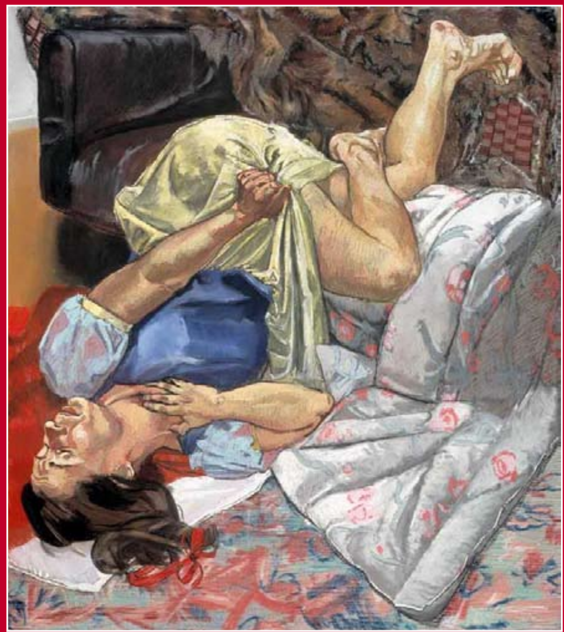
„Ich darf nichts annehmen.“ „Fürchtest du dich vor Gift?“ sprach die Alte, „siehst du, da schneide ich den Apfel in zwei Theile; den rothen Backen iß du, den weißen will ich essen.“ Der Apfel war aber so künstlich gemacht, daß der rothe Backen allein vergiftet war. Sneewittchen lusterte den schönen Apfel an, und als es sah, daß die Bäurin davon aß, so konnte es nicht länger widerstehen, streckte die Hand hinaus und nahm die giftige Hälfte.“

Schneewittchen und die sieben Zwerge, Grimms Märchen

“Snowwhite swallows the poisoned apple“ (1995), by Paula Rego depicts the interaction of risk and pain. Ever since Adam and Eve the apple symbolizes the temptation of risk, risky behaviour and wrong decisions: the consumption of this fruit leads to the knowledge of good and evil but also to the expulsion from paradise, to pain and death. Tempted by the apple Snowwhite ignores the dwarfts prohibition to accept offers from strangers and succumbs her disguised stepmothers’ attempt on her life.



ANNA MARIA JUDITH WITTWER HUMAN BEHAVIOUR UNDER THE INFLUENCE OF PAIN AND RISK. DISS. ETH No. 18806

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HUMAN BEHAVIOUR UNDER THE INFLUENCE OF PAIN AND RISK.

Physiological and Psychological Aspects of Unstable Cognitive-Affective States.

ABHANDLUNG
zur Erlangung des Titels

DOKTOR DER WISSENSCHAFTEN

der

ETH ZÜRICH

vorgelegt von

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Prof. Dr. Hans Rudolf Heinimann, Koreferent
Prof. Dr. Reinhard Nesper, Koreferent
Prof. Dr. Fritz Gutbrodt, Koreferent

2009

Entstand die Philosophie nicht auf griechischem Boden,
um die Meinung zu entthronen, in der alle Tyrannei lauert?

Vermittelst der Meinung sickert in die Seele das subtilste und perfideste Gift,
das die Seele in ihrem Grunde ändert, das aus ihr ein anderes macht.

Emmanuel Lévinas 1983

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Abstract

Human behaviour links will to actions and therefore has been the driver of human adaptation to the natural and social environment. Although numerous hypotheses and models of behaviour are described nowadays by physicians, economists, and psychologists, there still is an absence of well-founded knowledge about its basic processes. This thesis is based on the hypothesis that scientific advancement is triggered by the interaction of scientific concepts with empirical procedures, particularly experiments. Scientists create “problem spaces” where they look for new insights and findings. These border areas require expertise from various fields of knowledge: model-based experimentation (physics, engineering sciences, chemistry) and behavioural experiments (medicine, experimental economics, psychology, physiology). The Collegium Helveticum offers excellent opportunities for a transdisciplinary transfer and integration of knowledge.

The overall goal of this thesis was to study human behaviour under the influence of pain and risk in terms of physiological and psychological aspects. Our *mental model* (Chapter 1, Figure 1) integrates the relevant state-of-knowledge and the challenges: stimuli like pain or risk tasks undergo a cognitive-affective appraisal and initiate behavioural responses. This appraisal is a problem solving system, which is unstable, as it is influenced by variable physiological and psychological personality characteristics, e.g. stress levels or role-identity. The three empirical studies based on this model deliver results that are specifically discussed in six subprojects. Subprojects S1-S3 focus on pain, whereas the subprojects S4-S6 add risk. Additionally a new method of emotion induction and a new tool to measure risk behaviour were established and we built a bridge between the research fields of pain, risk and emotion:

(S1) creates a methodological basis for the analysis of pain perception and lateral effects. Our results indicate that the perception of heat pain is identical on various sites on both forearms.

To find new strategies that reduce pain perception, we analyzed in our second experiment the effect of *self-perceived role-identity* on acute pain. Results revealed that self-perceived role-identity can be elicited by our new method of emotion induction ($S2_a$) and alter pain perception: pain can be better tolerated in a hero identity, i.e. when role-identity is strong and has a meaning in life that gives pain a purpose ($S2_b$).

(S3) suggests for the first time salivary enzyme *Alpha-amylase* to be a new and objective biomarker for acute pain perception and positive arousal.

Moreover, we designed a specific task for decisions under risk, the *RALT* (Random Lottery Task). This task depicts for the first time the *limits of reproducibility* of single financial decisions with a new risk metric, the reproducible preference function. Risk taking decreased with winning probability and decision time. Moreover it is the first close-to-behaviour risk task that follows basic principles of experimental design like randomization (S4).

We analyzed several psychological and physiological correlates of risk behaviour and conclude that 1) the appreciation of security and control, and 2) calmness are *predictors* that explain inter-individual variations of risk behaviour. Interestingly, this subproject gives the first evidence that risk behaviour is consistent for the domains of coping with pain as well as financial decisions, as risk taking correlates with pain tolerance (S5).

Results of (S6) indicate that under the current conditions positive emotional states prime on gains as they increased risk taking behaviour and decreased pain perception, whereas negative emotional states prime on losses as they increased risk aversion and stress induced analgesia. This provides a basis for the understanding of emotions as maximum ruin avoidance strategies.

Our results can be seen under broader, more disputable aspects. The general discussion suggests that emotional states are *reproducible*, transferable between individuals and are not purely subjective. However our results indicate that the study of the *limits of reproducibility*, the instability in human behaviour under risk and pain is also of interest, as there is scope for the improvement of behaviour. Moreover, *biological sex* and role-identity had an effect on behaviour, as on average women were more risk averse in pain and financial decisions. We suggest that traditionally male gender roles like *hero identities* can mainly be of advantage in states of acute pain, though in financial decision they prime risk taking. High *social appraisal of risky decisions* is discussed as an important cause for the wrong decisions and the settings that caused disasters like the financial crisis. We presume that there is a need for men and women with „mixed skills“ in many positions, including an ability to accept criticism and a less aggressive, more empathic and loyal lead. Further research is required with respect to this point.

Ongoing research in this matter could help to integrate social sciences and natural sciences and improve economic and physiological concepts.

Zusammenfassung

Das menschliche Verhalten verbindet den Willen mit der Handlung und ermöglicht so die Anpassung des Menschen an sein natürliches und soziales Umfeld. Mediziner, Ökonomen und Psychologen haben zahlreiche Verhaltensmodelle entworfen, dennoch ist unser Wissen über die grundlegenden Prozesse noch immer begrenzt. Diese Arbeit basiert auf der Annahme, dass wissenschaftliche Erkenntnis durch die Interaktion zwischen Konzepten und empirischen Versuchen entsteht. Diese Konzepte beschreiben unerforschte Gebiete, deren Untersuchung oft Wissen aus unterschiedlichen Fachbereichen erfordert. Im Gegenstandsfall etwa modell-basierte Forschung (Physik, Chemie und Ingenieurwissenschaften) und Verhaltensforschung (Medizin, Ökonomie, Physiologie, Psychologie). Das Collegium Helveticum ermöglicht diese transdiszipilinäre Integration von Wissen in neuartiger Weise.

Das Ziel dieser Arbeit war die Untersuchung der physiologischen und psychologischen Aspekte des menschlichen Verhaltens unter dem Einfluss von Schmerz und Risiko. Unser mentales Modell bildet den Stand der Forschung und die Herausforderungen auf diesem Gebiet ab (Kapitel 1, Abbildung 1): Stimuli wie Schmerz oder Risikospiele werden affektiv-kognitiv bewertet und führen zu einem spezifischen Verhalten. Einfluss auf diese Bewertung haben variable physiologische und psychologische Eigenschaften wie Stress oder Rollenidentität. Auf diesem Modell basieren die drei empirischen Studien dieser Arbeit, deren Resultate anhand von sechs spezifischen Projekten (S1-S6) diskutiert werden. Die Projekte S1-S3 haben ihren Fokus auf dem Gebiet der Schmerzforschung, während S4-S6 zusätzlich Risikoforschung umfassen. Der Schwerpunkt dieser Arbeit liegt in der Entwicklung eines neuen Rollenspiels zur Emotionsinduktion und in der Entwicklung des neuen Risikotools RALT (Random Lottery Task). Weiters umfasst diese Arbeit erstmals die Bereiche Schmerzforschung, Risikoforschung und Emotionsforschung.

Das erste Experiment liefert eine methodische Grundlage, um *Schmerzempfindung* und Lateralitätseffekte weiter zu erforschen. Unsere Resultate zeigen, dass die Wahrnehmung von schmerzhaften Hitzereizen an verschiedenen Positionen auf beiden Unterarmen identisch ist (S1).

Mit dem Ziel, neue, emotionale Strategien zur Schmerzhemmung zu finden, untersuchten wir den Effekt des Selbstbildes auf die Schmerzempfindung. Ein neu entwickeltes *Rollenspiel* induzierte spezifische Selbstbilder ($S2_a$) welche einen *Effekt auf die Schmerzempfindung* hatten: In einer Heldenrolle, mit einem starken und sinnbehaften Selbstbild, war Schmerz besser erträglich ($S2_b$).

Projekt (S3) stellt das Speichelenzym Alpha-Amylase als neuen und objektiven Biomarker für akuten Schmerz und positive Erregung vor.

Das Risikotool *RALT* (Random Lottery Task) wurde entwickelt um finanzielle Entscheidungen unter dem Einfluss von Risiko zu messen und bildet erstmals die *Grenzen der Reproduzierbarkeit bei einzelnen finanziellen Entscheidungen* ab (S4). Unser neues Risikomass, die Präferenzfunktion, zeigten eine Abnahme der Risikobereitschaft mit zunehmender Gewinnwahrscheinlichkeit und Entscheidungszeit. RALT ist das erste Risikotool, das naturnahes Verhalten abbildet und insbesondere durch vollständige Randomisierung den grundlegenden Anforderungen für experimentelles Design entspricht.

Bei der Untersuchung von zahlreichen physiologischen und psychologischen Korrelaten von Risikoverhalten im Projekt (S5) stellte sich heraus, dass die Sammelbegriffe 1) Wertschätzung von Sicherheit und Kontrolle, sowie 2) Gelassenheit mit Risikoaversion einhergehen und uns somit eine *Vorhersage* von zwischenmenschlichen Unterschieden im Risikoverhalten erlauben. Interessant ist auch das Resultat, dass sich die Risikobereitschaft im Umgang mit Schmerz und bei finanziellen Entscheidungen entsprach: Hohe Schmerztoleranzen korrelierten mit hoher Risikobereitschaft.

Projekt (S6) liefert Grundlagen inwieweit sich Emotionen als Problemlösungsstrategien eignen. Die Resultate weisen darauf hin, dass positive emotionale Zustände das Verhalten auf Gewinne ausrichten, da sie zu risikobereitem Verhalten und zu einer Abnahme der Schmerzempfindung führen. Negative emotionale Zustände hingegen scheinen das Verhalten auf Verluste auszurichten, da sie mit Risikoaversion und Stressanalgesie einhergehen.

Unsere Forschungsresultate können auch aus einem weiteren, polemischen Blickwinkel betrachtet werden. Wir schlagen in der allgemeinen Diskussion dieser Arbeit vor, dass emotionale Zustände nicht rein subjektiv, sondern reproduzierbar, übertragbar von Individuum zu Individuum sind. Unsere Resultate beschreiben aber auch die Grenzen der Reproduzierbarkeit und zeigen, dass die Instabilität von menschlichem Verhalten unter dem Einfluss von Schmerz und Risiko von Interesse ist, da sie ein Potential einer positiven Veränderung des Verhaltens beinhaltet. Wichtige Einflussfaktoren auf das Verhalten waren sowohl das biologische Geschlecht der Probanden als auch ihre Geschlechterrolle. Im Durchschnitt waren Frauen risikoaverser bei Schmerz und bei finanziellen Entscheidungen. Wir schlagen vor, dass traditionelle, männliche Geschlechterrollen wie die Helden-Identitäten vor allem in Zuständen wie akutem Schmerz von Vorteil sind, während sie bei finanziellen Entscheidungen zu einer erhöhten Risikobereitschaft führen. Die positive, gesellschaftliche Bewertung von riskanten Entscheidungen ist vermutlich ein wichtiger Grund für kontinuierliche Fehlentscheidungen und ihre Folgen, wie etwa die Finanzkrise. Hier könnten „mixed skills“ wie Wertschätzung von Kontrolle und Sicherheit und Gelassenheit wichtige Pole sein. Sogar unsere Sorgen könnten ein guter Ratgeber sein, denn das Schlimmste fürchten, heilt oft das Schlimmste, das wusste schon William Shakespeare.

Weitere Studien könnten die Integration der Sozial- und Naturwissenschaften im Forschungsbereich Verhalten ermöglichen und zur Verbesserung ökonomischer und medizinischer Konzepte dienen.

Preface

Shared knowledge is the only meaningful resource.

After Peter Drucker

The abolition of torture as “the mother of many and big lies” (Praetorius) by Friedrich the Great was based upon insight from Montaigne, Voltaire, Montesquieu und Thomasius, upon knowledge from theology, philosophy, law and medicine. Who was the last great polymath? Us who are happy to stand on the shoulders of Einstein, Escher and Bach are on a tightrope walk when we are on our own. Can we share emotions? Can we measure risk? How do we decide? One field of science alone cannot answer today’s socially relevant questions. Thanks to serendipity we know that the “dirty drug”, the medicine that is not pure but contains many active components, is more effective. Now it is time to see if this concept can also be adapted to the deepening of knowledge.

A bottom up approach of transdisciplinar works at the Collegium Helveticum groups specialists from different fields in order to develop joint hypotheses. This approach is in strong contrast to common interdisciplinary methods that develop a hypotheses in one field while adapting methods from other scientific fields. If my knowledge were a landscape and my discipline a lawn, this method would allow me to let the grass spread further over the borders. – In contrast to this, the bottom up approach is a winged seed that sprouts in unknown landscapes. Observations in absolutely new fields of science, the development of new hypotheses or even a shift of paradigm can be achieved. Is the work presented in this thesis a spreading of the lawn? I cannot answer this question, but I surely know that the scientific process from vague ideas to almost stone hard facts was truly “dirty science”. I was allowed to develop, present and sharpen ideas and hypothesis with experts from several fields. Intense discussions at many meetings influenced our ways of thinking and allowed me to improve a precision of language, hypotheses and study protocols that would otherwise hardly have been found. In these open, inspiring and interested surroundings, it was possible to bridge between the fields of emotion, pain and risk research. This collaboration was a truly transdisciplinar approach combining engineering science with pain research in each step of scientific progress. How correct is the work presented in this thesis? In contrast to common sense or opinion, science is humble. Scientific results are only valid until they are proven wrong. In accordance with this, our results are only valid until they are found to be wrong.

I thank my doctoral adviser, Professor Gerd Folkers for the way he is able to bring out the best of each student by giving him all his freedom, advice and support. I admire his infectious enthusiasm, originality, well-founded knowledge, and his visionary guidance. I thank him for his interest in new ideas. He has created a unique environment for doing a doctorate. I am looking forward to our future work!

I thank my co-referee, Professor Hans Rudolf Heinimann for his advice and his support. I admire his interest in basic research that pushes the envelope, his funded knowledge in various fields, especially in statistics and mathematics. I am grateful that he seized the opportunity for our collaboration on risk behaviour and I am looking forward to our future work!

I thank my co-referee, Professor Reinhard Nesper for his inspiring ideas, and his interest for my research. I admire his ability of looking over the edge and his creativity. For years he has been the defender of abilities that would be otherwise neglected by traditional education.

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I thank Elvan Kut and Nils Schaffner. We spent a very wonderful and a very fruitful time in our office doing science and also on favourite excursions. Amongst others, I admire their friendliness, and their ability to plan ahead, make to-do lists, work most efficiently, and to be relaxed. Last but not least their skills to program, apply, and repair all kinds of strange and mean machines.

I thank Doctor Victor Candia, our senior scientist, who accompanied all our empirical research. I admire his abilities in experimental design, statistical analysis and paper writing skills, as well as his ability to keep a tight focus. He helped to adapt this work to the standards of scientific research, from the ethical proposals to the finished journal paper. I am looking forward to our future work.

I gratefully thank Philipp Elbert who kindly accompanied me throughout my thesis. I admire his fruitful advice, also concerning presentations or articles. I thank him for his IT support and also for carefully proofreading my thesis.

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I thank Hartmut von Sass for discussions and excursions on the edge between philosophy and biology. I would like to spend hours just listening. I am looking forward to our studies on ambiguity.

I thank Raffaella Pitzurra for our scientific and statistical discussions and her solutions for the good life of a PhD student.

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I specially thank Albert Wittwer for his inspiring scientific ideas and the mentoring throughout my thesis.

Herzlichst danke ich vor allem Marina Wittwer, Irma Muther, Suma Wittwer und Elfriede Hueller für ihre liebevolle Unterstützung während meines Doktorates.

I thank all my colleagues in the Collegium Helveticum. I thank Rainer Egloff for his beautiful book "Archäologie der Zukunft" and valuable advice in many different scientific topics, Sebastian Ulbrich for our discussion on the structure of the Collegium Helveticum, Johannes Fehr for his scepticism and for his advice concerning the role-plays, Hanspeter Gschwend for our inspiring discussions with Alice, Martin Boyer for our time especially in the Villa Lanna and in the Drucki, Rene Bill for transforming words into emotions, Thomas Meier for converting emotions into words, Vladimir Pliska for our discussions in Villa Lanna and on gender differences, Professor Wolfgang Gessler for our discussions on animals and robots.

I thank the Collegium Helveticum, the Cogito Foundation, the ETH Zürich and the University of Zürich for supporting this thesis.

