there is an underlying current emotional state (Ding 2005) that can be described as the emotional baseline of the decision maker. This current emotional state is influenced by immediate emotions as well as anticipated emotions.

Auction research has recently addressed the question which factors influence the current emotional state of a financial decision maker in a market environment.

Several behavioural phenomena that have been associated with irrational, emotion driven behavior will be introduced in the upcoming subsections.

### 6.3.2.1 Competition

The degree of subjectively perceived competition by bidders has often been identified as one driving force for irrational behavior, like auction fever, in financial decision making.

Malhotra et al. (2008) and Ku et al. (2005) name this emotional state “competitive arousal”. They propose time pressure, rivalry, and social facilitation and rivalry as its main driving forces.

**Time Pressure**

Time pressure is generally known for feeling arousal and increasing decision makers’ willingness to take risk (e.g. Maule et al., 2000).

According to Ku et al. (2005) one main factor that triggers perceived competition is time pressure. With respect to time pressure, Ku (2000) denotes: “bidders are highly aroused and unable to think clearly, and since decisions need to be made quickly, bidders keep bidding”.

In a Dutch auction (see description above for information about the procedure of a Dutch auction) time pressure can be induced for the decider by manipulation the speed of the clock that is used for price setting. Katok and Kwasnica (2008) show in a laboratory experiment that fast clock speeds yield lower prices in Dutch auctions than slow clock speeds. This experimental result can be interpreted as an increase in risk taking elicited by increased time pressure. Considering that financial decisions, especially those of professionals, are often made under immense in a very limited time frame time pressure is a very important factor to study in the context of financial decision making.

But time pressure is only one factor that can lead to biased decision making. Another factor that Ku et al. (2005) indentify is that of social facilitation.
Social Facilitation

The presence of other individuals undoubtedly affects the way we behave. The area of social psychology has devoted years of research on how the presence of other influences our behavior. The impact of the presence of others becomes apparent in the phenomenon of social facilitation. Social facilitation describes the finding that having an audience while performing a task can facilitate habitual responses on simple tasks and lead to better performance, whereas more complicated tasks performance is distracted by too much arousal (Zajonc, 1965). Thus experts for experts in a specific field like trading it can be beneficial for performance to have an audience, whereas for novices audience is more likely to be detrimental for performance.

Social facilitation seems to be less prominent in Internet auctions than in live auctions. Malhotra et al. (2008) attribute this to the higher degree of privacy in Internet auctions and denote that the “spotlight is dimmer” in this environment. In a field study, Ku et al. (2005) report lower revenues in Internet auctions in comparison to simultaneously conducted live auctions for the same commodity - fiberglass cows auctioned off for charities. The authors partially explain these results with an increased spotlight and media attention in the live auctions.

Rivalry & Spitefulness

Rivalry is an inherent characteristic of live and Internet auctions, as “each bidder competes against others who want the same item” (Stern and Stafford, 2006).

Literature discusses rivalry as another important factor that enhances the perception of competition in a decision maker. Ockenfels et al. (2006) argue that the “thrill of competing against other bidders” can cause an excited and competitive state-of-mind. Heyman et al. (2004) refer to this phenomenon as the “opponent effect” and Delgado et al. (2008) argue that actually the fear of losing the “social competition” inherent in auctions is responsible for seemingly risk-averse overbidding. A concept that is closely related to rivalry is spitefulness. A bidder is spiteful, if she derives an additional negative utility when her opponent wins an auction, which depends on the monetary profit of the competitor (cf. Morgan et al., 2003). For instance, firms may gain a competitive disadvantage from losing an auction, which eventually results in monetary losses (e.g. Brandt et al., 2007). Morgan et al. (2003) show that symmetric equilibrium bidding becomes more aggressive in various auctions, if bidders are spiteful. Therefore, if an agent’s utility comprises the outcomes of other agents, it can be a (rational) best response to place higher bids. In contrast, a bidder experiences a nonmonetary joy of winning, if she derives an additional positive utility from the “uniqueness of being first” in the social competition of an auction (Ku et al., 2005). Morgan et al. (2003) refer to this nonmonetary component of the joy of winning an auction as “love of winning”.