1 Mental Model, Aims and Essence of the Thesis

1.1 Introduction to this thesis

Human behaviour is not yet well understood. The Technology Review magazine asked readers about the most profound questions of science (Hazen 1997). About one third of all respondents – by far the largest group – placed questions about the mind, the brain, and the nature of consciousness near the top of their lists. Typical questions were: How does the mind work? What are emotions? What is love? Can you build a conscious machine? What is the origin of creativity? *Behaviour* ultimately links will to actions and therefore has been the driver of human adaptation to the natural and social environment. Humans have to be able to construct novel combinations of responses, to plan ahead, and to choose the most advantageous option of response. Behaviour is a result of the mechanisms that economists, doctors and psychologists for a long time could only study on at the surface, by observation. Complex organisms in complex environments cannot rely on standard response patterns, they need problem solving strategies. Moreover, traditional disciplines study human behaviour mainly within the scope of the conscious levels of life regulation. Currently, novel interface disciplines have been emerging, especially neuroeconomics, cognitive neurosciences, or neurobiology.

This chapter integrates the *relevant state-of-knowledge,* the *challenges*, and our *hypotheses* about human behaviour under influence of pain and risk. Moreover it offers an overview of objectives, methods, results, deliverables and innovative aspects of this thesis. The hypotheses were tested in empirical experiments with healthy volunteers. The specific background, challenges and the results of these experiments are discussed in *six subprojects* (Chapters 4-9). The first two subprojects have been published in Pain and Neuroscience Letters, the other four show potential for their submission as journal papers. Subprojects S1-S3 focus on pain, to which risk is added in the subprojects S4-S6. Importantly this thesis has established a new method of emotion induction (S2) and a new tool to measure risk behaviour (S4). The appendix contains the role-plays developed for this purpose. Chapter 2 gives an overview on the relevant state of knowledge: the effect of unstable cognitive-affective states on unstable human behaviour under the influence of pain and risk. Moreover it offers working definitions for the terms “*emotion*”, “*pain*” and “*risk*”. In the general discussion the results of the empirical experiments are presented under broader, more disputable aspects: the reproducibility of emotional states between individuals; the effect of biological sex on human behaviour; hero identities and their effect on behaviour under the influence of risk and pain; the limits of reproducibility in human behaviour that offer scope for its improvement. The work presented in this thesis can be continued in different fields, however we focus on the limits of reproducibility in human behaviour. Chapter 10.8 presents further studies that show potential for publication, as data has already been collected.

1.2 Subject matter model of human behaviour under the influence of pain and risk

Our abstract subject matter model illustrates the integration of the relevant state-of-knowledge and the challenges in the field of human behaviour under the influence of pain and risk: Figure 1 depicts that stimuli like pain or risk tasks (input) undergo a cognitive-affective appraisal system, which senses, appraises and transforms external stimuli and initiates behavioural responses (output). This appraisal system is a problem solving strategy and it is unstable, as it is influenced by emotion induction (control factor). The measurement of blocks will control other nuisance factors like biological gender and domain specific expertise (nuisance factors). The output variables of interest (output) are *pain perception, risk behaviour,* as well as *physiological* and *physiological parameters* like skin conductance and Alpha-amylase levels.

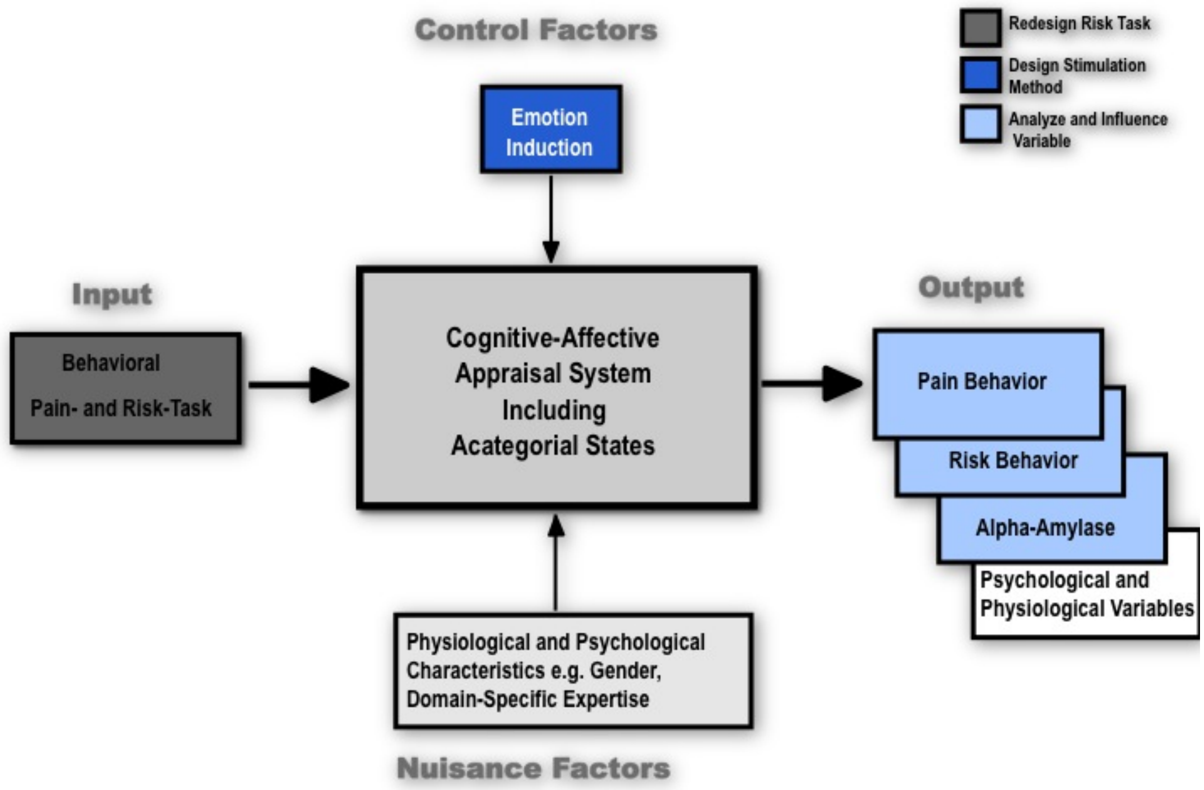


Figure 1 Our subject matter model to study the mechanisms of human behaviour. The systems view shows the transformation of input (task) into output (behaviour) that has one or more observable responses. Some of the process variables (control factors) are assumed to be fully controllable for the purpose of experimental testing, whereas other variables (nuisance factors) are uncontrollable and produce noise that affects response.

1.3 Eight aims and short hypotheses

This thesis aims at understanding the effects of cognitive-affective appraisal on behaviour and builds a bridge between the research fields of risk, pain, and emotion. Observing our subject matter model (Figure 1) we face *eight challenges* that shall be achieved by behavioural experiments and present eight short hypotheses:

S1) Analyze heat pain perception on the forearm.

"The perception of heat pain is identical on both human forearm sides and different sites."

$S2_a$) Design a new method of emotion induction by *role-play strategies*.

"Literary role plays spoken by a professional actor induce specific emotions."

$S2_b$) Analyze the effect of self-perceived role-identity on pain perception.

"Hero role identities that imply a strong character and concepts that give pain a meaning reduce pain."

S0) Observations on the reproducibility of mental states.

"Literature, arts, and humanities allow the sharing of subjective states".

S3) Analyze the salivary enzyme salivary Alpha-amylase (sAA) as a marker for pain perception and arousal.

"Pain stimuli, and antithetic emotions activate sAA."

S4) Design a new "close-to-behaviour" *financial risk task* RALT (Random Lottery Task).

"RALT is an improved risk task for decisions under risk. It depicts that risk behaviour can be measured but is not always reproducible."

S5) Predict risk taking in RALT with personality specific correlates.

"Calmness and appreciation of security and control predict risk behaviour in RALT"

S6) Analyze the effect of affective picture viewing on pain perception and RALT.

"Positive pictures prime on gains and reduce pain perception and risk aversion, whereas negative pictures prime on losses."

Points (S1) and (S2b) have been published as two first author journal papers together with Nils Schaffner and Elvan Kut (Kut, Schaffner et al. 2007; Schaffner, Wittwer et al. 2008). Point (S2a) has been published in the latter paper. Point (S0) has been published together with Gerd Folkers in a conference paper (Folkers and Wittwer 2006). Point (S3) is to be submitted as a journal paper. Points (S4)-(S6) will also be submitted in 2010 together with Hans Rudolf Heinimann. Ongoing research shall evaluate correlates for good/prosperous decisions and evolve training concepts for executive positions. In cooperation with Jannis Wernery, Reinhard Nesper, and Harald Atmanspacher concepts of "reproducibility" and "acategoriality" will be further analyzed.

1.4 Essence of the Subprojects

Table 1 Essence of the behavioural experiments of the subprojects. Subprojects S1-S3 focus on pain behaviour, Subprojects S4-S6 focus on pain and risk behaviour. Most importantly this thesis established a new method of emotion induction (S2) and a new tool to measure risk behaviour (S4).

	(S1)	(S2)	(S3)	(S4)	(S5)	(S6)
Short Title	**Heat pain perception on the forearm**	**Role play study**	**Alpha-amylase (sAA) as a biomarker**	**Design of a new risk task RALT**	**The prediction of financial risk behaviour**	**Emotions modulate behaviour in risk and pain**
Main Topic	The basic principles of the psycho physiolo-gical measure-ment of pain perception.	The effect of self-perceived role-identity on pain perception.	sAA as a potential biomarker for the human stress response.	The design of a tool to measure financial risk behaviour.	The prediction of financial risk behaviour with physiological prognostics.	The effect of antithetic emotions on pain and risk behaviour.

Objectives	▪ Investigate the relation between forearm side and site and heat pain threshold and tolerance. ▪ Provide a methodological basis for experiments concerning pain perception and laterality effects.	▪ Design a new method for emotion induction: the role-play strategies. ▪ Identify the effect of antithetic role identities of *heroes* and *victims* and their associated emotions on pain perception. ▪ Provide a inducible and reproducible role-identity that can reduce pain perception.	▪ Establish sAA as a new biomarker for pain perception and emotion induction.	▪ Depict within subject variability in behaviour ▪ Design online task to meet standards of experimental design [randomization, independent decisions, no framing] and measure "laboratory-world behaviour". ▪ Improve statistical inference approach	▪ Explain and predict *inter-individual* variation of risk behaviour with physiological and psychological correlates of RALT. ▪ Physiological objectivation of risk preference.	▪ Identify the effect of positive and negative emotional states on pain perception and risk behaviour in RALT (*intra personal* variation) ▪ Understand mechanisms of good and prosperous decisions.
Approach Method	▪ Factorial experiment with 18 volunteers. ▪ Blocking controls the nuisance factor gender and the control factors forearm side and forearm site.	▪ Factorial experiment with 21 actors and role players. ▪ Blocking controls the nuisance factor gender and control factor role-identity. ▪ Based on methodology of package S1.	▪ Factorial experiment with 27 volunteers (S3-S6). ▪ Blocking controls the nuisance factor gender.	▪ Factorial experiment with 27 volunteers (S3-S6). ▪ Design approach, following a systems engineering sequence (requirements, design, implementation, verification, test, validation). ▪ Model-based analysis of test data, based on generalized linear model theory. ▪ Blocking controls nuisance factor gender.	▪ Factorial experiment with 27 volunteers (S3-S6). ▪ Blocking controls nuisance factor gender. ▪ Based on methodology of package S4. ▪ Principal component analysis of correlates.	▪ Factorial experiment with 27 volunteers (S3-S6). ▪ Blocking controls nuisance factor gender and control factor emotion induction. ▪ Based on methodology of package S4.

Results	1. Pain threshold and tolerance do not differ within and across forearm sites. 2. Men showed higher pain tolerance than women.	1. Specific role identities and associated emotions are elicited through role-plays. 2. Role identities alter quality and intensity of pain perception: pain can be better tolerated in an unpleasant context, when role-identity confers pain as meaningful. 3. Pain tolerance increased for actors in *heroes/heroine* identities and was evaluated as more intense whereas pain tolerance decreased for the same actors in *victim* identities and was evaluated as more affectively loaded. 4. Men showed higher pain tolerance than women but hero identities had the same effect on men and women.	1. Visual analogue scale intensity and valence ratings of acute heat pain stimuli correlate with sAA levels. 2. Antithetic picture viewing increases sAA levels. 3. Perceived intensity of erotic pictures correlates with sAA levels.	1. First risk tool closer to behaviour, without a framing effect, supporting nuisance control techniques. 2. Preference functions are *a new risk metric* that depicts a lack of reproducibi-lity by intra-individual variation of risk behaviour. 3. Women were more risk averse and had wider preference functions. 4. Increasing *winning probability* decreased risk proneness; *slow* decisions were more risk averse than fast decisions; risk aversion increased with *accumulated playtime*. 5. RALT results correlate with standard winning lotteries (Fehr-Duda 2006).	1. Risk aversion occurs with a role-identity including 1) calmness and 2) an estimation of security and control, whereas risk proneness occurs for the opposite. 2. High *estimation of security and control* included focus on the security of decisions, high self efficacy, low feminine and high masculine gender role, low narcissism, low social externality, low pain tolerance. 3. High levels of *calmness* included high calmness ratings and low ratings of subjective pain perception and arousal by erotic pictures.	1. Concerning pain perception negative picture viewing lead to stress induced analgesia, while positive picture viewing increased tolerance and threshold. 2. Concerning RALT, negative picture viewing increased risk aversion, while positive picture viewing increased risk proneness. 3. Apparently negative affective pictures prime the decision-maker on losses and increase conservative behaviour while positive affective pictures prime on gains and increase risk proneness.

Innovative Aspects	1. Comple-tion of previous reports on side effects in heat pain perception by analyzing the effect of *site*.	1. New and specific *method of emotion induction*. 2. First study on the effect of a learnable role-identity on pain perception.	1. First study on sAA as a biomarker for acute *pain perception* and *positive arousal during erotic picture viewing*.	1. First risk tool for the investigation of risky decisions. 2. First depiction of *intra-individual variation* of risk behaviour (preference switch). 3. First close-to-behaviour risk tasks following basic principals of experimental design.	1. First bridge between the two research fields of pain and risk. 2. First prediction of risk behaviour including pain perception and several physiological correlates.	1. First evidence on the effect of antithetic picture viewing on decisions under risk, heat pain threshold and tolerance.
Deliverables	Secure basis for experimen-ters who can freely chose and change three stimulation sites on both forearms. Secure basis for the assessment of laterality effects of painful stimulation.	▪ Scientific basis for the fortification of role identities in pain therapy. ▪ Role-play strategies may be of value for new pain management strategies. ▪ Literary role-plays as a new method of role induction that produce reproducible subjective states.	▪ New biomarker for the objectiva-tion of pain perception and positive arousal.	▪ New risk tool RALT. ▪ Better measurement of risk behaviour. ▪ Improved understanding on the limits of reproducibility in decision behaviour.	▪ Psycho Physiolo-gical objectivation of risk preference.	▪ Basis for the understanding of antithetic emotions on decision behaviour and ▪ on good and prosperous decision-making. ▪ Training concepts.

2 State of Knowledge

2.1 What is an emotion?

…it is a mistake to confuse the evidence that we have about a subject matter for the subject matter itself. The subject matter of psychology is the human mind, and human behaviour is evidence for the existence and features of the mind, but is not itself the mind.

John Searle (Searle 2004)

...Emotional phenomena are noninstrumental behaviours and noninstrumental features of behaviour, physiological changes, and evaluative, subject-related experiences, as evoked by external or mental events, and primarily by the significance of such events. An emotion is either the occurrence of such phenomena or the inner determinant of such phenomena...

Nico H. Frijda (Frijda 1886)

2.1.1 Attributes of emotions

Numerous models and definitions of emotions are discussed nowadays, and emotions have been analyzed by the worlds leading philosophers. They have been regarded as mere physiological, mere psychological and as the opposite of cognition. This Chapter shall give a brief overview of specific attributes of emotional states:

Approaches: William James and Carl Lange concluded in the 19th century that the experience of emotions results from the perception of specific, unique patterns of somatovisceral arousal (James 1884). Currently researchers like Antonio Damasio or Joseph LeDoux follow this way of reasoning (Bechera and Damasio 2002). These *Materialist* and *Behaviouralist* approaches depict emotional states as experiences of bodily states, or as increased activity of the brain. *Functionalist* approaches, such as some appraisal models, define emotions as their function and causal relation rather than their effects on brain and body (Scherer and Ekman 1984; Frijda 1986; Lazarus 1991). Researchers like Scherer et al. placed the study of emotions on an accepted empirical base, e.g. by the study of facial expressions and their relation to emotions. Some aspects of such expressions are agreed to be human universals, as was already suggested by Charles Darwin (Darwin 1871) in "*The expression of the emotions in man and animals*" although how they are best analyzed remains controversial.

Approaches of *biological naturalism* suggest that the scientific study of emotions also needs a description of what is subjectively felt, as knowing about the brain activity alone will not provide full scientific account of emotion experience. Biological naturalism accounts to John Searle's approach to the body-mind problem. Consciousness is treated as a biological phenomenon part of the natural world. Conscious states are defined as subjective, content rich, primarily intentional events that are constituted by but not redefined as neurobiological events (Barrett, Mesquita et al. 2007).

Problem solving. Already in the late 60ies Simon et al. argued that because resources are always finite, any computational system operating in a complex environment needs some system for handling interruptions, like the emotional system of human beings (Simon 1967). Keith Oatley defines three large problems in the ordinary world. These three problems ensure that fully rational solutions to most problems in life are rare:

1. Mental models are always incomplete and sometimes incorrect; resources of time and power are always limited.
2. A human being typically has multiple goals, not all can be reconciled.
3. Human beings are those agents who accomplish together what they cannot do alone; hence individual goals and plans are typically parts of distributed cognitive systems.

„Humans′ biologically based solution is the system of emotions. These provide genetically based heuristics for situations that affect ongoing action and that have recurred during evolution (e.g., threats, losses, frustrations), they outline scripts for coordination with others during cooperation, social threat, interpersonal conflict, etc.; and they serve as bases for constructing new parts of the cognitive system when older parts are found wrong or inadequate.“ (Oatley 2008)

Relationality. Emotions are relational – they relate selves to events in the world (Arnold 1954). These events are consciously or unconsciously appraised as to their effect on the subject's *goals*. *Appraisal* researchers have shown that the produced emotion depends on the appraisal of the event. Each emotion produces an action impulse, a “core relational theme” (Lazarus 1991) or “action tendency” (Frijda 1886) priming behaviour.

Neuro-physiological systems. In line with previous research, Lang et al. proposed that emotions are the products of Darwinian evolution (Lang 1995). It is assumed that emotions developed from primitive and reflexive reactions to appetitive or aversive stimuli that facilitated survival. As the authors propose the neural mechanisms of human emotion and motivation are preserved in the human brain in sub-cortical and deep-cortical structures that have a two factor motivational organization, in the form of an *appetitive* and a *defensive system*. Thus these two brain systems respond to appetitive or aversive stimuli like fear (LeDoux 2000). Moreover there are good arguments to support the so-called "circumplex model" which assumes that all emotions can also be described as a linear combination of two underlying, largely independent neuro-physiological systems of *valence* and *arousal*. The valence system determines the degree to which an emotion is pleasant or unpleasant, whereas the arousal system determines the degree by which it is behaviourally activating (Posner, Russell et al. 2008)

Emotion and Cognition. The mechanisms of emotion and cognition appear to be intertwined in all stages of stimulus processing – the neural substrates are not segregated. Scientists agree that classic divisions between studies on emotion and cognition may be unrealistic, as an understanding of human cognition without an appreciation of emotional aspects like the social, and motivational context results in a limited understanding (Phelps 2006; Pessoa 2008).

2.1.2 A short definition of emotion

In this thesis, in appreciation of William James, Baruch de Spinoza, and Nico Frijda emotions are understood as *a psycho-physiological process that functions in the management of goals*, a readiness to act in a certain way, a prioritization. They are triggered by a certain stimulus, and lead to a change of the *physiological state*. This change of physiology undergoes an appraisal and leads to an *action tendency,* the core of an emotion, and a *specific behaviour*, e.g. to run away or to fight. Emotions prime behaviour in a very efficient way in order to survive in difficult situations, when there is no time to think or ponder whether it is wrong or right to run. This process is often accompanied by a *subjective change of feelings*, though emotions are not always conscious. An emotion is positive, when a goal is intended and negative, when a goal is impeded. We inherited our emotions, as they reflect neuro-genetic memory, hence the product of a Darwinian evolution. Still we can influence emotions by training.

Terminology on emotion is not consistent. Terms like “affect”, “emotion”, “mood”, and “visceral factors” have been in use for similar phenomena. We are following Loewenstein who has been using visceral factors (passions) as an umbrella term for three different phenomena: (1) drive states like hunger or thirst that are stimulated by the internal environment, (2) intense states like emotions or affects, or milder, longer lasting moods stimulated by the external environment, and (3) feeling states, such as pain (Loewenstein 2000).

2.2 What is pain?

The typical concern of the Philosopher of Mind might be represented by the three questions: (1) How do we know that other people have pains? (2) Are pains brain states, (3) What is the analysis of the concept of pain?

Hilary Puntam

2.2.1 Attributes of pain

Pain is a multi-faceted experience. Nobody in a state of pain would deny its objectivity, though pain sensation with its emotional and subjective quality remains difficult to measure, it's causes still need to be discovered, we are still in search of better physiological and psychological painkillers. It seems as if some leading thinker holds indeed every conceivable position today. Some philosophers and neuroscientists find pain is completely *objective*, a functional state, a behavioural reaction or some type of perception. Some think it is completely *subjective*, essentially private and mysterious. Finally some disagree with both conceptions and propose it is not a state at all but an attitudinal relation. While reading the following paragraphs, we can at least conclude that several philosophers are mistaken when they conclude that there are no such things as pain, that pain is located in our limbs, that pain is purely subjective, or that pain is a reactive behaviour – for our pain system is complex and contains subsystems processing different information (Hardcastle 1999).

A scattered history on pain. During antiquity pain was neither considered an alarm bell nor a watchdog, but a disorder itself and remedies were, of course rather primitive. Indeed the old adage saying cited in the Hippocratic Corpus (ca. 430–380 A.D.) still holds today, namely that "pain cures pain"; that "pain signifies" the locus of illness and is essential to diagnostics and the medical interventions necessary to achieve healing. Galen (second century A.D.) argued that pain is a sense. Around the twelfth century with Christianity's emphasis on Christ's suffering and incarnation, pain became a divine punishment or a sign of having been chosen by God. Descartes returns us to the view of Galen. For Descartes, animal spirits move through the body's nerve tubes. Pain is a sensation perceived by the soul, instead of by the body. Sydenham in the seventeenth century hypothesized that there was an "internal man" sensing pain consciously through reason. By the eighteenth century pain had become secularized, it's study was divorced from sin, evil and punishment. Pain was now seen as a warning, drawing attention to danger to our bodies. There was some discussion whether silencing the pain would also silence the messenger. Medicine caused suffering and doctors were calculating the value of life against the extent of suffering. There was still disagreement whether pain was mechanistic (mechanists) or both physiological and psychological (vitalists). By the end of the eighteenth century vitalists were the majority and science strove to understand it's detailed mechanisms. Twentieth century research sees us trying to figure our how pain works as both physiological and psychological phenomena. Pain historian Roselyn Rey concludes that there was no decisive progress between the methods available in Greco-Roman times and those at the beginning of the 19th century; there may actually have been some regressions. Whereas the beginning of the 19th century witnessed a major leap forward with the discovery of morphine, ending with the discovery of aspirin, the 20th century has yet to have to produce anything of such revolutionary moment (Rey 1995). (Hardcastle 1999)

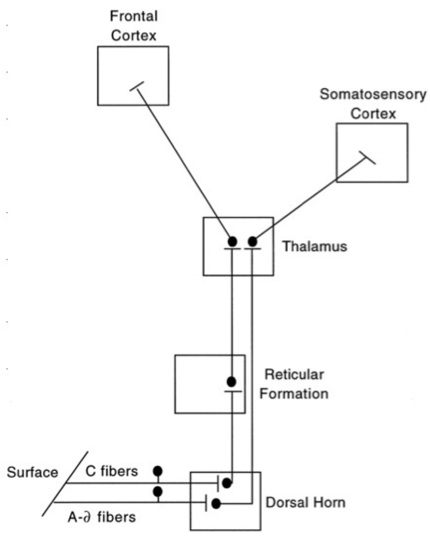
The human sensory reception (Britannica 2007). The human sensory reception is a means by which the human organism reacts to changes in the external and internal environments. Ancient philosophers called the human senses "the windows of the soul," and Aristotle enumerated at least five senses – sight, hearing, smell, taste, and touch – and his influence has been so enduring that many people still speak of the five senses as if there were no others. Yet, the human skin alone is now regarded as mediating a number of different modalities or senses e.g., hot, cold, pressure, and pain. The modern sensory catalogue also includes a kinaesthetic sense in muscles, tendons, and joints, and a sense of balance or equilibrium, the so-called vestibular organs of the inner ear stimulated by gravity and acceleration. In addition, there are receptors within the circulatory system that are sensitive to carbon dioxide gas in the blood or to changes in blood pressure; and there are receptors in the digestive tract that appear to mediate such experiences as hunger and thirst. Not all receptors give rise to direct sensory awareness; cardiovascular receptors function largely in reflexes that adjust blood pressure or heart rate without the person being conscious of them. Though perceptible as hunger pangs, feelings of hunger are not exclusively mediated by the gastric receptors. Some brain cells may also participate as "hunger" receptors. This is especially true of cells in the lower parts of the brain such as the hypothalamus where some cells have been found to be sensitive to changes in blood chemistry (water and other products of digestion) and even to changes in temperature within the brain itself.

One way to classify sensory structures is by the stimuli to which they normally respond; thus, there are photoreceptors for light, mechanoreceptors for distortion or bending, thermoreceptors for heat, chemoreceptors e.g., for chemical odours, and *nociceptors* for painful stimuli. This classification is useful because it makes clear that various sense organs can share common features in the way they transduce stimulus energy into nerve impulses. Thus, auditory cells and balance receptors in the ear and some receptors in the skin all respond similarly to mechanical distortion. Because many of the same principles apply to other animals, their receptors can be studied as models of the human senses[1].

Nociception, the chain of functionality from tissue damage to pain perception (Gallacchi 2005; Hendry 2007). Pain perception begins with the activation of two types of specialized receptors in the skin, muscles, and viscera, the nociceptors. This process is called 1) *transduction*. The nociceptors lie on the primary nociceptive neurons. One receptor responds only to very forceful mechanical energy and the other, polymodal receptor responds to noxious stimuli of many kinds, like thermical or chemical stimuli. Both receptor types, unlike all other somatosensory receptors, are uncovered by tissue and are thus unprotected against the diffusion of chemical agents released by surrounding cells. These agents include a variety of small molecules such as ions, amines and peptides that can produce or change activity in nociceptors over a distance of several millimetres. These stimuli are coded into an electrical impulse by a change of membrane potential of the nociceptor by an influx of cations, especially sodium. Repeated noxious stimulation leads to a heightened nociceptor response, referred to as *hyperalgesia*. In the process of 2) *transmission* the peripheral axons of the primary nociceptive neurons send these electrical impulses into the central nervous system (CNS). Larger, lightly myelinated (Aδ) axons stem from mechano-receptive neurons, whereas the smallest, unmyelinated (C) axons end as polymodal nociceptors. Differences in axon diameter and level of myelination translate into differences of conductivity velocity and thus the time taken by signals from the two nociceptor types to reach the CNS, as they enter the spinal cord in the dorsal root. Pricking pain, carried by Aδ fibres, is the more rapidly transmitted (5-20 m/sec), better localized, and a more easily bearable component of pain. The perception of pricking pain is followed after a substantial delay by second component, a poorly localized, agonizing, burning pain carried by C fibres (2-5 m/sec). Convergence of inputs from many pain afferents at this level leads to a wrong location of pain occurring in viscera to sites that are more peripheral, such as those that occur during heart attacks. This nociceptive information is 3) *modulated* and controlled by specific inhibiting systems like the descending pain modulatory system and conducted to the cortex. These inhibitory mechanisms can therapeutically and psychologically be inhibited or activated, e.g. by stress or morphine. Opiates and other pharmacological agents that mimic the effects of encephalin are effective as analgesics in part because of their action on spinal synapses. At last, 3) *pain perception* involves a change of cortical activity in the

[1] Many animals are endowed with specialized receptors that permit them to detect stimuli that man cannot sense. The pit viper boasts a receptor of exquisite sensitivity to “invisible” infrared light; some insects have receptors for ultraviolet light and for pheromones (chemical sex attractants and aphrodisiacs unique to their own species) thereby also exceeding human sensory capabilities.

pain matrix (Figure 2, right) the subjective pain perception and the manifestation. The somatosensory cortex computes the location and characteristics of the pain, whereas the frontal lobe processes the actual suffering. However the exact way of pain procession in the brain is not known.



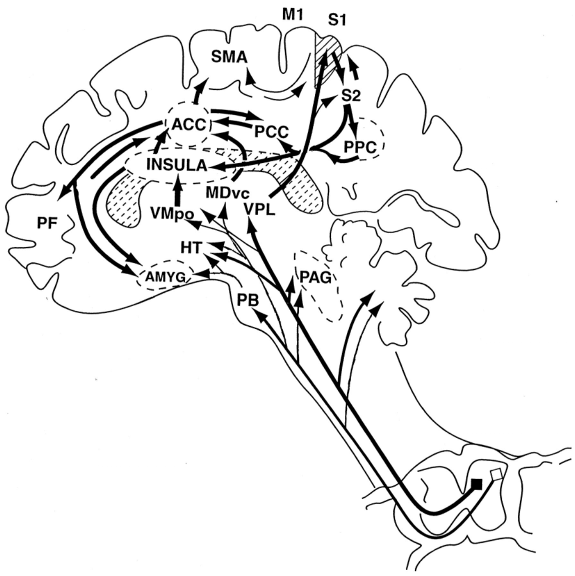


Figure 2 Left: Diagram of our pain sensory system. The first set of neurons takes in information from the periphery and then synapses with a second set of neurons in the dorsal horn. These neurons ascend to the brain stem or the thalamus. Then neurons project into the frontal and somatosensory cortex. Right: Schematic of ascending pathways, subcortical structures, and cerebral cortical structures involved in processing pain. (Price 2000).

2.2.2 The emotional modulation of pain.

Numerous evidence indicates that pain perception is influenced not only by physiological factors like testosterone and oestrogen (Craft, Mogil et al. 2004) but also by psychological factors: pain includes sensory, affective and evaluative dimensions, whereas emotions influence the affective dimension (Melzack and Casey 1968). There is a strong relationship between emotion and pain – brain regions that involve pain and emotions are closely connected (Eisenberger 2003; Vogt 2005). Scientists agree that moderately arousing pleasant affective states reduce pain perception, whereas unpleasant affective states exacerbate it at lower arousal levels but inhibit it at higher arousal levels (Meagher 2001; Rainville 2005). Consistently, dysfunctional emotional and cognitive processing has an important influence on pain perception (Klossika, Flor et al. 2006). The effect of self-perceived role-identity on pain perception, has so far been investigated in gender role studies, including coping strategies (Keogh and Herdenfeldt 2002) pain catastrophizing (Thorn, Clements et al. 2004), situational context (Kallai, Barke et al. 2004), gender role expectations (Robinson, Riley et al. 2001), hypervigilance (Rollman, Abdel-Shaheed et al.

2004) and anxiety (Edwards, Augustson et al. 2000). These and other empirical studies on acute and chronical pain agree that women are the more pain sensitive gender: women more often report pain, are less pain tolerant and have enhanced pain sensation in comparison to men (Riley, Robinson et al. 1998; Rollman, Abdel-Shaheed et al. 2004).

2.2.3 A short definition of pain

In this thesis pain is defined as a “defensive behaviour” (Rhudy and Williams 2005) accompanied by pain perception, here defined as the product of the brain’s abstraction and elaboration of a nociceptive input (Basbaum and Jessell 2000). It functions according to the same basic rules as any sensory system. Pain helps organisms to avoid actual or potential tissue damage and its neurocircuitry is thought to be part of a defensive system (LeDoux 2000). So a high readiness to endure pain involves forced risk taking. It is important to state that pain experts do not any more differentiate between negative emotions and physiological states of pain. – The official definition of the International Association for the Study of Pain (IASP) proposes that pain is “an unpleasant *sensory* and *emotional* experience associated with *actual* or *potentia*l tissue damage, or described in terms of such damage.”[2] (IASP 1994). Brain imaging studies support this hypothesis as negative feelings result in physiological activity in the pain matrix of the brain (Becerra, Breiter et al. 2001; Eisenberger, Lieberman et al. 2003; Singer, Seymour et al. 2004; Vogt 2005). This entanglement of acute pain and negative emotional states is especially important with pathological states of pain like chronic pain incurable by traditional pharmacotherapy. All in all, pain can be regarded as a negative feeling. Sometimes it is necessary to bring us into a state of caution; sometimes it is an independent overreaction and has to be counteracted.

[2] Note: The inability to communicate verbally does not negate the possibility that an individual is experiencing pain and is in need of appropriate pain-relieving treatment. Pain is always subjective. Each individual learns how to use the word through experiences related to injury in early life… pain is that experience which we associate with actual or potential tissue damage. It is unquestionably a sensation in a part or parts of the body, but it is also always unpleasant and therefore also an emotional experience. ... Many people report pain in the absence of tissue damage or any likely pathophysiological cause; usually this happens for psychological reasons. There is usually no way to distinguish their experience from that due to tissue damage if we take the subjective report. If they regard their experience as pain and if they report it in the same ways as pain caused by tissue damage, it should be accepted as pain. This definition avoids tying pain to the stimulus. Activity induced in the nociceptor and nociceptive pathways by a noxious stimulus is not pain, which is always a psychological state...(IASP, 1994).

2.3 What is risk?

2.3.1 Expected Utility Theory

Traditional Expected Utility Theory (EUT) assumes that human beings behave rationally. The basic assumptions are: (1) a consistent system of preferences in time and in different contexts, (2) utility maximization, and (3) complete information about possible options and their consequences. This classical theory clearly puts the focus on reason, neglecting emotions. It dates back to 1738 when Daniel Bernoulli suggested that people only make decisions that maximize their expected utilities (Bernoulli 1738). He also introduced the concept of "risk-aversion" to explain the fact that gamblers often act irrationally because of preferring an option with a lower, safer expected utility to an option with an expected higher utility but carrying a bigger risk. Bernoulli also demonstrated that the degree of risk-aversion decreases with increasing wealth. Modern expected utility theory began in 1944, when von Neumann and Morgenstern (Von Neumann and Morgenstern 1944) presented an axiomatic explanation. Soon after, empirical evidence showed that people violate the axioms, as they do not always behave rationally and cooperatively. One famous example is Allis's paradox that considers a choice between two options. Option A is winning 1 million for sure, whereas option B is a 10% chance of winning 2 millions, and a 90% chance of winning 1 million. The expected value of option B is 1.1 million, which is higher than the value of option A. However, most people prefer A to B. Another set of options C and D consists of a 10% chance of winning 1 million versus a 10% chance of winning 2 millions. Most people prefer D to C, which contradicts the previous expression. However, economists routinely are still using models based on expected utility theory that are inconsistent with empirical findings (Camerer 1999).

2.3.2 Prospect theory

A recent approach called "behavioural economics", seeks to use psychology to inform economics, while maintaining the emphasis on mathematical structure and explanation of field data that distinguish economics from other social sciences (Camerer 1999). In the 1950s, Herbert Simon – later a Noble Laureate in economics – laid the foundation to unify psychology and economics (Simon 1955). Considering that humans have limited cognitive abilities, especially regarding computation and prediction, Simon questioned two of the original assumptions, completeness of information and utility maximization. Individuals gather only a small amount of information; they are "looking in the neighbourhood" for choice options, contenting themselves with only a small selection, out of many options. Simon proposed that individuals are – instead of maximizing utility – just looking for options that satisfy their expectations.

In the 1970s two outstanding scientists, Amos Tversky and Daniel Kahneman, investigated three lines of research (Kahneman 2003), (1) heuristics that people use and the biases to which they are prone in various tasks of judgment under uncertainty, (2) models of choice under risk, resulting in prospect theory (Kahneman and Tversky 1979; Tversky and Kahneman 1992), and (3) the so-called framing effect (Tversky and Kahneman 1986). They proposed an architecture of human cognition, based on two modes of thinking and deciding, which correspond roughly to the concepts of self-reasoning and intuition. They characterized the intuition system as fast, parallel, automatic, effortless, associative, slow learning, and emotional, while they regarded the reasoning system as slow, serial, controlled, effortful, rule-governed, flexible, and neutral (Kahneman 2003). *Prospect theory* is a descriptive theory of decision behaviour under risk that may be characterized with the metaphor "from states to changes". People are not evaluating outcomes in absolute values, but are assessing deviations from a reference point, usually the status quo. It is much easier to make statements like "A is better than B", or "C is warmer than D". Kahneman called this the overcome of "Bernoulli's error" (Kahneman 2003). The second proposition is that people have different attitudes against gains and losses (Kahneman 2003). The so-called "*framing effect*" consists of the proposition that variations in the representation of (1) the present situation and of (2) expectations about all future opportunities and risks result in preference inconsistencies. Tversky and Kahneman identified four factors which control framing: the manner in which the choice problem is presented, and the norms, habits and expectancies of the decision maker (Tversky and Kahneman 1986). It seems a linguistic explanation of problems that are widely used in questionnaires have a high potential to induce framing effects.