If bidders’ utility functions comprise such interdependencies, this can result in “head-to-head battles” (Ku et al., 2008) among a small (sub-) group of bidders. In a survey among bidders from live auctions, Johns and Zaichkowsky, Judith L. (2003) observe a U shape dependency between the number of bidders and the degree of rivalry. In auctions with only two active bidders, the authors state that “the bidding war was more personal”. However, when an auction attracted a large number of active bidders, there is a “race to bid on and win the item”. Murnighan (2002) observes an extreme case of how a head-to-head battle between two bidders can result in gross overbidding. Ku et al. (2005) argue that rivalry is particularly intense when only two bidders compete in a single auction. Based on data from a laboratory experiment, the authors report that bidders experience higher levels of self-report arousal and place higher bids in high rivalry treatments, i.e. when bidders face one single opponent in comparison to facing eight other individuals. Thus, so the authors conclude, rivalry and arousal seem to be higher with few rather than with many bidders. Especially for professional trades who know who the others “big players” in the market are the concept of rivalry is of practical importance.
6.3.2.2 Escalation of commitment

Literature has discovered previous investments as another elicitor for irrational decision making. The underlying concept is commonly referred to as “sunk cost fallacy” (e.g. Arkes and Blumer, 1985; Friedman et al., 2007) or “escalation of commitment” (e.g. Staw, 1976; Ariely and Simonson, 2003). These terms describe the observation that a human decider usually puts too much emphasis on recouping previous investments for which she feels personally responsible by investing further effort. Following economic theory, a decider should actually ignore sunk costs associated with previous investments and only consider future costs and benefits. Staw and Ross (1989) describe escalation of commitment as “situations in which losses have resulted from an original course of action, but where there is the possibility of turning the situation around by investing further time, money, or effort”. In the context of auctions, bidders invest in particular auction fees (e.g. Ivanova-Stenzel and Salmon, 2004b), search costs (e.g. Ariely and Simonson, 2003), transaction costs (e.g. Carare and Rothkopf, 2005), and waiting costs. According to the assumptions of this phenomenon an investor will irrationally hold on to a bad investment if she has previously put a lot of resources into it. Ku et al. (2005) report that high sunk costs lead to increased self-report levels of arousal and higher bidding activity. The authors conducted a survey experiment. Students were asked to imagine taking part in an Internet auction, for which they had already invested low, medium, or high search efforts, i.e. sunk search costs.

6.3.2.3 Joy of winning

The immediate emotion triggered by the event of actually winning an auction and receiving a positive monetary payoff is referred to as “joy of winning” (e.g. Goeree and Offerman, 2003). Traditionally, the utility from winning an auction is thought to only depend on the monetary payoff (Vickrey, 1961). However, bidders may also derive a utility from winning the social competition of an auction that goes beyond any monetary payoff (Cooper and Fang, 2008). Fliessbach et al. (2007) argue that “outperforming someone else” can induce a joy of winning in addition to mere monetary reward. This nonmonetary component is also referred to as “love of winning” (e.g. Morgan et al., 2003; Kogan and Morgan, 2009). In the following, the term joy of winning will be used to refer to its nonmonetary component.

There are contradictory results in the literature regarding the impact of anticipated joy of winning. Cooper and Fang (2008) conduct a laboratory experiment in order to analyze how the anticipation of joy of winning affects bidding behavior in a second-price sealed-bid (SPSB) auction. Although Vickrey (1961) has shown that bidders have a weakly dominant strategy in a SPSB auction to truthfully bid their individual valuation for the item, it is a common observation in experimental economics that up to 60% of the bidders place bids which exceed their valuation (cf. Kagel and Levin, 1993). Cooper and Fang report that one main explanation for such overbidding is bounded rationality, as bidders learn how to avoid costly overbidding over time. According to the authors another part of irrational behavior can be explained with interdependent utilities associated with joy of winning and spite. In contrast Goeree and Offerman (2003) find no support for the theory of anticipated joy of winning in their experiment. They explain their results with loss aversion. Another emotion that plays a role in auctions is “fear of losing” which is closely linked to the concept of regret. Delgado et al. (2008) postulate a fear of losing a social competition and argue that anticipated loser regret is much stronger that anticipated joy of winning. The role of regret will be discussed in the next section.

6.3.2.4 Regret

Regret can be defined as an aversive emotion a decider experiences upon the discovery that she could have gained a higher level of utility, if she had taken a different choice in the past (Humphrey, 2004).
Emphasizing the importance of regret in human emotional processing, Levinson (1978) argues that “regret is a common, possibly a universal, human experience”. As regret is characterized as an aversive emotion, human deciders tend to anticipate future regret and consequently avoid this emotion by changing their behavior. Ivanova-Stenzel and Salmon (2004a) argue that even if “feelings of regret” are considered irrational from a theoretical perspective, this “does not preclude their existence”. Gilovich and Medvec (1995) show, that regret is an essential experience for learning how to take advantageous decisions in the future. In terms of the somatic marker hypothesis of Bechara and Damasio (2005), the auction outcome is a primary inducer of regret, while thinking about the auction outcome during the process of decision-making is regarded as a secondary inducer. Crone et al. (2004) show that those individuals who have a stronger emotional processing of secondary inducers also take more advantageous decisions on average.

Engelbrecht-Wiggans (1989) introduces a model of post-auction regret for first-price sealed-bid (FPSB) auctions. In this model, a bidder’s utility does not only depend on her monetary profit, but also on winner and loser regret. The author argues that a winner can experience winner regret if she is told the amount of the second highest bid upon winning. Engelbrecht-Wiggans refers to this feeling as “money left on the table” regret, because ex post the winner of a FPSB auction could have gained a higher profit by shading her bid. In contrast, the loser of an auction can suffer from loser regret if she is told the amount of the highest bid upon losing. Engelbrecht-Wiggans refers to this feeling as “missed opportunities” regret, because ex post the loser of a FPSB auction may have gained a profit by raising her bid. If bidders know that they will receive post-auction information on the highest and second highest bid, they can anticipate winner and loser regret during decision-making and reflect this concern in their bidding strategy. Engelbrecht-Wiggans analytically shows that a bidder’s utility maximizing bidding strategy is independent of regret, if she puts equal weights on winner and loser regret. However, bidders place higher (lower) bids in equilibrium, if they put more weight on loser (winner) regret.

Filiz-Ozbay and Ozbay (2007) conduct a laboratory experiment in order to analyze the impact of anticipated winner and loser regret in FPSB auctions. In a between-subject design, individuals participate in a FPSB auction in which either the highest bid (loser regret), the second highest bid (winner regret), or no such information (no feedback) is revealed. In order to exclude learning effects, the authors decided for a one-shot design, in which bidders simultaneously place bids for a couple of auctions of which only one is then randomly chosen and conducted. Filiz-Ozbay and Ozbay find support for anticipated loser regret, as bidders place significantly higher bids under this condition. However, subjects did not seem to anticipate winner regret, as these bids are not significantly different from those in the no feedback treatment. Based on a post-auction questionnaire, in which subjects subjectively reported their individual feelings of regret, Filiz-Ozbay and Ozbay conclude that loser regret is significantly stronger than winner regret. However, although winner regret is not reflected in the bidding behavior, it is still experienced as soon as the auction outcome is revealed.