The seminal work of Kahneman and Tversky had big implications on the behavioural economics community (Camerer 1999). First, it allowed to explain and predict field phenomena, such as stock market pricing anomalies, or investor overreaction (De Bondt and Thaler 1985; De Bondt and Thaler 1987). Second, empirical studies as a scientific tool became an essential part of economic research. Probability weighting functions have been used to characterize inter-personal behavioural differences, for example the influence of gender on risk behaviour (Fehr-Duda 2006). Third the "hyper rational" assumptions underlying the “homo oeconomicus[3]” have continuously lost acceptance, resulting in a more emotional homo oeconomicus (Thaler 2000)

2.3.3 The emotional modulation of risk behaviour

Studies in Economy, Psychology, as well as Behavioural Economy, and Neuroscience conclude that cognitive and affective appraisal are involved in decision-making. This means that the formerly dominant model of decision making the “Expected Utility Theory” (Von Neumann and Morgenstern 1944) is replaced by a more emotional homo oeconomicus: his empirically observable decisions do not fit to the formerly postulated axioms (Camerer 1999), his information is not complete, he is influenced by the framing of the context and expectation of the decision and he has different attitudes towards gains and losses (Kahneman and Tversky 1979; Tversky and Kahneman 1986; Tversky and Kahneman 1992).

Experimental data on brain lesions (Bechara 2004), addiction (Bechara and Damasio 2002) and adolescence of the brain (Giedd 2004) provide further evidence on the important role of affect in decision behaviour, as a disturbance of centers ascribed to affective processing prevents proper decisions. Though neurobiological systems of *emotion and cognition* are closely entangled; emotions are thought to control cognition, and cognitions initiate emotions (Phelps 2006). But how these systems exactly affect decision behaviour is still unclear.

Loewenstein et al. talk about “risk as a feeling” because current emotional states and chronic dispositions to specific emotions influence risk behaviour. They describe a “cold/hot empathy gap” and state that positive emotions lead to optimistic decisions whereas negative emotions lead to pessimistic decisions (Loewenstein 2003). Others accentuate that the effect of the emotional dimension of *security and control* might be of more importance than the emotional *valence* (Lerner and Keltner 2001; Tiedens and Linton 2001). According to them emotions that can be characterized by security and control favour the role of thumb, whereas uncertainty and lack of control lead to careful

[3]The “homo oeconomicus” has the logical and unemotional goal to maximize his own utility; his system of preferences is consistent and he has complete information about options and consequences – the effect of emotion and the social construct of probability are totally neglected. (Bernuoulli 1738).

consideration of the facts. (Lerner and Keltner 2001; Tiedens and Linton 2001; Loewenstein 2003). Not only acute emotional states affect risk behaviour. Emotions probably reflect ancestral neuro-genetic memories that link up with capacities to learn about environmental contingencies (Panksepp 2006). This means that people have chronic dispositions to specific emotions. Some focus rather on the potential, others on the security of a decision (Lopes and Oden 1999). Important factors that influence risk behaviour are personality characteristics like *hormones* (Johnson, McDermott et al. 2006; Klinesmith, Kasser et al. 2006)*, stress reactions* (Kirschbaum, Kudielka et al. 1999; Nater, Abbruzzese et al. 2006) and *biological gender*. *Women* are more anxious and in general more sensitive to negative emotions than men. They are risk averse, in many domains they take less hazards, e.g. in health, sports or finance (Byrnes 1999; Croson 2004; Croson Rachel in press). In winning Lotteries they tend to be more risk averse in large and medium probabilities of gains (Fehr-Duda 2006) which points out at a higher reciprocity.

2.3.4 A short definition of risk

Risk describes the expected value of one or more results in one or more future events. Decisions are “*risky*”, were the probabilities and the outcomes are known in contrast to “*uncertain*”, where only the outcomes are known and to “*ambiguous*”, where both probability and outcome are unknown. In this thesis, risk behaviour stands for *behaviour in binary financial decisions under risky information*. As a risk metric, we use the participants *risk premium* (RP) depicted on our new risk metric the *preference function* (see Chapter 7, [2]). The risk premium has been an important metric to characterize aberrations of individual risk behaviour from rational behaviour by calculation. It is the difference between the expected value of a risky prospect and a guaranteed payoff that an agent is indifferent to. It indicates the probable positive or negative profit a subject will receive according to his decision behaviour. It has been used to characterize phenomena such as risk-aversion, risk-proneness, or sex differences in decision-making under risk. However limits of reproducibility of participants risk behaviour have been neglected by existing risk tools.

2.4 Overview based on the levels of life regulation

Complex organisms living in complex environments cannot rely on standard response patterns. They need the ability to construct novel combinations of responses, to plan ahead, and to choose the most advantageous option of response. Economics and psychology are traditional disciplines to study human behaviour, mainly limiting their scope to the conscious “levels of life regulation” (Damasio 1999). However research on human behaviour clearly needs interdisciplinary approaches. As an overview, a general framework proposed by Damasio could be used. Damasio introduced four levels of life regulation (Figure 3) the basic neural mechanisms, emotions, feelings, and reason. Level 1 of life regulation, "the survival kit", consists of biological states and neural mechanisms, some of which give raise to feelings, level 3 of life regulation. Level 1 and 3 are linked by what Damasio calls emotions; The dual arrows indicate that constraints work both upwards and downwards. For instance, pain can induce emotions, and some emotions can include the state of pain. Level 4 of life regulation, cognitive processes such as thinking, decision-making, planning, etc, refers to adaptive behaviour. In this thesis, all levels of life regulation are integrated to improve knowledge on behaviour under the influence of pain and risk.

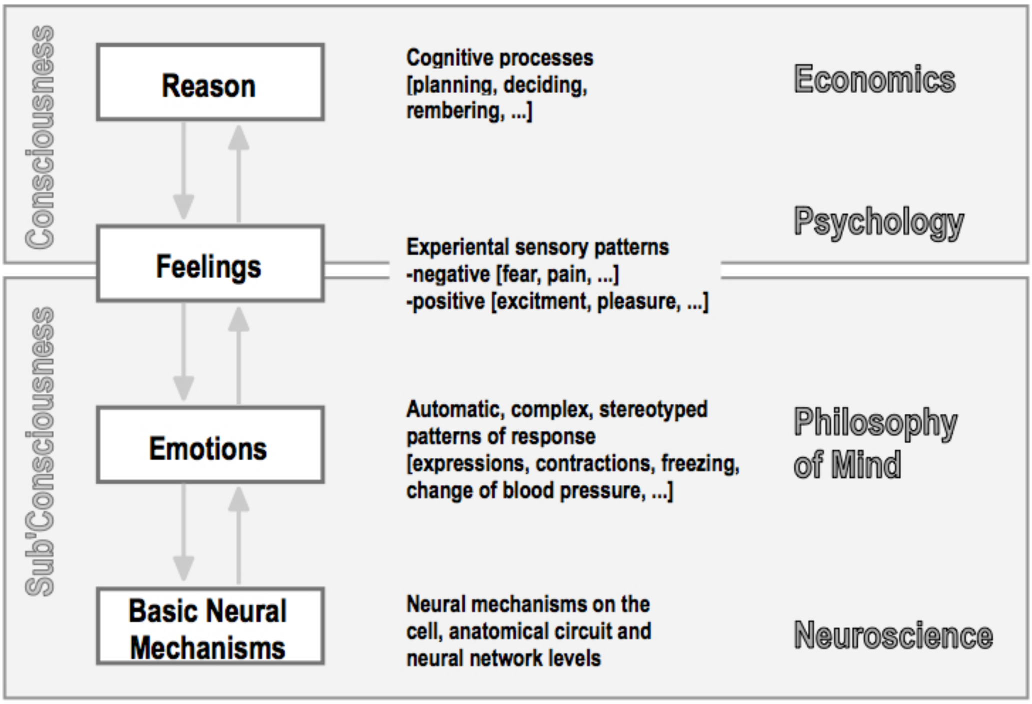


Figure 3 Levels of life regulation – a framework to integrate the state of research on human behaviour, following Damasio (Damasio 1999). The study of human behaviour has been addressing different levels of life regulation with a disciplinary approach. For a long time economics, psychology and philosophy observed behaviour and tried to derive models from behaviour. The emergence of neuroscience has been providing insight into neural mechanisms, resulting in the emergence of novel "interface-disciplines", such as neuro-economics, or cognitive neuroscience. However the relations between the different levels of life regulation are still not well understood.

3 Methods

3.1 Subjects

The studies were approved by the local Ethics Committee and were conducted according to the guidelines of the Declaration of Helsinki for the treatment of experimental subjects. Prior to the beginning of the study all volunteers gave fully, written informed consent. To exclude acute or chronic pain and the effect of pain medication among volunteers, each participant was screened with a homemade questionnaire. Participants were also asked not to drink caffeinated or alcoholic beverages 6 hours prior to the experiment and not to take pain relievers 24 hours prior to the experiment.

Study S1 Eighteen healthy, right-handed volunteers, eight women and ten men, were recruited for the study. They were pain-free and free of any sensory abnormalities as stated in the self-report. Handedness was determined using a standard handedness inventory (Oldfield 1971). Mean age of participants was 35.2 years (s.d. 9.46).

Study S2 Twenty-one healthy volunteers experienced in adopting roles, either by regularly playing role-playing games or acting on stage, were recruited for the study. Two participants were excluded because their pain tolerances exceeded the security limit set at 52°C. Mean age of participants was 28.2 years (10.0 s.d.). Ten women (mean age 31.2 years, 12.7 s.d.) and nine men (age 24.9 years, 4.5 s.d.) were included in the study. Handedness was determined using a standard handedness inventory.

Studies S3-S6 Twenty-seven healthy volunteers were recruited for the study. Mean age of participants was 25.8 years (3.6 s.d.). Thirteen women (mean age 25.0 years, 3.3 s.d.) and fourteen men (age 27.0 years, 3.7 s.d.) were included in the study. Moreover, they were asked not to drink caffeinated or alcoholic beverages 12 hours before the experiment and not to drink, eat or brush teeth or chew chewing gum 30 minutes before the start of the experiment. Two participants who took substances that affect the central nervous system or strong painkillers within 12 hours before the experiment were excluded from pain measurements.

3.2 Pain stimuli

Noxious heat stimuli were administered to the volar forearm of the non-dominant hand using a 30 x 30-mm peltier device (Medoc, Ramat-Yishai, Israel; TSA-II). To avoid physical injuries the pain tolerance measurement stopped automatically at a maximal temperature of 52°C. Prior to the actual measurements subjects were made familiar with the heat stimuli and the handling of the controlling device (Granot, Sprecher et al. 2003). Pain tolerance, the variable of interest, was measured always prior to pain threshold. This was done in order to avoid washout of role-induced effects due to the considerably longer time delays needed to measure sensory thresholds (S2) or to avoid sensitization effects arising from longer stimulus duration of tolerance measurements, and counterbalance the fact that random paradigms in which intense stimuli immediately precede threshold measurements result in changed threshold estimates.

S1 On both forearms three homologous *sites* were individually assigned dividing the distance from wrist to elbow into equidistant segments. To check small perceptual variations resulting from variations in probe positioning (Price, McHaffie et al. 1989) the stimulus *sites* were marked on the skin with a water insoluble pen (see Chapter 4). Pain threshold and pain tolerance according to *site* were both determined by calculating the average of two measurements starting at 32°C with a constant rise of temperature (0.5°C/sec). Two device readouts were considered to be an acceptable criterion on the one hand because the amount of stimulation is reduced to a minimum thus making sensitization and habituation effects less probable, and on the other hand because assessment times are considerably reduced, thereby reducing attention confounds.

S2 S3 S5 S6 The thermode was placed at 2/3 of the distance from wrist to elbow. Individual pain threshold was measured to determine the turning point from warm into pain perception using the search method starting at 43°C: participants were asked to increase or decrease the magnitude of the heat stimulus by themselves to the point they felt it changing from “hot” to “painful”. Pain tolerance was determined by the method of limits. Participants were asked to stop the increasing heat stimulus at the moment they could not stand the heat any longer. Four measurements starting at 35°C, with a rise of 0.6°C/sec, were averaged.

3.3 Risk tools

3.3.1 The random lottery task

S7-S9 Design and Implementation see Chapter 7

3.3.2 Winning lotteries on option sheets

S7 The winning lotteries used by Fehr-Duda et al (Fehr-Duda 2006) depict subjects' certainty equivalents that serve as a base for estimating value and probability weighting functions. Subjects were confronted with investment decisions in a contextual environment. Each subject had to consider the same seven decision sheets with gains lotteries appearing in random order for each subject. The experimental design comprised lotteries with winning probabilities of 5, 10, 25, 50, 75, 90, and 95%. Monetary outcomes ranged from zero to 50 Swiss Francs. Participants filled out a separate decision sheet for each one of these lotteries. One decision's sheet displayed the respective lottery (option A) and a list of 20 guaranteed payoffs (options B; see Figure 4). These guaranteed payoffs were arranged in algebraically descending order, starting with the larger gamble outcome and descending in equal steps towards the smaller gamble outcome. Going down the list, on each line of the decision sheet the subjects had to decide whether they preferred the (fixed) lottery (option A) or the respective guaranteed payoff (option B) by marking the box next to the preferred option, reconsider their choices or stick to their previous entries. A lottery's certainty equivalent was determined as the arithmetic mean of the minimum guaranteed payoff, which was preferred to the lottery, and the following smaller guaranteed payment on the list.

Decision situation:				
	Option A	Your Choice:		Option B Certain payoff amounting to:
1		A	B	50
2		A	B	47.5
3		A	B	45
4		A	B	42.5
5		A	B	40
6		A	B	37.5
7		A	B	35
8		A	B	32.5
9	Profit of CHF 50 with probability 10% and profit of CHF 0 with probability 90%	A	B	30
10		A	B	27.5
11		A	B	25
12		A	B	22.5
13		A	B	20
14		A	B	17.5
15		A	B	15
16		A	B	12.5
17		A	B	10
18		A	B	7.5
19		A	B	5
20		A	B	2.5

Figure 4 Design of the option sheets of winning lotteries (Fehr-Duda 2006). For each of the 20 lines on the sheet subjects had to decide whether they prefer option A, the lottery, or option B, the guaranteed payoff in the respective line. Marking the box next to A or B indicated the preference in each line. Suppose the subject chose the guaranteed option for payoffs from CHF 50 to 20 and then switched to the lottery. In this case the certainty equivalent amounted to CHF 18.75. Participants were informed in the experimental instructions that option B was taken to be their choice throughout if they did not make any entries.

3.4 Emotion induction

3.4.1 The role play strategies

S2 The story lines described the main character whose identity should be adopted. The hero/heroine role-identity implied a winner image with strong personality and athletic build, and had the motivated task to save a princess. In contrast, the faint-heart character meant the role-identity of a victim with weak personality, and no motivated task for his/her suffering at all. Both roles started as robber-knights attacked a kingdom. While the faint-heart was threatened in his castle, the hero was on his way to liberate a princess. Both entered a fatal labyrinth. In contrast to the hero the faint-heart was violently forced into it, without any hope to escape. He resented his fate, and was plagued by fire, rats and vertigo. On his search for the princess, the hero overcame these dangers. Both characters ended up facing a guardian, who unjustifiably punished the faint-heart and offered a deal to the hero: He was free to escape with the princess, provided that he was willing to suffer for her. The volunteers received painful heat stimuli seconds after the main character of the story line endured. The pain test stimulus was incorporated in the hero and the faint-hearted condition alike. Most importantly, at this point in time, the hero/heroine focused on the motivating task of saving the princess, while the faint-heart did not, thus experiencing emotionally unmotivated pain. It is important that actual pain stimuli and story line never overlapped.

3.4.2 The international affective picture system

S5 S6 Pictures of the International Affective Picture System (IAPS) (Lang and Bradley 1997) were used to induce positive and negative emotional states. Each picture viewing condition consisted of 12 IAPS pictures that were shown for 8 seconds each. The first positive block consisted of pictures with an average value of valence of 7.18 (1.6 s.d.) and an average value of arousal of 6.16 (2.2 s.d.). The second positive block consisted of pictures with an average value of valence of 7.16 (1.66 s.d.) and an average value of arousal of 6.13 (.2.1 s.d.). The first negative block pictures consisted of pictures with an average value of valence of 2.11 (1.45 s.d.) and an average value of arousal of 6.19 (2.2 s.d.), and the second negative block consisted of pictures with an average value of valence of 2.15 (1.42 s.d.) and an average value of arousal of 6.17 (2.24 s.d.).

3.5 Autonomic reactivity

3.5.1 Skin conductance

S2 Skin conductance (SC) level was measured with a Varioport Measurement System (Becker Meditec, Karlsruhe, Germany), an 8-channel recording system. After filtering and a tenfold-amplification (Anti-Alias filter to cut off high frequencies), data were digitized (12 Bit resolution) and saved on a compact flash card. For measurements, one single channel was used. Channel parameters were set as follows: sampling rate 256 Hz, saving rate 16 Hz, range 0.1–100 µS and resolution of 0.001 µS. During SCL recordings, current across electrodes was held constant at 0.5 V by means of a 16 Bit-resolution unit. Before recording, the palm of the non-dominant hand was cleansed with distilled water and two Ag/AgCl electrodes (5 mm contact area diameter, Marquette Hellige Medical Systems, Freiburg, Germany) filled with lubricating jelly (SC-Paste, 0.5 % NaCl, Becker Meditec, Karlsruhe, Germany) were placed adjacently on the hypothenar eminence of the palm. In order to analyze peak amplitudes of the recorded skin conductance signals triggered by pain measurements, signal peaks were related to each one of the four pain tolerance stimuli (pre- and post every condition) by using the automatically recorded time as a marker, upon the participants' stopping of the pain stimulus. Peak amplitude was calculated by subtracting the value at the beginning of the rising phase of the recorded signal from the value at the apex of the same signal slope. Thereafter, the median corresponding to the four peak heights of the pain tolerance measurements were calculated and used for statistical analysis. In order to control for possible differences in skin conductance levels due to the role-specific adjustments of the characters of the story line, SC of heroines/heroes, female and male faint-hearts were separately averaged throughout the role-playing story (including their pain-stimuli associated responses at the end). To correlate the average SC of male and female participants of the same condition, the length of the first part of the female role-playing story was adjusted to the male story line. Due to detached electrodes, data of two participants (1 woman, 1 man) were excluded from SC analysis.