In contrast to Filiz-Ozbay and Ozbay (2007), Engelbrecht-Wiggans and Katok (2008) explicitly include learning effects in their laboratory experiment by letting bidders consecutively take part in a series of FPSB auctions. Additionally, the authors introduce a both regret treatment, in which the highest as well as the second highest bid are revealed. Engelbrecht-Wiggans and Katok also find support for the theory of loser regret. Further, the authors report a significant decrease of bids over time in the winner regret treatment and a slight decrease in the both regret treatment. Engelbrecht-Wiggans and Katok conclude that individuals can only then reflect winner regret in their behavior, if they have “actually experienced it several times”. However, although winner regret can supposedly be learned over time, individuals still “put more weight on the loser’s regret than on the winner’s regret”.

The impact of regret has not only been studied in the context of laboratory auctions. Kahneman and Tversky (1979) for example integrate regret and anticipated regret into their explanation why humans
tend to become more risk-loving in the domain of losses than in the domain of gains. Shefrin and Sateman (1985) follow their argumentation and to explain how the feeling of regret explains the “disposition effect”. The disposition effect describes the tendency of stock holders to hold on to losing stocks for too long while selling winning stocks too early. Thus regret is an emotion with powerful implications for decision making in trading and investment.

### 6.4 Physioeconomics

The methodology called Physioeconomics starts from the intuition that decision making is a dynamic process, which comprises not only rational but also emotional components. In order to better understand the influence of emotions and the dynamic process of human decision making, we introduce this new methodology. Physioeconomics extends existing methods of experimental economics by measuring autonomic nervous system activity using well-established Psychophysiological methodology.

In the following subsection we will provide a short introduction and a literature overview on economic experiments which already apply physiological measures.

Although the precise functional role of autonomic responses in information processing and decision-making is still debated (Bechara et al., 2005; Maia and McCelland, 2004), it has been repeatedly shown that physiological arousal systematically varies with the outcome of a choice even before feedback is given (e.g. Bechara et al., 1997; Biermann et al., 2005). These results demonstrate that autonomic responses are modulated by economic decisions and are thus capable to reveal a deeper insight into human information processing in such situations.

How do emotions affect human decision making and how can the study of emotions help economists to better understand decisions of human individuals? In his forecast on the future of economics, Thaler (2000) claims that the well-known and perfectly rational “homo economicus will become more emotional”. Thereby he indicates that economists will devote more attention to the study of emotions and include emotional factors in their models of decision making. While economic theory provides a highly elaborate methodology for analyzing organizational behavior and complex macroeconomic interrelations, economic models, though highly sophisticated and rich, often fail to capture the complexity of individual (human) decision making. Economic models tend to understand decision making as a single rational maximization of expected utility, rather than as a dynamic process involving both rational and affective components. Camerer (2003) argues that “most economic theories minimize the influence of human emotions” and Sanfey et al. (2003) even claims that economic models “idealize the decision maker as a perfectly rational cognitive machine”. While the assumption of a perfectly rational decision maker seems sensible for organizational entities, it does not hold for explaining individual behavior of human agents.

The methodology of physioeconomic is founded on the intuition that decision making is as well a cognitive process as an affective process and not a single, indivisible maximization of utility. This dynamic process comprises strategic considerations of the agents concerning the maximization of their expected payoff on the one hand (these aspects are the main focus of game theory today and are fairly well understood). On the other hand, however, there is an inevitable influence of affective or factors that also have a strong impact on the decision making process. Bechara and Damasio (2005) even argue that taking advantageous decisions is only possible in consequence of a prior accurate emotional processing. In order to better understand the influence of emotions and the dynamic process of decision making, we propose the structured methodology of Physioeconomics, which we define as:

Physioeconomics extends existing methods of experimental economics by measuring autonomic nervous system activity using well-established psychophysiological methodology, in
order to gain a deep understanding of the dynamic process of human economic decision making.