3.5.2 Voice measurement

S2 Participants were asked to phonate the vowel /a/ at two different moments of each run: once right at the beginning of the run, and a second time close to the end of the role-playing story, the scientific text or after the 8 minutes silence. Voice signals were recorded by means of a personal computer using the "Göttinger Heiserkeitsdiagramm" (Rehder und Partner Medizintechnik, Hamburg). From the recorded voice signals only middle parts without voice onset and offset phase were used to obtain Fundamental Frequency (F0), Jitter (variation of F0) and Shimmer (variation of amplitude). Voice parameter analysis was carried out off-line after the experiment. Two participants (1 woman, 1 man) had to be excluded from the voice analysis-data, because their voices were strongly irregular and showed symptoms of functional voice disorders.

3.5.3 Salivary Alpha-amylase

S3 S5 S6 Salivary Alpha-amylase (sAA) is a salivary enzyme that digests sugar and is used as a new and highly sensitive marker of stress (Nater, La Marca et al. 2006). Saliva samples for Alpha-amylase measurements were always collected at the beginning of the experiment and at four different conditions: directly after the first pain measurement, during the first positive and first negative picture viewing and during the first RALT (Random Lottery Task). Participants were asked to take the cotton pad out of the salivette (Sarstedt, Sevelen, Switzerland) and to chew it with a regular frequency of about 1Hz in order to maintain the salivary flow rate as constant as possible. After 1-minute participants spat the cotton pad back into the plastic tube of the salivette. At the end of the experiment the salivettes were directly frozen at -20 °C until biochemical analysis took place as described by Nater et al (Nater, Rohleder et al. 2005).

3.6 Subjective reports

3.6.1 Pain ratings

S2 S3 S5 S6 After each pain tolerance measurement participants were asked to rate the pain they felt at the point they could not stand it any longer by means of a) two visual analogue scales (VAS), and b) the McGill Pain Questionnaire (MPQ) (Melzack 1975). In the first scale, used to evaluate pain intensity, 0 indicated “no pain” while 10 represented the “worst pain experienced”. The second scale was used to asses pain unpleasantness (Price, McGrath et al. 1983), with 0 indicating “neutral” and 10 “extremely unpleasant”. The German version of the MPQ (Stein and Mendl 1988) was evaluated according to the methodology originally employed by Melzack and Togerson (Melzack 1975). The rank values of the words chosen per each subscale were added up to obtain a score for the sensory and affective subscales. Moreover the pain rating index (PRI) as the sum of all scale values of all the words in all categories and the total number of words chosen (NWC) were determined.

3.6.2 Role empathy

S2 At the end of both role conditions participants had to complete further VAS and a home-made Role-play questionnaire: Three VAS with end values of 0 indicating “not at all” and 10 “very strong” were used to assess for 1) a reason to stand the pain, 2) the intensity of role empathy, and 3) the intensity of role empathy in comparison to acting or playing other role-plays. To asses whether the implicit character imbedded in the corresponding story line was truly captured, participants were asked to freely label the nature of the emotional state they experienced using single words or short phrases, a method commonly used in research on emotions (Scherer 2005). 92% of the given adjectives were quoted in a standard German Synonyms’ Dictionary (2004) and were included in the analyses. Adjectives were then split into the three categories “Appropriate”, “Antonym” or “Strange” to the role-identity of a hero/heroine or faint-heart facing pain. Category frequencies were expressed in percentages. In addition, in order to assign an emotional valence to the named words, a word B was considered a synonym of another word A, when B was directly found in the list of synonyms for word A in the dictionary, or when B was connected to A via another synonym C that was directly found in the list of synonyms for word A. To assign a normative valence and arousal score to the named words, the following strategy was used: 1) a translation for the German word was done by means of LEO, a world-wide-web accessible German-English dictionary (http://dict.leo.org/) 2) the translated word was then searched in the Affective Norms for English Words (ANEW), which provides a set of normative emotional ratings for a large number of words in the English language (Bradley and Lang 1999), and the corresponding valence and arousal scores for that word were recorded 3) when the first translated word was not found in the ANEW, the next synonym of the German word, as found in the German Dictionary (See above) was used. All named adjectives were represented by one of their synonyms found in the ANEW-catalogue, whose All Subjects norms were used.

In order to evaluate which emotional states would be associated with each role-identity under painful conditions, a group of volunteers not aware of the study under consideration (3 men and 4 women, mean age 34.9 s.d. 14.9, all with academic educational background) were asked to respond in written to the question: “which emotions would you expect of a hero/faint-heart facing danger and physical pain?”, by using single words or short phrases in the same way as described above for participants in the main study. The given adjectives were treated in the same form as for role-players. The words of this group were then compared to those named in the main study group. Results were reported as percentage of congruent answers amongst groups.

3.6.3 Emotional state

S5 S6 At the end of each run, the Self-Assessment Manikin scale (SAM) (Bradley and Lang 1994) was completed to rate the valence and the intensity of emotions induced by picture viewing. The “Mehrdimensionale Befindlichkeitsfragebogen” (MDBF) (Steyer, Schwenkmezger et al. 1997) with the subscales good/bad (G/S), calm/agitated (R/U) and alert/tired (W/M) was completed four times: 1) at the very beginning of the experiment, 2) directly after the first two runs and 3) directly after the second two runs 4) after a break of three minutes at the second part of the experiment, before participants completed winning Lotteries (Fehr-Duda 2006).

3.6.4 Natural role identity

S5 S6 At the very end of the experiment participants completed German versions of questionnaires including the Narcissism Personality Inventory (Raskin and Hall 1979), the FKK questionnaire for competence and control (Krampen 1991), the Gender Role Questionnaire (Bem 1974), the State Trait Anxiety questionnaire (Marteau and Bekker 1992), and the Interpersonal Reactivity Index (Davis 1983).

3.7 Principles of experimentation

The conclusions that can be drawn from an experiment mainly depend on the manner in which data were collected. A systematic experimental and analysis approach has to answer the following questions: (1) What is the response (output) variable? (2) What are the factors, which will be systematically varied to simulate the behaviour of the system (treatment)? (3) How do we cope with uncontrollable nuisance factors? Nuisance control, which is extremely important, is based on three strategies (Montgomery 1996).

1. *Direct measurement*. If a nuisance factor is known and can be measured on a cardinal scale.
2. *Blocking*. A block is a subset of specimens or participants with specific discrete characteristics, such as sex, etc.
3. *Randomization* is the cornerstone underlying the use of statistical methods in experimental design. Randomization means that both the allocation of specimen/participants and the sequence of trials are determined randomly.

3.8 Experimental procedures

S1 Noxious heat stimuli were randomly administered to six predefined *sites* within the volar aspect of the left and right anterior forearm. The time interval between the end of one stimulus and the start of the next stimulus was set at 10 seconds. The thermode was in contact with the skin approximately 5 seconds before stimulus commencement. On both forearms three homologous *sites* were individually assigned dividing the distance from wrist to elbow into equidistant segments. In order to diminish visual distraction, participants were blindfolded during the full length of measurements. Pain threshold and pain tolerance were assessed for all *sites* in two separate measurement runs. In the first run, the individual pain thresholds were determined. Here, volunteers were asked to stop the heat stimulus when they felt it turning from “hot” to “painful”. Thereafter, in the second run, individual pain tolerances were measured: participants were asked to stop the increasingly painful stimulus at the point they could not stand it any longer.

S2 Participants lay on a couch in half-lying position but still were able to easily read the instructions displayed in a monitor placed at an arbitrary, yet constant distance in front of them. The experimenter affixed the thermode and the electrodes for SCL-recording, as explained under “Pain Stimuli”. Video and SCL were recorded from that moment on. Thereafter participants were instructed on how to self-control the delivery of the painful stimuli by using two response buttons connected to the TSA-II. In addition, two different acoustic signals indicated either a tolerance or a threshold measurement. Participants were instructed to concentrate on pain stimuli during pain measurements throughout conditions. Participants were blindfolded with an appropriate mask for the full length of the experiment, except for the periods in which they had to complete a questionnaire. An experimental session consisted of three runs comprising both roles and one of the control conditions (Figure 5). At the beginning of each run, participants' voice signal was recorded followed by pain tolerance first, and then pain threshold measurements. Subsequently, subjective ratings concerning pain tolerance were collected. Thereafter, a role-playing story, the scientific text or the silent condition followed. Eight minutes after the start of a condition, the second voice measurement was carried out. Pain tolerance and pain threshold were both measured a second time immediately at the end of any condition. In order to sustain the role-identity effects during pain measurements, the role-playing story continued for 25 seconds after the first two stimuli of the second series consisting of four pain stimuli. Time interval between the four pain stimuli was always held constant and there was no overlap between listening periods and pain stimuli. After voice-, pain tolerance- and pain threshold measurements, subjective pain ratings were again collected. Subsequent to both role conditions the questionnaire concerning role empathy was completed. After five minutes rest a new run was started. To control for confounding factors associated to circadian variations, all participants were tested starting either at 5 pm or 6 pm. The total duration of an experimental session was approximately two hours. Volunteers were debriefed after the three experimental runs were completed, and they received a monetary compensation for their participation in the study.

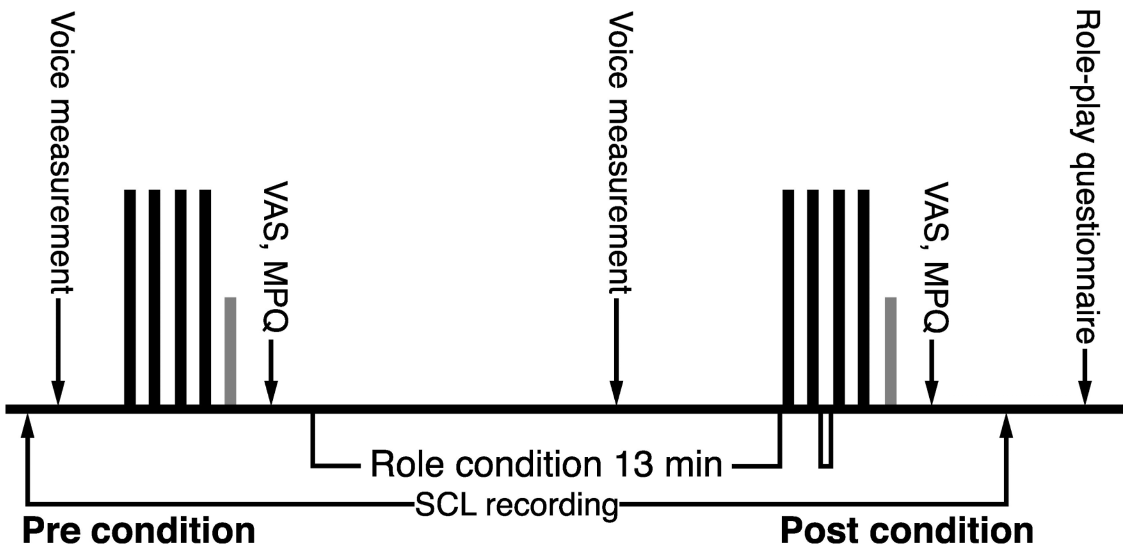


Figure 5: Schematic depiction of an experimental run (S2). Every experimental session included three of such runs comprising the three following conditions presented in a randomized and counterbalanced order: 1) Role induction of a hero/heroine, 2) role induction of a faint-heart and 3) listening to a scientific text or ten minutes silence without any other task. A break of five minutes was inserted between runs. Solid black bars represent the use of noxious heat stimuli with the associated pain tolerance measurement. Grey bars represent the use of a noxious stimulus and its corresponding pain threshold measurement. The unfilled white-bar, in the middle of the second pain tolerance measurement, represents the continuation of the story line to avoid vanishing of the possible effects resulting from role induction procedures. VAS = Visual Analogue Scale; MPQ = McGill Pain Questionnaire; SCL = Skin Conductance Level.

S3-S6 Participants sat on a seat in half-lying position and received their instructions on a monitor placed at an arbitrary, yet constant distance in front of them. The experimenter affixed the heat pain thermode on the non-dominant hand, as explained under “pain stimuli”. Thereafter, participants were instructed on saliva collection, risk tasks and on how to self-control the delivery of the painful stimuli by using the two response buttons connected to the TSA-II. In addition, two different acoustic signals indicated either tolerance or threshold measurement. Participants were instructed to concentrate on pain stimuli during pain measurements throughout conditions. Participants were blindfolded with a mask during pain measurement.

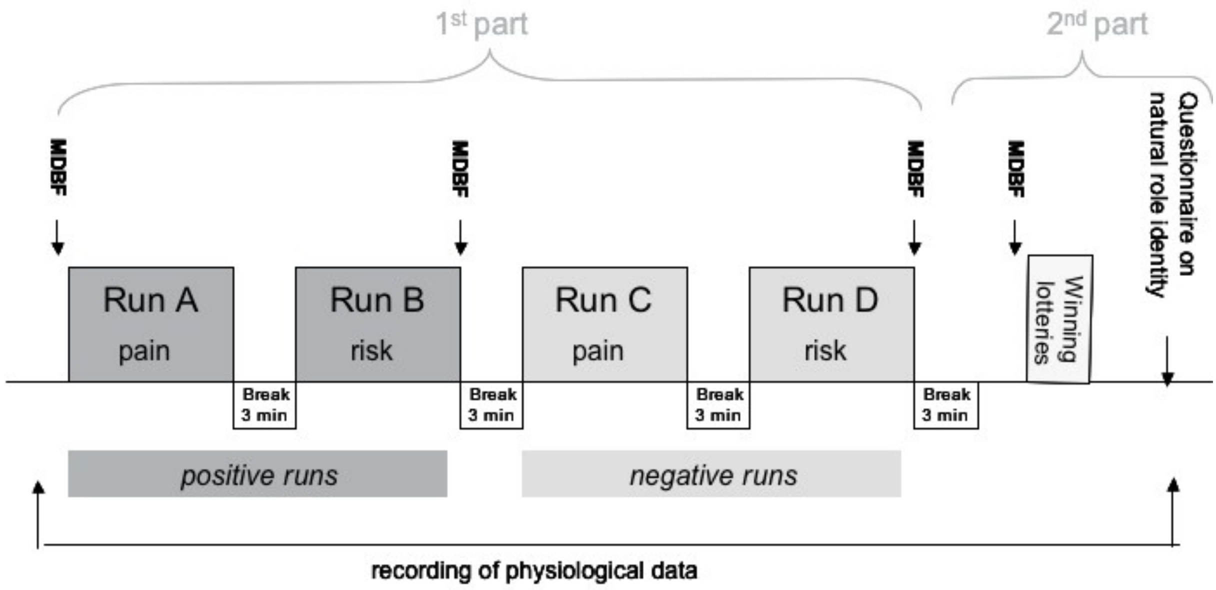


Figure 6 Schematic depiction of an experimental session (S3-S6). Every experimental session included two parts. The first part consisted of four runs A-C, comprising two runs for each of the variables risk premium or pain perception. For each variable one run was conducted with positive and one with negative emotion induction. The succession of the valence of the runs (positive or negative) and the succession of measured variable (RALT risk premium or pain perception) was presented in counterbalanced order. The MDBF was completed four times, at the beginning of the first and the second part of the experiment, and after the positive and negative runs. Alpha-amylase samples in saliva were collected at the beginning of the experiment and during each new condition. Winning Lotteries (Fehr-Duda 2006) and personality questionnaires about the natural role-identity including gender role, competence and control, narcissism, empathy and anxiety were completed in the second part of the experiment.

Every experimental session (Figure 6) included two parts. The *first,* and main, part consisted of four runs A-C, comprising two runs for each of the variables risk premium and pain perception. After each run participants rested for 3 minutes. For each variable one run was conducted with positive and one with negative picture viewing. This means that two runs of the same emotional valence always followed each other in order to minimize changes of emotional valence. The succession of the valence of the runs (positive or negative) and the succession of measured variable (RALT risk premium or pain perception) was presented in counterbalanced order. At the beginning of each run, the variable of interest during "*neutral*" states was recorded (Figure 7). Thereafter followed picture viewing of positive and negative pictures of IASP and then the variable of interest was recorded during a "positive or "negative" state. There was no overlap between picture viewing periods and measurements of the variables of interest. So, each variable of interest was measured twice in a "*neutral*" state (2 x pre picture viewing) and once in "*positive*" and "*negative*" states (2 x post picture viewing). To obtain subjective ratings about the emotional state after picture viewing, participants gave their ratings on SAM scales at the end of each run.

In the *second* and shorter part of the experiment lasting for approximately 10 minutes, winning Lotteries (Fehr-Duda 2006) were filled out to compare RALT with another risk measure. In addition, questionnaires concerning role-identity were completed. The MDBF was completed four times, at the beginning of the first and the second part of the experiment, and after the positive and negative runs. Participants were informed that they would receive a monetary compensation between 0 and 50 CHF for their participation in the study, depending on their performance during the risk tasks. They did not know that they would anyhow receive a show up fee of 30 CHF. The total duration of an experimental session was approximately 1.5 h. After the study, volunteers were informed about the experimental aims.

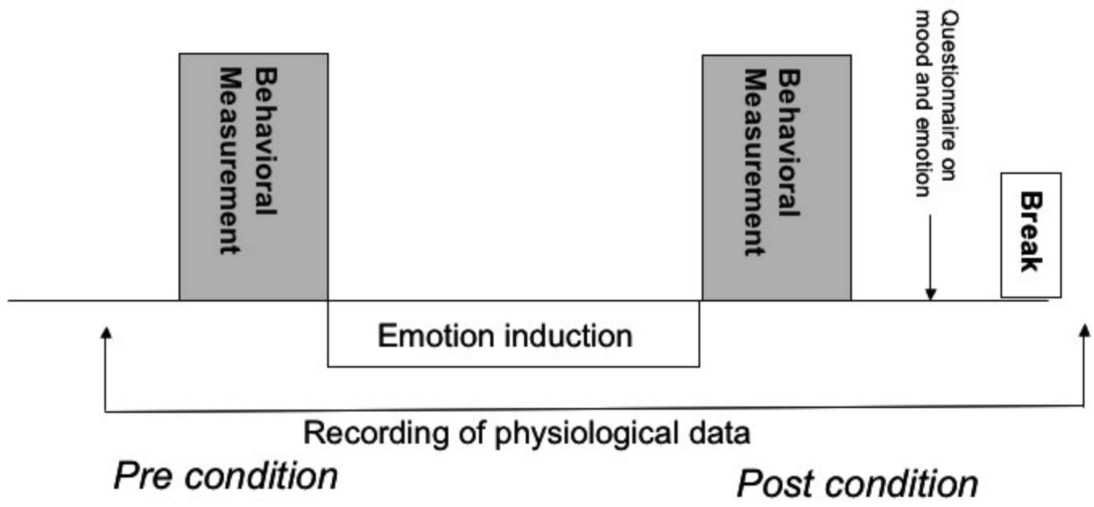


Figure 7 Schematic depiction of an experimental run (S3-S6). Grey bars symbolize either both risk premium (RP), or both pain perception measurements before and after picture viewing. A break of 5 minutes was inserted between each of the runs. SAM scales were rated at the end of each new run.