While experimental economics provides a highly reliable and sophisticated methodology for analyzing economic behavior in the laboratory, research in the domain of psychophysiology focuses on the complex interrelationship of physiological states, perceptual, cognitive, or emotional processes, and human behavior. We believe that the appropriate adaptation of psychophysiological parameters, e.g., skin conductance and heart rate, to traditional methods of experimental economics can contribute to a better understanding of human decision making. In contrast to the mere use of questionnaires and interviews, which often have to deal with the problem of subjectivity and social-desirability bias, the analysis of physiological parameters offers the intriguing opportunity to complementarily examine objective parameters that show robust correlations to emotional processes of human agents. In contrast to the domain of Neuroeconomics, Physio-economics focuses on activation of the autonomic nervous system (ANS) only, as this can be achieved with a comparatively low amount of measurement overhead and thus allows for collecting empirical data for much larger samples. Moreover, this allows for analyzing emotional processing in strategic interaction of two or more deciders in a wider range of experimental environments.

6.4.1 Existing Research

This subsection provides a literature overview on experiments in the laboratory and the field which already apply physiological measurements and have a focus on economic decision making.

6.4.1.1 Iowa gambling task experiment

One of the most prominent experiments combining economic decision making with the measurement of physiological parameters is the Iowa gambling task by Bechara et al. (1997). In the Iowa gambling task a single decision maker is given four decks of cards, from which she continuously has to draw cards without knowing how many cards have to be drawn until the game ends. Each card results either in a gain or a loss for the decision-maker. While decks A and B are disadvantageous in the long run and lead to an overall loss, the advantageous decks C and D lead to an overall gain. In a clinical study, Bechara et al. (1997) report that normal participants had higher SCRs prior to selecting from disadvantageous in comparison to advantageous decks even before the participants had reported a "hunch" which decks might be better. Even in this "pre-hunch" period, these participants decided more often for the advantageous decks. On the contrary, patients with bilateral damage of the ventromedial part of the prefrontal cortex did not show higher SCRs (skin conductance level) when deciding for disadvantageous decks. Even more striking, those participants (patients) who correctly described which were the good and bad decks still chose disadvantageously. Based on the results of the Iowa gambling task experiment, Bechara and Damasio (2005) proposed in their somatic marker hypothesis that advantageous decision making is only possible in consequence of a prior accurate emotional processing. Therefore, emotions are beneficial for decision making if they are integral to the task, but may be disruptive if they are unrelated to the task. Crone et al. (2004) analyze differences in emotional processing of healthy individuals playing the Iowa gambling task by categorizing them ex post in three performance groups: bad, moderate, and good. The authors demonstrate that there are no differences in emotional processing of participants in response to immediate punishment (primary inducer). However, Crone et al. (2004) show that bad performers turn out to have significantly lower SCRs generated by secondary inducers (i.e., thoughts regarding future losses in the moment of decision making) than good performers. Again, an accurate emotional processing seems to be essential for advantageous decision making.
6.4.1.2 Social ranking

Bault et al. (2008) analyze the influence of social ranking on decision making. In their experiment, participants chose continuously between two lotteries with different levels of risk. In the two player setting, participants can observe the choice and result of one other player, while in the one player setting, participants decide without observing the behavior of another participant. In the treatment in which the player can observe the result of the other player a concern for social ranking is induced. Skin conductance and heart rate of the participants, as well as a self-report scale indicating their subjective feeling from extremely negative to extremely positive were recorded. In comparison to regret (losses) and relief (gains) in the one player setting, Bault et al. (2008) report overall stronger SCRs when experiencing envy and gloating, i.e. the feeling associated with a loss when the other wins and vice versa. On the contrary, the authors report lower SCRs when participants experience shared regret and shared relief. Most interestingly, participants’ behavior seems to be affected by emotional experience, as they become more risk averse in later trials when playing with a risk loving counterpart and less risk averse when playing with a highly risk averse counterpart. From a game theoretic perspective there is clearly no strategic interaction. Analyzing the subjective and objective parameters of arousal, Bault et al. (2008) report a high correlation between self-reported arousal in the questionnaire and physiological SCRs. This shows that physiological measures yield valuable information about the emotional state of a decision maker which can be measured without having to rely on time absorbing self-report questionnaires. Physiological measures can be taken, while the decision maker is “at work”. This makes physiological measures so valuable for xDelia.