3.9 Statistical analyses

S1 To evaluate the effect of *site* and *side* of the body on pain threshold and pain tolerance a three factorial repeated measurements analysis of variance (ANOVA) with the factors *Site* (1-3), *Side* (right vs. left) and *Gender*, was calculated. Two male participants exceeded the security limit set at 52°C, so that exact device readouts for their pain tolerance were not available. We then arbitrarily assigned them the security limit as their tolerance value. However these values were included only in the average gender comparisons. P-values in the ANOVAs were Greenhouse-Geisser corrected. Post-hoc comparisons were made with t-tests for dependent samples, and their p-values were adjusted using a simple Bonferroni correction. In order to test for correlations amongst equivalent body parts, simple linear regressions were calculated. The significance level was set at $p < 0.05$ for all statistical calculations other than post-hoc comparisons, which were corrected as stated above.

S2 Two participants were excluded from all data analyses because their pain tolerance exceeded the security limit set at 52°C. Ten women (9 right-handed, 1 left-handed), and nine men (8 right-handed, 1 left-handed) were included. Whenever the factor *Gender* was considered in an analysis, this was done to secure that the observed differences were not a result of gender specific effects. Most of the studies on acute and chronic pain showed that women are more sensitive to pain (Rollman, Abdel-Shaheed et al. 2004). We first compared results of the control conditions “Scientific Text” (n = 10, 5 women, 5 men) and “Silence” (n = 9, 5 women, 4 men) with a one factorial repeated measurements analysis of variance (ANOVA) involving the factor *Time* (pre vs.- post). Values of pain measurements, vocal and SCL recordings, as well as subjective reports did not show significant differences among the two control conditions. Thus, both, the “Scientific Text” and “Silence” control groups were merged into a single control group for further comparisons. To evaluate the effect of role induction on pain tolerance and pain threshold respectively, repeated measurements analyses of variance with the between-subject factor *Role* (Hero/Heroine, Faint-heart and Control), and the within-subject factors *Time* (pre/post) and *Gender* were separately calculated. Post-hoc comparisons were made by means of paired single t-tests. Single repeated measurements ANOVAs were computed on VAS ratings of pain intensity and pain unpleasantness. In addition, for the sensory and affective subscales of the MPQ, also individual repeated measurements ANOVAs were used. To assess for the effect of *Time* (Run1/Run2/Run3; See under “Experimental Procedure”) on pain intensity and pain unpleasantness, a one factorial repeated measurements ANOVA on the scores resulting from the arithmetic addition of pre- and post-role induction in any of the three runs was calculated. Both ANOVAs included the between-subject factor *Gender* and the within-subjects factor *Run*. To assess for changes in participant's emotional status during and after role induction, voice measurements, skin conductance level and role-play questionnaires were again evaluated by means of ANOVAs and Spearman's Rank correlations. Significance level was set at 0.05 for all statistical calculations. P-values in the ANOVAs were corrected using the Greenhouse-Geisser correction. For post-hoc t-test comparisons, the significance level was adjusted using the simple Bonferroni correction by dividing 0.05 by the number of possible single multiple comparisons in the corresponding effect (i.e. alpha-corrected: 0.0033 for the *Role*Time* interaction and alpha-corrected: 0.016 for the *Time* effect (Run1/Run2/Run3) in the VAS ratings).

S3-S6 Two participants were excluded from all pain measurements' analyses because they had taken painkillers during the night before the start of the experiment. For all other measurements, thirteen women (all right-handed), and fourteen men (12 right-handed, 2 left-handed) were included. To evaluate the effect of picture viewing on pain tolerance and pain threshold respectively, repeated measurements analyses of variance (ANOVA) with the between-subject factor *Valence* (positive/negative), and the within-subject factors *Time* (pre/post) and *Gender* were separately calculated. Post-hoc comparisons were made by means of paired single t-tests. Single repeated measurements ANOVAs were computed on VAS ratings of pain intensity and pain unpleasantness. In addition, for the sensory, affective, PRI and NWC subscales of the MPQ, also individual repeated measurements ANOVAs were used. Both ANOVAs included the between-subject factor *Gender* and the within-subject factor *Run* (1/2). To assess for changes in participants' emotional status during and after emotion induction, Alpha-amylase levels, SAM, and MDBF were again evaluated by means of ANOVAs and Spearman's Rank correlations. Significance level was set at 0.05 for all statistical calculations. P-values in the ANOVAs were corrected using the Greenhouse-Geisser correction. For post-hoc t-test comparisons, the significance level was adjusted using a simple Bonferroni correction by dividing 0.05 by the number of reasonable single multiple comparisons in the corresponding effect (i.e. alpha-corrected: 0.0125 for the four reasonable comparisons of the Time*Gender interaction, and alpha-corrected: 0.005 for the 10 reasonable comparisons of the condition effect in the Alpha-amylase levels). Principal component analysis (PCA) involves a mathematical procedure that transforms a number of possibly correlated variables into a smaller number of uncorrelated variables called principal components. The first principal component accounts for as much of the variability in the data as possible, and each succeeding component accounts for as much of the remaining variability as possible.

3.10 Overview of the variables

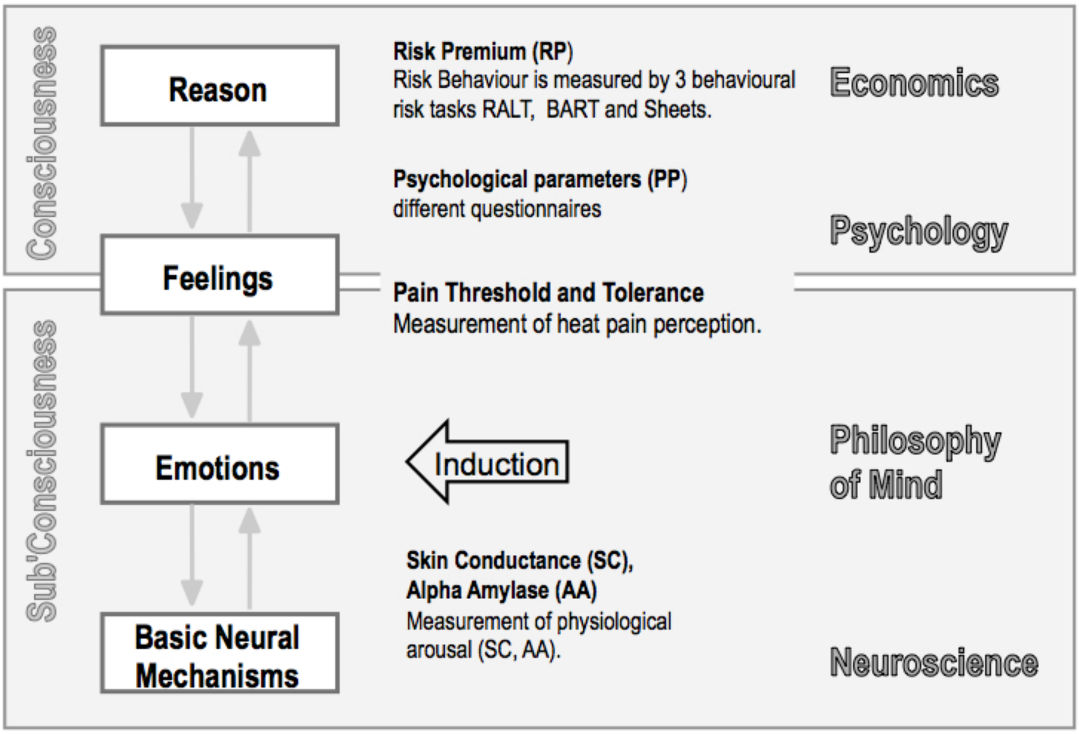


Figure 8 Overview of the variables measured during the experiments in relation to Damasio's levels of life regulation. In order to explain risk and pain behaviour, variables from each of Damasio's levels of life regulation are measured and combined. Emotions, as a nuisance factor, are induced by the roles plays that are presented in this thesis or by pictures of IAPS (Lang and Bradley 1997), controlled by blocking and measured by self report and physiological parameters.

Table 2 **Variables measured during experiments:** their characteristics and their acquisition procedures.

	Variable	Characteristics	Procedure
Response	Risk Premium (RP)	RP = EU – CE EU (expected value) = probability of the lottery * amount of the lottery. CE (certainty equivalent) = point of indifference of participant; is experimentally detected.	Two risk tasks are compared: 1) Random Lottery Task (RALT) is newly established, 2) Lotteries are used in their original form (Fehr-Duda 2006). Participants are informed that they get paid depending on their decisions. 1. Subproject S4 describes the newly developed risk task RALT. The RALT comprises 50 decisions to make that are contextualized as a transaction in a bank. In each decision participants choose between 2 options A or B. Option A is a lottery with a randomly ascribed probability to win 50 CHF. Option B is a guaranteed payoff of a randomly ascribed amount of money. 2. Lotteries consist of sheets, each sheet comprising 20 decisions to make. For each decision the participant chooses between one fixed option A with a probability to win a certain amount of money and several Options B with decreasing fixed amounts of guaranteed payoffs. (Fehr-Duda 2006).
	Pain Threshold	Pain threshold is defined as the turning point from "warm" into "painful" pain perception.	All heat pain measurements are measured on the non-dominant forearm and carried out with a 30 x 30-mm Peltier Element (Medoc, Ramat-Yishai, Israel; TSA-II). All measurements stop automatically at a maximal temperature of 52°C. Participants are blindfolded to avoid distraction and are instructed to concentrate on pain stimuli during pain measurements throughout conditions. Subjects are made familiar with the heat stimuli and the handling of the controlling device. To measure pain threshold the search method starting at 43°C is used. Participants are asked to increase or decrease the magnitude of the heat stimulus by themselves to the point they felt it changing from ''hot'' to ''painful''.
	Pain Tolerance	Pain tolerance is defined as the turning point when participants cannot stand the painful heat any longer.	The method of limits with three measurements starting at 35°C and a rise of 0.6 °C/sec is used. Participants are asked to stop the increasing heat stimulus at the moment they cannot stand the heat any longer. For each measurement three values are averaged.
	Skin Conductance Response (SC)	SC is a method of measuring the electrical resistance of the skin (the amount of sweating changes the amount of resistance).	SC is measured on the dominant hand with a Varioport Measurement System (Becker Meditec, Karlsruhe, Germany), an 8-channel recording system and processed. SC correlates with sympathetic activity and emotional arousal, although one cannot identify the specific emotion being elicited. (Gomez and Danuser 2004; Kut, Schaffner et al. 2007)

	Alpha-amylase (sAA)	sAA is a salivary enzyme that digests sugar and is used as a new and very sensitive marker of stress and negative emotions (Nater, Rohleder et al. 2005).	Saliva samples for Alpha-amylase measurement are collected in salivette (Sarstedt, Sevelen, Switzerland), and freezed until further analysis.
	Self assessments of "natural" role-identity	1. Narcissism 2. Self efficacy 3. Gender role 4. Anxiety 5. Empathy 6. Pain Perception 7. Emotional state 8. Mood	Questionnaires: 1. Narcissism Personality Inventory (Raskin and Hall 1979) 2. FKK questionnaire for competence and control (Krampen 1991) 3. Gender role questionnaire (Bem 1974) 4. State Trait Anxiety (Marteau and Bekker 1992) 5. Interpersonal Reactivity Index (Davis 1983) 6. 10-cm visual analogue scales (VAS) to evaluate pain intensity and pain unpleasantness (Price, McGrath et al. 1983); Mc Gill Pain Questionnaire (Melzack 1975) 7. SAM (Bradley and Lang 1994) 8. MDBF (Steyer, Schwenkmezger et al. 1997)
Design	Positive emotion induction Negative emotion induction	An emotion is typically positive, when a goal is advanced and negative, when a goal is impeded. Empathy triggers emotion induction e.g. in cases of pictures, films or role games (Weisenberg, Raz et al. 1998; Meagher 2001; Eisenberger 2003; Kut, Schaffner et al. 2007)	2) Our in this thesis established role preparation design can induce very specific role identities and their associated emotions in about ten minutes by means of literary role-plays. Role identities can be learned or adapted. 1) Pictures of the International Affective Picture System IAPS (Lang and Bradley 1997) are used to induce unspecific positive and negative emotions. Each emotion induction consists of 12 IAPS pictures that are shown for 8000 milliseconds each.
Nuisance	Gender	Biological gender.	Assessed by blocking, the grouping of men and women in the statistical analysis.
	Position	Effect of the chronology in which the variables are measured.	Randomization.
	Time	Effects of a repetition of measurement e.g. fatigue, sensitization or adaptation.	Randomization and one repetition of measurement during "neutral" states for each variable.
	Attention	Desired or unwanted concentration of the participant onto one certain aspect of the environment while ignoring others.	Blindfolding during pain measurements, resting times during the experiment in order to avoid fatigue.

3.11 Abbreviations

ANS	Autonomic nervous system
BART	Balloon analogue risk task
COND	Condition
CE	Certainty Equivalent; guaranteed payoff
CHF	Swiss Franks
EUT	Expected Utility Theory
EU	Expected utility
EV	Expected value
FKK	Questionnaire on competence and control
IAPS	International affective picture system
IASP	International Association for the Study of Pain
MPQ	Mc Gill pain questionnaire
MDBF	Mehrdimensionaler Befindlichkeits Fragebogen
P	Winning probability of the risky prospect
PC	Principal component
R/A	Reproducibility/Acategoriality
RALT	Random lottery task
RP	Risk premium
sAA	Salivary Alpha-amylase
SAM	Self-assessment manekin for emotional valence and arousal
SAMS	Sympathetic adrenal medullar system
SC	Skin conductance
SNS	Sympathetic nervous system
VAS	Visual analogue scale
Q	Preference point; Probability of risky choice

4 Heat Pain Threshold and Tolerance Show no Left-Right Perceptual Differences at Complementary Sites of the Human Forearm

Objectives: Pain threshold and pain tolerance of heat noxious stimuli were assessed to determine whether they are equivalent when measured at 3 equidistant *sites* of both volar forearms. *Mehods:* Heat pain threshold and tolerance were measured in 18 healthy volunteers using a standard stimulation device consisting of a thermode. *Results*: Pain threshold and pain tolerance did not differ within and across forearm *sites*. Experimenters addressing heat pain threshold and tolerance in healthy volunteers may freely choose and change stimulation *sites* on both volar forearms, without the risk of confounding *site* effects on dependent variables. This data completes previous reports on *side* effects by analyzing the effect of *site* on the forearm for both heat pain threshold and tolerance. The absence of *side* and *site* effects may contribute to set a more secure basis for assessments of laterality effects of painful stimulation. [4]

[4] Nils Schaffner*, Amrei Wittwer*, Elvan Kut*, Gerd Folkers, David H. Benninger and Victor Candia, Neuroscience Letters 440 (2008) 309–313. *These authors contributed equally to this work.
The work described in this chapter has been done in collaboration with the following people: Nils Schaffner, Elvan Kut, Victor Candia, Gerd Folkers.

4.1 Introduction

Quantification of experimental pain depends on the type of noxious stimuli used, their application and the assessment method: the stimuli are usually applied in fixed or ascending magnitudes, they can be assessed by threshold and tolerance measurements and subjectively characterized by pain scores (Granot, Sprecher et al. 2003; Shy, Frohman et al. 2003). It can be assumed that especially pain threshold and tolerance reflect the sensory experience provoked by a noxious stimulus more directly than subjective reports, because no time delay and no reflection veils the painful experience. Particularly pain tolerance cannot be regarded as a simple sensory endpoint, but most probably manifests a combination of sensory, affective, cognitive and psychosocial inputs. Amongst others, heat pain tolerance measurements on the forearm have been proved to be a useful tool to investigate the effect of role-identity (Kut, Schaffner et al. 2007) gender (Fillingim, Maixner et al. 1998) and mental state (Bar, Greiner et al. 2003; Bar, Brehm et al. 2005) on pain perception. In addition, a careful characterization of tolerance and threshold psychophysics at complementary *sites* oft the human forearm may provide a methodological basis for the growing number of psychophysical pain studies and might be of value for imaging studies on the laterality of brain dynamics during pain stimulation. Therefore, we focus on the psychophysics of frequently used heat pain stimuli when applied to the forearms. To our knowledge, no systematical evidence concerning pain thresholds and pain tolerance at different and homologous skin *sites* on the volar forearms has been presented so far, neither involving heat pain nor other noxious stimuli. Regarding the effect of *side* on heat *pain threshold*, results have been heterogeneous: while pain threshold measurements using a thermode did not reveal differences between *sides* on forearm (Meh and Denislic 1994), hand, face and foot (Rolke, Baron et al. 2006; Rolke, Magerl et al. 2006), studies using heat stimuli without tactile components (e.g., laser radiant heat) found lower thresholds on the dorsum of the right hand (Schlereth, Baumgartner et al. 2003). Methods of sensory discrimination with tonic heat stimuli using subjective pain scores also showed contradictory results. Some studies did not find left-right perceptual differences (Long 1994; Lugo, Isturiz et al. 2002; Sarlani, Farooq et al. 2003), while another showed higher pain perception of the left hand (Lugo, Isturiz et al. 2002). Furthermore, for heat pain tolerance on the volar wrist, a body region near to the forearm region assessed here, laterality effects were found in patients with major depression, but not in healthy volunteers (Bar, Greiner et al. 2003; Bar, Brehm et al. 2005). Fundamental work on cell responses to heat noxious stimuli in the forearms and finger pads of animals (Kenshalo, Giesler et al. 1980) showed highly symmetrical contralateral distribution of thalamo-cortical projections (Kenshalo, Giesler et al. 1980; Bushnell, Duncan et al. 1999; Hofbauer, Rainville et al. 2001).

To further characterize psychophysics of heat noxious stimuli, we assessed whether varying the stimulus *site* on and across forearms may reveal equivalent pain threshold and tolerance values when randomly applied to either body *side* of healthy volunteers. These characterizations are important because there is a need for reference data of each body area, as Rolke et al. pointed out in seminal work (Rolke, Magerl et al. 2006). In particular, we hypothesized that 1*) pain tolerance* and 2) *threshold* of heat noxious stimuli in three corresponding left and right forearms' *sites* of healthy volunteers will be equivalent.

4.2 Results

Figure 9 Locations of the three stimulation sites on both forearms.

4.2.1 Pain threshold

The repeated measurements ANOVA for pain thresholds did not reveal any significant differences, neither in the main factors *Gender* (DF (1,16) F = 3.137, p = 0.096), *Site* (DF (2,32) F = 1.664, p = 0.206) and *Side* (DF (1,16) F = 0.320, p = 0.579), nor in their interactions (See Table 3 for the average thresholds of all *sites* tested). Linear regression analysis revealed a significant relationship of pain threshold between averages from equivalent *sites* on the left and the right forearm (*Site 1 left vs. site 1 right:* DF (1,16) F = 30.478, R = 0.81, R Squared = 0.66, p < 0.0001; *site 2 left vs. site 2 right:* DF (1,16) F = 23.251, R = 0.77, R Squared = 0.59, p = 0.0002; *site 3 left vs. site 3 right:* DF (1,16) F = 92.565, R = 0.92, R Squared = 0.85, p < 0.0001, see Figure 10, 1a).