6.4.1.3 Power-to-take game

Another economic experiment applying physiological parameters is based on the power-to-take game. In this game two players, the take authority and the responder, are initially endowed with an equal amount of money. In the first stage the take authority decides how much money, denoted as the take rate, to take from the responder. In the second stage, the responder can decide to destroy any percentage of her own money. Ben-Shakhar et al. (2007) analyse the power-to-take game while continuously recording the responders’ SCL (skin conductance level). Additionally, the authors assess the perceived arousal of participants by using self-report questionnaires. The authors report that those responders who had a stronger increase in arousal measured by SCL destroyed larger amounts of their initial endowment. Furthermore, they find a strong correlation between self-reported anger in the questionnaire and the physiological arousal level. Ben-Shakhar et al. (2007) also tested for possible effects of the measurement equipment on participants’ behavior and found no such effects. Therefore, participants do not seem to change their behavior when physiological responses are recorded.

6.4.1.4 Dutch Auction versus English Auction

Smith and Dickhaut (2005) analyze the impact of different economic institutions on the arousal of market participants. In particular, they compare the average heart rate of decision makers while participating in a sequence of Dutch and English auctions. The authors conclude that the English auction, as a collection of all relevant stimuli, induces less emotional arousal than the Dutch auction. However, the authors do not address which specific features of the Dutch auction are in fact responsible for the reported increased emotionality. Thus, as the design of electronic markets has a significant impact of participants’ emotional processing, there is a need for further research on the emotional impact of single facets of market design.
6.4.1.5 Trading and arousal

The influence of emotions on decision making of financial traders is a highly topical discussion. In a field experiment, Lo and Repin (2002) measure physiological parameters of professional security traders during live trading sessions. A large variety of physiological parameters is subject of their analysis: skin conductance, finger pulse amplitudes, heart rate, electromyographical signals, respiration, and body temperature. The authors analyzed the impact of market events, e.g. changes in the spread or the volatility, on the physiological parameters recorded. In their results, Lo and Repin (2002) report significant physiological responses to various market events. This indicates that the decision making process of financial traders seems to be accompanied by emotions. Most interestingly, the authors find that physiological responses to market events seem to depend on the expertise of the trader, i.e. senior traders show a different pattern of emotional arousal than junior traders. This finding can be interpreted as a support for the somatic marker hypothesis of Bechara and Damasio (2005), who state that taking advantageous decisions is only possible in consequence of a prior accurate emotional processing.

6.5 Conclusion

There is a rising consensus that financial decision makers do not always follow fully rational motives like profit maximization. Instead other factors like emotional processes play part in guiding financial decisions. Laboratory research in auctions has started to reveal emotional factors that systematically influence human decision making. The question of how emotion regulation can influence behaviour in auctions has not been addressed thus far.

Auction research yields valuable insights for studying emotions in trading and investing because auctions are a simplified model of the stock market. Isolated, relevant decision situations and emotions can be studied under control and in detail in the laboratory. Because of the conceptual similarity of the decision situation in an auction and in trading the resulting achievements can be transferred to and challenged in a field study setting.

Physioeconomics is a promising new research methodology that allows for investigating emotional reactions while the decision maker is “at work”. Physiological measures mirror aspects of the emotional state of the decider without having to rely solely on time absorbing self-report questionnaires that can interfere with the dynamics of the decision process and that potentially suffer from the drawback of biased answers. Thus the combination of this methodology with experimental auctions is the perfect means to study emotions and emotion regulation. This approach sets the ground work to develop and test learning support interventions that incorporate sensor technology under controlled conditions.

6.6 References