4.2.2 Pain tolerance

The repeated measurements ANOVA for pain tolerance including the factors *Gender, Site and Side*, revealed a significant main effect for the factor *Gender* (DF (1,16) F = 6.252 p = 0.024): men showed higher pain tolerance for heat noxious stimuli than women (See Table 1 for the average tolerances of all *sites* tested). No other main effects or interactions were significant (*Site* (DF (2,32) F = 1.413, p = 0.259) and *Side* (DF (1,16) F = 0.002, p = 0.965). All computed regression analyses amongst averages of equivalent *sites* on the left and the right forearm were significant (*Site 1 left vs. site 1 right:* DF (1,14) F = 31.768, R = 0.83, R = Squared = 0.69, p < 0.0001; *site 2 left vs. site 2 right:* DF (1,14) F = 24.655, R = 0.80, R Squared = 0.64, p = 0.0002; *site 3 left vs. site 3 right:* DF (1,14) F = 38.896, R = 0.86, R Squared = 0.74, p < 0.0001). See Figure 10, 1b).

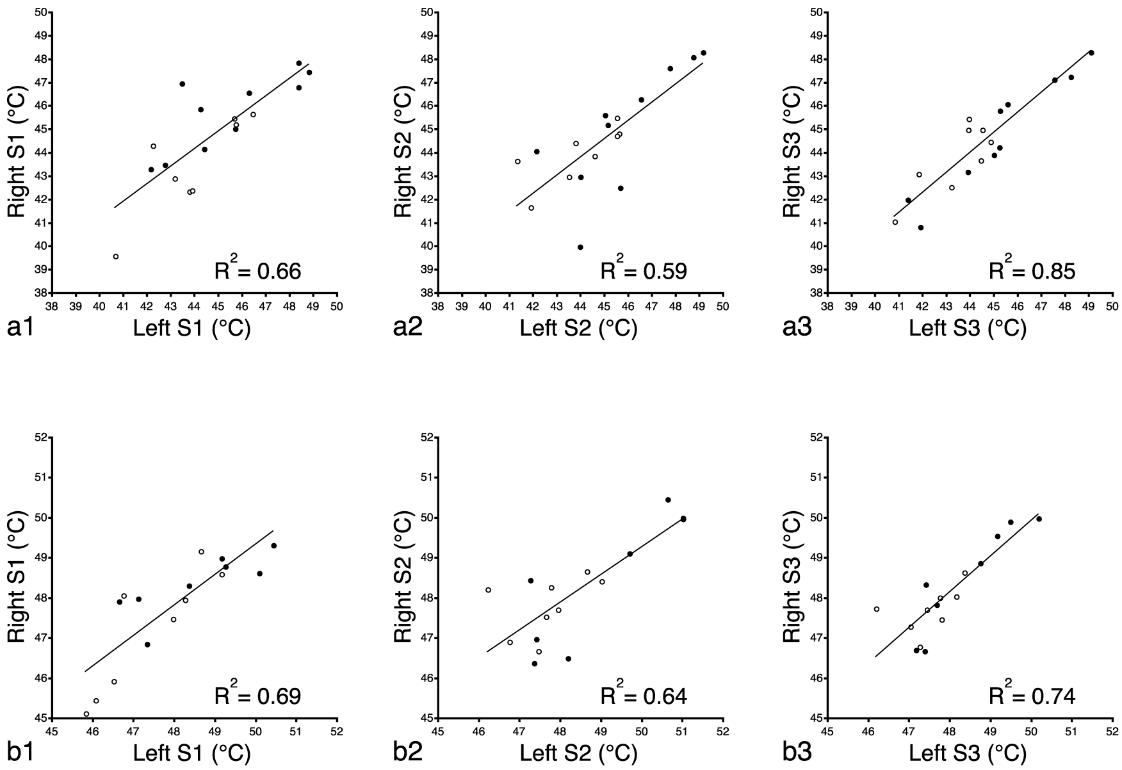


Figure 10 Linear regressions of pain threshold (a) and tolerances (b) in °C between averages from equivalent sites on the left and the right forearms. Depicted in the upper panel are regressions for pain thresholds at site 1 (a1), site 2 (a2) and site 3 (a3). Shown in the lower panel are regressions for pain tolerances at site 1 (b1), site 2 (b2) and site 3 (b3). S, site; filled dots = male subjects; unfilled dots = female subjects.

Table 3 **Mean pain thresholds and pain tolerances (°C) split by gender.** Values are means and standard deviations (SD) for all three *sites* tested at the volar aspect of the right and left forearms. The numbers 1, 2 and 3 correspond to the stimulation *site* from wrist to elbow.

Threshold	Right *side*					Left *side*			
Forearm *site*	1	2	3	Mean (SD)		1	2	3	Mean (SD)
Males (n=10)	45.77 (1.66)	45.08 (2.70)	44.89 (2.44)	45.25 (2.17)		45.44 (2.44)	45.87 (2.24)	45.28 (2.52)	45.50 (2.33)
Females (n=8)	43.51 (2.08)	43.97 (1.21)	43.80 (1.49)	43.76 (1.50)		43.92 (1.95)	43.95 (1.66)	43.42 (1.42)	43.76 (1.61)
All (n=18)	44.77 (2.14)	44.59 (2.19)	44.41 (2.09)	44.59 (2.00)		44.76 (2.31)	44.97 (2.16)	44.45 (2.26)	44.73 (2.18)
Tolerance									
Males (n = 10)	49.03 (1.24)	49.04 (1.86)	49.00 (1.58)	49.02 (1.51)		49.03 (1.62)	49.50 (1.75)	48.91 (1.49)	49.14 (1.56)
Females (n=8)	47.41 (1.52)	47.81 (0.72)	47.72 (0.55)	47.65 (0.79)		47.39 (1.26)	47.67 (0.91)	47.49 (0.69)	47.52 (0.85)
All (n=18)	48.31 (1.57)	48.50 (1.57)	48.43 (1.37)	48.41 (1.39)		48.30 (1.66)	48.69 (1.68)	48.28 (1.38)	48.42 (1.51)

4.3 Discussion

In this study we showed that, in healthy volunteers, no perceptual differences in pain threshold and pain tolerance could be observed when a heat pain stimulus is randomly applied to three different equidistant stimulus *sites* on the volar aspect of both forearms. These results were gender independent for pain thresholds and tolerances though overall, men had higher pain tolerances.

On either *side* of the body we found equivalent thresholds for randomly applied heat pain stimuli for all three homologous *sites*. These results correspond to several studies using experimental heat pain stimuli reporting no *side* differences of thresholds on the forearm (Taylor, McGillis et al. 1993; Meh and Denislic 1994; Spernal, Krieg et al. 2003) the hand (Yarnitsky, Sprecher et al. 1995) and the hand, foot and face (Rolke, Baron et al. 2006; Rolke, Magerl et al. 2006). Concerning this absence of *side* effects on threshold, the study with the largest sample size was conducted by Rolke et al. (Rolke, Baron et al. 2006). While some studies using tonic heat stimuli and subjective pain scores did not find left-right perceptual differences either (Long 1994; Sarlani, Farooq et al. 2003), others found higher pain perception of the left hand (Lugo, Isturiz et al. 2002). Studies using other painful stimuli than heat showed lower thresholds for electrical (Meador, Ray et al. 1998), pressure (Pauli, Wiedemann et al. 1999) and cold (Schiff and Gagliese 1994) stimuli presented to the left *side* of the body, but lower threshold for the dorsum of the right hand for heat noxious stimuli without tactile components (Schlereth, Baumgartner et al. 2003). Several factors might explain these heterogeneous results concerning the effect of *side* on pain threshold. Laterality biases may strongly depend on the kind of noxious stimulation being used, resulting in the stimulation of different nociceptors with particular properties and impact on central mechanisms (Spernal, Krieg et al. 2003). Some contradictory results regarding laterality of pain perception have also been obtained by using subjective pain ratings (e.g. visual analogue scales). Alternatively, differences in random vs. non-random stimulus presentation might explain the incongruence of these results. It is likely that an interaction of the above mentioned factors might have caused the observed differences.

In healthy volunteers and in patients, pain thresholds for heat pain stimuli have been analyzed for different parts of the body on one *side*, such as forearm, foot and hand (Yarnitsky, Simone et al. 1992; Taylor, McGillis et al. 1993; Kalter-Leibovici, Yosipovitch et al. 2001). Mean receptor threshold for heat on receptive fields of C nociceptors in the dorsum of foot and hand was found to be uniform (Yarnitsky, Simone et al. 1992). Significant differences in thresholds were found between glabrous and hairy skin *sites*, but not between the thenar eminence of the hand and the plantar surface of the foot (Taylor, McGillis et al. 1993). Our results show for the first time that heat pain threshold *and* tolerance are highly similar across three different *sites* within the volar aspect of each forearm. These results add objective data to the findings of others who have observed that subjective ratings of supra threshold heat pain stimuli do not differ between *sites* within one forearm (Granot, Sprecher et al. 2003) or between thenar, volar and dorsal *sites* of the hand (Hagander, Midani et al. 2000).

To our knowledge the psychophysics of heat pain tolerance at different *sites* of the forearm has not been investigated so far, and only two studies have investigated the effect of body *side* at the volar wrist: in depressed patients, right hand *side* tolerance for thermal and electrical pain was increased whereas healthy controls showed no laterality effects (Bar, Greiner et al. 2003; Bar, Brehm et al. 2005). The present results reveal that pain tolerance is not only equivalent on the volar wrists, but also on the other two equidistant *sites* on both forearms.

Several experimental and clinical studies on acute and chronic pain have shown that women are more sensitive to pain (Rollman, Abdel-Shaheed et al. 2004; Kuba and Quinones-Jenab 2005; Rhudy and Williams 2005) In agreement with previous studies, our data show that overall, men have an higher pain tolerance than women for induced heat pain (Fillingim, Maixner et al. 1998; Kut, Schaffner et al. 2007). Similarly we did not observe a gender difference in pain threshold, only a light tendency (p=0.096), although the small number of subjects may have obscured a possible difference. A power analysis including a power value of .80 and a difference in heat pain threshold between genders of 1.62°C, with a joint sigma value of 2.04, revealed that a sample size of 25 volunteers for each sample would be needed to achieve a significant gender effect. This should be considered for a gender difference study in the future.

Concerning heat pain threshold existing data are controversial: in 180 patients Rolke et al. found gender differences (Rolke, Baron et al. 2006) while others observed no gender effect (Yosipovitch, Meredith et al. 2004; Kut, Schaffner et al. 2007).

Some limitations of our data should be considered. Given the large influence of age on thermal thresholds including older subjects (the oldest participant included was 43 years old) might reveal different outcomes for the measured perceptual parameters (Rolke, Baron et al. 2006). In addition, our sample included only 18 subjects. Though, our sample size is similar to those in other studies on pain perception that used a comparable methodology (Rolke, Magerl et al. 2006). Differences in thermode pressure against the skin were not controlled in any special way. This factor has been discussed to be a potential confound in similar pain measurement setups (Symonds, Gordon et al. 2006). The strong relationships we observed suggest that slight pressure differences do not significantly affect position-temperature relationships, at least amongst homologous body locations.

Regression lines for thresholds and tolerances show that the y-intercept is slightly -but consistently- positive (see Figure 1). This may suggest that psychophysical outcomes on laterality would depend on the physical intensity of the stimulus. By computing a simple regression including the left and right averages over all *sites* of any single subject, a high linear fit for both, tolerances and thresholds is again obtained. Results are highly similar, irrespective of the fact that the y-intercept is forced to be zero or not. In addition, residuals do not reveal apparent outliers (see supplementary information). Therefore, our results appear to be valid at the individual level as well, and at least for heat pain thresholds and tolerances, laterality results do not appear to depend on stimulus intensity.

The high correlations of threshold and tolerance values across *sites* and *side* of stimulation suggest a rather evenly distributed density of heat pain receptors amongst the *sites* in the forearms. – Different receptor densities across pain receptive fields would probably lead to differences in threshold and tolerance values. As has been demonstrated in the forearms of monkeys, the heat threshold and the response magnitude at suprathreshold intensities depends on the size of the skin area overlapped by the heat stimulus (Treede, Meyer et al. 1990). Infrared-recorded thermal imprints of our heat stimuli on both forearms of a volunteer not included in the present series cover an equivalent skin area (see supplementary information).

Some recent brain imaging studies have reported right brain lateralization for the processing of electrical pain stimuli (Symonds, Gordon et al. 2006). In contrast, other studies using laser stimulation, which is selective for the stimulation of nociceptors, have clearly shown a significant contralateral bias within the somatosensory cortex for stimulation of either hand (Bingel, Quante et al. 2003) and the legs (Youell, Wise et al. 2004). Whether results would be different in patients remains an open issue. It is an interesting question to what extent this technique might be discriminative for focal or distal sensory deficits. For example, left-right differences might be observed in patients with focal lesions while *site*-to-*site* differences in patients suffering from polyneuropathy. In addition, the magnitude of *side* and *site* differences, which may be considered to be within normal limits, in single individuals, should be clarified in future work. The still reduced number of subjects prevents us from computing normative estimates. Nevertheless, in assessing basic psychophysical properties of pain threshold and tolerance, our data may contribute to a more conclusive interpretation of brain imaging studies aiming at assessing laterality effects.

5 Changes of self-perceived role-identity modulate pain perception

Objectives: Pain is an experience including physiological and psychological factors. We assume that emotions may be elicited and increased through self-perceived role-identity and that change of role-identity alters quality and intensity of pain perception. *Methods*: We used role-play strategies to assess whether pain can be better tolerated when, in an unavoidable and unpleasant context, role-identity confers pain a meaningful and thus suitable character. We induced antithetic roles in 21 actors who received heat stimuli on their arms before and after role-play conditions. Pain tolerance, skin conductance and voice signals were measured. *Results*: Pain tolerance increased for heroes/heroines and decreased for faint-hearts. Men showed higher pain tolerance. Heroes/heroines evaluated heat stimuli as more intense. Faint-hearts found pain stimuli more affectively loaded at lower temperatures. Women showed higher pain ratings. Hence, self-perception influences pain perception. Role-play strategies may be of value for new pain management strategies. [5]

[5] Elvan Kut*, Nils Schaffner*, Amrei Wittwer*, Victor Candia, Meike Brockmann, Claudio Storck, Gerd Folkers. *These authors contributed equally to this work. Pain 131 (2007) 191–201

The work described in this chapter has been done in collaboration with the following people: Nils Schaffner, Elvan Kut, Victor Candia, Meike Brockmann, Rene Bill, Gerd Folkers.

5.1 Introduction

Figure 11 Two paintings of the Napolitano Gaspare Traversi (1732 ca.-1769) depicting opposing vivid pain perceptions. (Left) The wounded sufferer, when forced and on his own grimaces with intense pain. "L'operazione chirurgica" reproduced with permission of the Staatsgalerie Stuttgart. (Right) Comforted by a woman, he endures the awful procedure. "Il Ferito" reproduced with permission of the Gallerie dell'Accademia di Venezia.

The two paintings of the Napolitano Gaspare Traversi (1732 ca.-1769), are strikingly similar (Figure 11) but to the attentive observer, they vividly depict opposing pain perceptions in the face of the wounded sufferer: forced and on his own, he grimaces with intense pain, yet facing the proximity of a comforting woman he bravely and calmly endures the awful medical intervention. Apparently, the man perceives himself differently, and this changes his tolerance for the unbearable pain.

The effect of self-perceived role-identity on pain perception, here defined as the product of the brain's abstraction and elaboration of a nociceptive input (Basbaum and Jessell 2000) has been investigated in gender role studies, including coping strategies (Keogh and Herdenfeldt 2002), pain catastrophizing (Thorn, Clements K.L. et al. 2004), situational context (Kallai, Barke et al. 2004), gender role expectations (Robinson, Riley et al. 2001) and hyper-vigilance (Rollman, Abdel-Shaheed et al. 2004) or anxiety (Edwards, Augustson et al. 2000). Miscellaneous evidence indicates that pain perception is influenced by physiological and psychological factors like testosterone and oestrogen (Craft, Mogil et al. 2004), athletic status (Manning and Fillingim 2002) and pain history (Rollman, Abdel-Shaheed et al. 2004). Moreover, correlations between arousal (Lang, Bradley et al. 1990) and skin conductance (SC) and voice parameters (Mendoza 1998; Johnstone and Scherer 2000) have been demonstrated. Pain includes sensory, affective and evaluative dimensions, whereas emotions can influence the affective dimension (Melzack and Casey 1968). Recent studies showed a close connection of brain centers that involve pain and emotions (Eisenberger, Lieberman et al. 2003; Koyama, McHaffie et al. 2005; Vogt 2005). Several authors (de Wied and Verbaten 2001; Meagher, Arnau et al. 2001; Rainville, Bao et al. 2005) agree that pleasant affective states reduce pain perception, whereas unpleasant affective states exacerbate it. Consistently, dysfunctional emotional and cognitive processing has an important influence on pain perception (Klossika, Flor et al. 2006).

To induce emotions, pictures (Junghofer, Sabatinelli et al. 2006), films (Weisenberg, Raz et al. 1998), odours (Villemure, Slotnick et al. 2003), music (Robazza, Macaluso et al. 1994; Koelsch, Fritz et al. 2006), mental imagery (Holmes and Mathews 2005) and respiration (Philippot, Chapelle et al. 2002), hypnosis (Rainville, Bao et al. 2005) and games have been used. During games a strong identification with the played role-identity occurs (de Quervain, Fischbacher et al. 2004; Singer, Seymour et al. 2006).

From own experience we know how self-perceived role-identity allows us to tolerate pain more easily. For example, parents encourage their children to adopt a brave and strong attitude in order to diminish unpleasantness during a painful medical intervention aimed at protecting them from- or alleviating a distressing illness. Thus, understanding the alleviating power of a vaccination and empathizing with an archetype, which has the implicit ability to tolerate danger and to overcome pain (e.g., a hero) can transform the painful procedure into a meaningful and tolerable experience. Therefore, we assume that a) pain can be better tolerated whenever role-identity is embedded in an unavoidable, unpleasant context, but which confers pain a meaningful and thus suitable character, and b) that the self-perceived identity changes emotions accordingly, and affects intensity and quality of pain perception.

5.2 Results

5.2.1 Pain tolerance and pain threshold

The ANOVA for pain tolerance was significant for the within-subjects factor Role ($F_{2,17}$ = 9.580, P = 0.001). Most importantly, the interaction *Role*Time* was highly significant ($F_{2,17}$ = 21.461, P = 0.000; Figure 12). Post-hoc t-tests showed that pain tolerance increased significantly with the induction of the hero/heroine role (t_{18} = -3.707, P = 0.002), however it significantly decreased in the case of the faint-heart role (t_{18} = 3.867, P = 0.001). Listening to a scientific text or ten minutes silence without any other task led to a significant decrease in pain tolerance as well (t_{18} = 4.491, P = 0.000). The interaction *Role*Gender* was not significant ($F_{2,17}$ = 1.566, P = 0.229). The between-subjects factor *Gender* revealed that overall men showed higher pain tolerance than women ($F_{1,17}$ = 5.435, P = 0.032; Figure 13). In contrast to pain tolerance, pain threshold measurements did not significantly differ in any of the main factors or their interactions. Corrected alpha level for post-hoc t-tests: 0.0033.

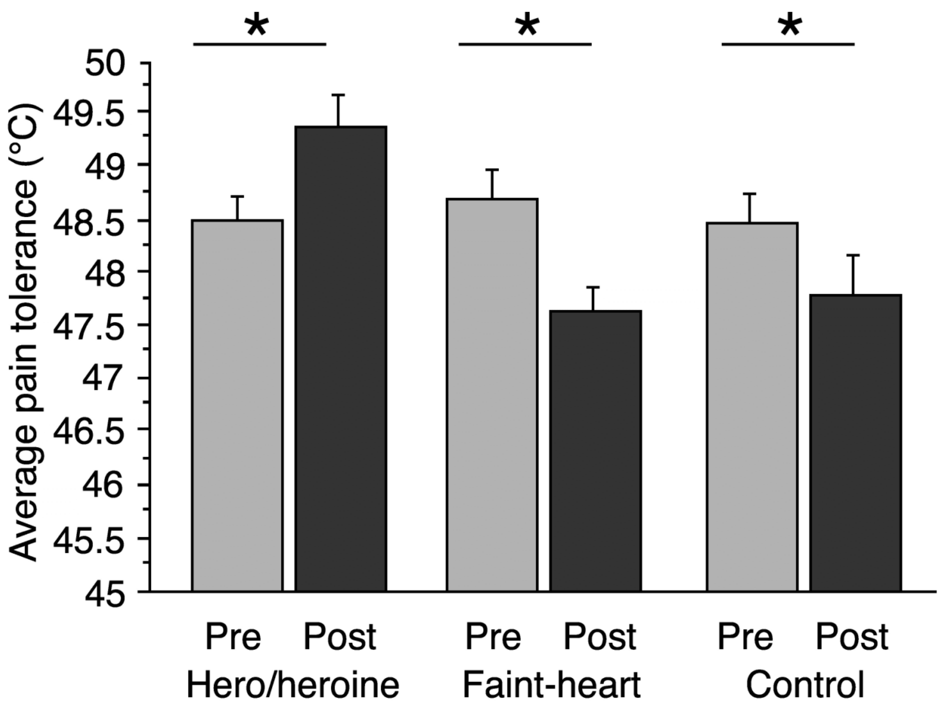


Figure 12: Mean levels of pain tolerance (°C) pre- and post role induction and control conditions. Asterisks (*) indicate significant, post-hoc comparisons (P < 0.0033). Pre = pre-role induction/control conditions; Post = post-role induction/control conditions; Bars depict average values and s.e.m.

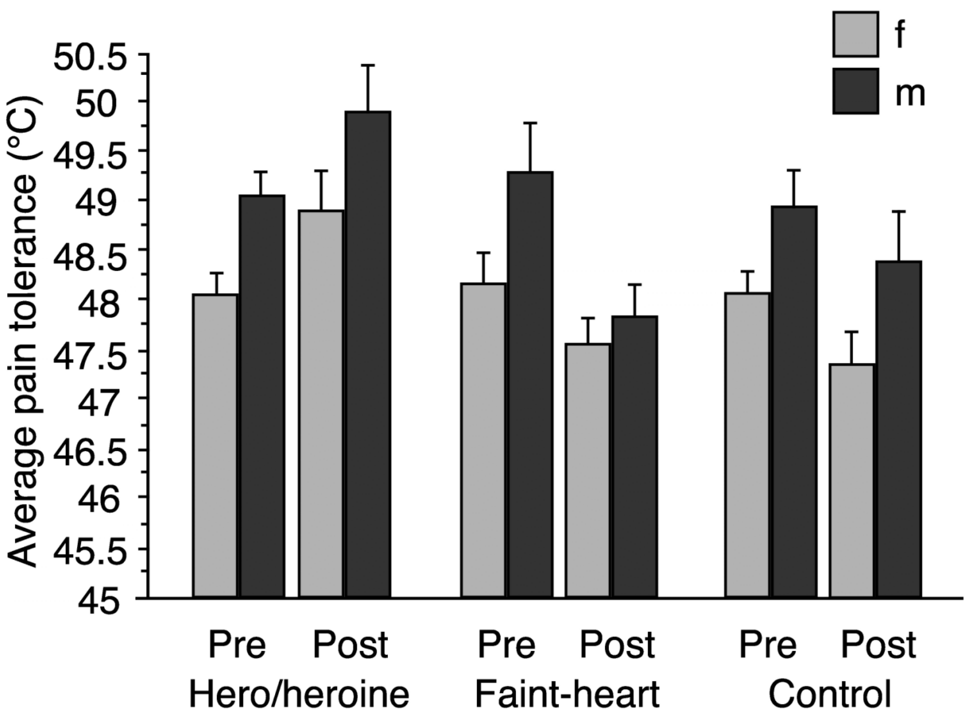


Figure 13: Difference in pain tolerance between men and women. Overall, men showed higher pain tolerance than women. Pre = pre-role induction/control conditions; Post = post-role induction/control conditions; f = females; m = males. Bars depict average values and their s.e.m.

5.2.2 McGill pain questionnaire

The ANOVA for the sensory subscale of the McGill pain Questionnaire (MPQ) was significant for the interaction *Role*Time* ($F_{2,17} = 9.244$, $P = 0.002$). Post-hoc t-tests revealed that only heroes/heroines increased their sensory pain ratings significantly ($t_{18} = -4.041$, $P = 0.001$; Figure 14a). The ANOVA for the affective subscale of the MPQ was significant for the interaction *Role*Time* as well ($F_{2,17} = 6.462$, $P = 0.005$). The post-hoc comparisons revealed that only faint-hearts significantly increased their affective pain ratings ($t_{18} = -3.584$, $P = 0.002$; Figure 14b). The between-subjects factor *Gender* revealed that overall, female volunteers gave higher MPQ ratings than men (sensory: $F_{1,17} = 11.404$, $P = 0.004$; affective: $F_{1,17} = 7.462$, $P = 0.014$). Control conditions showed no significant change in sensory and affective subscale scores. Corrected alpha level for post-hoc t-tests: 0.0033.

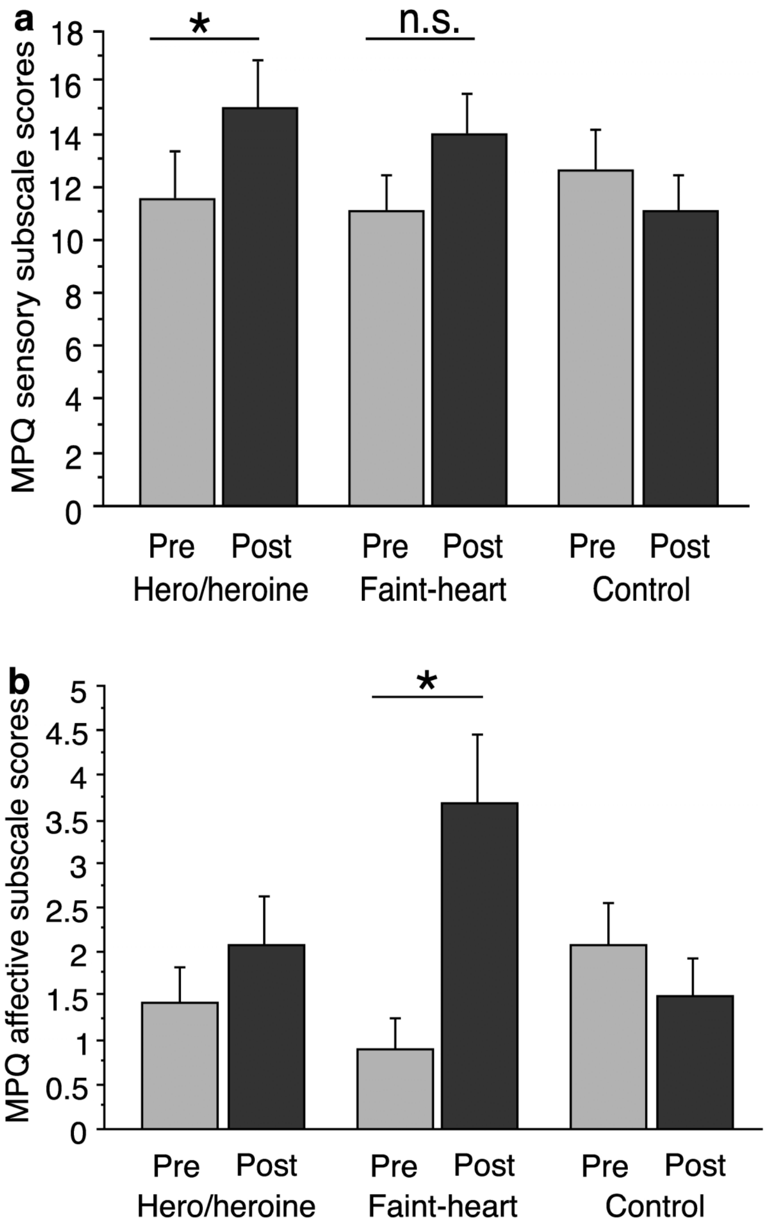


Figure 14: Mean MPQ subscale scores pre- and post role induction and control conditions. (a) Sensory subscale scores increased significantly only after the role induction of a hero/heroine. (b) Affective subscale ratings increased significantly only after the role induction of a faint-heart. Asterisks (*) indicate significant post-hoc comparisons ($P < 0.0033$). Pre = pre-role induction/control conditions; Post = post-role induction/control conditions. Bars depict average values and s.e.m.

5.2.3 Visual analogue scale

The ANOVA for the VAS on pain intensity ratings was significant for the interaction *Role*Time* ($F_{2,17}$ = 3.936, P = 0.032). Post-hoc t-tests showed a significant increase of pain intensity ratings for heroes/heroines (t_{18} = -4.043, P = 0.001). Neither role nor control conditions altered VAS ratings for pain unpleasantness. The ANOVA for the effect of time (Run1/Run2/Run3) on pain intensity was significant for the within-subjects effect *Time* ($F_{2,17}$ = 3.664, P = 0.047) as well as the corresponding ANOVA for pain unpleasantness ($F_{2,17}$ = 8.013, P = 0.004): over time, scores on both measures increased. The between-subjects factor *Gender* was not significant. Nevertheless, post-hoc t-tests of pain intensity scores did not survive Bonferroni corrections. Conversely, mean pain unpleasantness ratings increased significantly from Run1 to Run3 (t_{18} = -3.302, P = 0.004). Corrected alpha level for post-hoc t-tests: 0.0033 and 0.016 respectively (See under "Methods"). The between-subjects factor *Gender* was significant indicating that women gave significantly higher pain unpleasantness ratings than men ($F_{1,17}$ = 4.993, P = 0.039).

5.2.4 Role-play questionnaire

The ANOVA for VAS ratings for pain meaningfulness was significant for the within-subjects factor *Role* ($F_{1,17}$ = 12.401, P = 0.003). Pain had more meaning for heroes/heroines than for faint-hearts. Conversely, the between-subjects factor Gender was not significant as well as any interaction. The nonparametric Spearman Rank correlation revealed a significant correlation between the increase in pain tolerances of heroes/heroines (differences post-pre) and their corresponding VAS ratings on meaningfulness of pain collected at the end of the role induction (rho = 0.569, P = 0.011). We found no such correlations for faint-hearts (rho = -0.167, P = 0.495). VAS ratings on role empathy at the end of role induction of hero/heroine (71.4 ± 21.8 s.d.) and faint-heart (65.3 ± 22.3 s.d.) did not differ significantly from each other ($F_{1,17}$ = 0.031, P = 0.862). The between-subjects factor *Gender* had no impact on role empathy either ($F_{1,17}$ = 2.920, P = 0.106). In addition, the repeated measurements ANOVA for VAS ratings of the intensity of role empathy during the experimental procedure compared to during normal role-playing games showed no significant difference for the within-subjects factors *Role* ($F_{1,17}$ = 0.411, P = 0.530) or the between-subjects factor Gender ($F_{1,17}$ = 0.606, P = 0.447); (heroes/heroines: 56.6 ± 25.5 s.d., faint-hearts: 60.5 ± 20.2 s.d.). Freely chosen words or phrases at the end of each role condition indicating whether the implicit character imbedded in the corresponding story line was truly captured were mostly appropriate to the role-identity of a hero/heroine or a faint-heart facing pain. In the hero/heroine condition 58% of the adjectives belonged to the category "Appropriate", whereas 27% were "Antonyms" to the role-identity of a hero. The remaining 15% were "Strange" adjectives. In the faint-heart condition 89% of the adjectives fell into the category “Appropriate” and 11% into the category “Strange”. At the end of the experimental session, participants reported no significant preference in having empathized with one role or the other: 3 men and 4 women preferred the hero/heroine identity, 4 men and 2 women preferred the faint-heart identity, while the remaining 6 reported they have equally empathized with both roles.

In their majority, the synonyms named by the seven volunteers not aware of the present study matched those named by role-players: 64% of the synonyms correspond to a hero-identity facing pain, and 73% correspond to a faint-heart identity facing pain. All synonym groups were represented by one of their synonyms that were found to have a number with valence and arousal scores in the ANEW-catalogue. These synonyms were congruent with high-valence-high-arousal words, in the case of a hero-identity, and with low-valence-high-arousal words, in the case of faint-hearts. [ANEW-numbers for the words representing the synonyms named by role-play participants after the hero identity condition and its percentage of appearances, considering all 33 adjectives pertaining to this identity condition: 8 = afraid (6%), 9 = aggressive (3%), 62 = capable (3%), 79 = confident (3%), 95 = curious (3%), 135 = easygoing (9%), 206 = helpless (18%), 241 = joyful (6%), 263 = love (3%), 323 = power (9%), 415 = stupid (3%), 494 = win (3%), 668 = brave (27.3%), 1011 = tender (3%); results of seven volunteers unaware of the present study (number of adjectives = 33): 8 = afraid (15.1%), 9= aggressive (3%), 11 = alert (3%), 14 = ambition (6%), 18 = angry (3%), 53 = brutal (3%), 79 = confident (6%), 95 = curious (3%), 104 = defiant (9%), 135 = easygoing (18%), 201 = hate (3%), 323 = power (3%), 335 = punishment (3%), 668 = brave (15.1%), 713 = danger (6%); ANEW-numbers for the words representing the synonyms named by role-play participants during the faint-heart identity condition and its percentage of appearances, considering all 38 adjectives pertaining to this identity condition: 8 = afraid (21%), 12 = alone (10.5%), 18 = angry (2.6%), 28 = astonished (2.6%), 120 = disappoint (2.6%), 206 = helpless (36.8%), 329 = prison (2.6%), 713 = danger (5%), 827 = jolly (2.6%), 852 = lost (10.5%), 880 = mistake (2.6%); results of seven volunteers unaware of the present study (number of adjectives = 33): 8 = afraid (48.5%), 24 = aroused (18%), 197 = guilty (3%), 206 = helpless (24.2%), 601 = panic (6%). Bold values represent equivalence between both groups].

5.2.5 Autonomic response

Both skin conductance levels (SCL) of heroines and heroes and SCL of female and male faint-hearts correlated highly significant (rho = 0.824, P = 0.000 and rho = 0.662, P = 0.000 respectively). Moreover, same signal traces of heroines and heroes together significantly correlated with those of faint-hearts (rho = 0.787, P = 0.000; Figure 15). The repeated measurements ANOVA for stimulus-related peak height of SCL during pain tolerance measurements was highly significant for the interaction *Role*Time* ($F_{2,15}$ = 17.722, P = 0.000). The between-subjects factor *Gender* was not significant. Post-hoc t-tests showed that the induction of the hero/heroine role lead to increased stimulus-related SCL peaks (t_{16} = -4.327, P = 0.001), whereas the test results of faint-hearts and control conditions did not alter stimulus-related SCL peaks at all (faint-heart: t_{16} = 2.746, P = 0.014; control: t_{16} = 0.971, P = 0.346). Corrected alpha level for post-hoc t-tests: 0.0033.

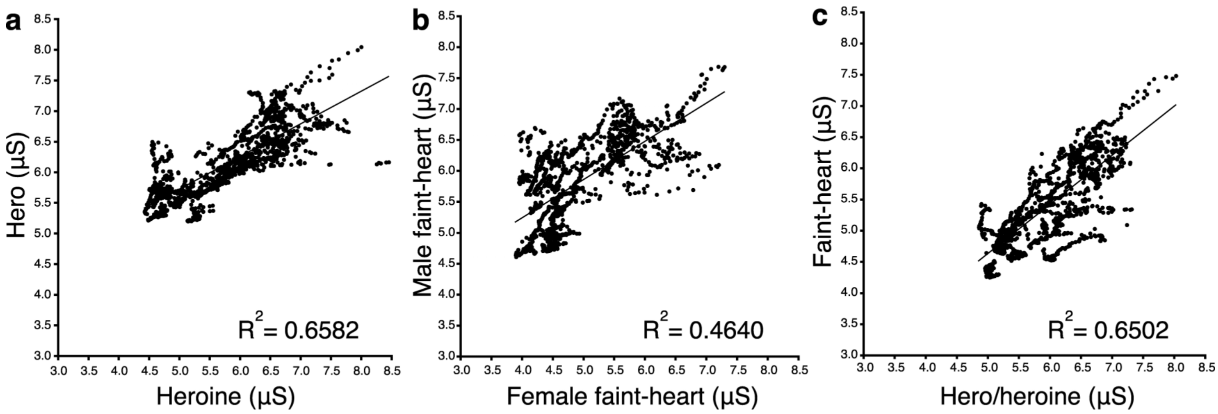


Figure 15: Correlations of SC of different roles and genders. SC were correlated from the start of a role induction up to and including the pain stimuli at the end of the role induction. Both SC of heroines and heroes (a) and SC of female and male faint-hearts (b) correlated highly significant. Moreover, same signal traces of heroines and heroes together significantly correlated with those of faint-hearts (c).

5.2.6 Voice measurement

The repeated measurements ANOVA for the voice measurements with the within-subjects factors Time and Role and the between-subjects factor *Gender* revealed highly significant differences of Fundamental Frequency (F0) for the factor *Gender*: men showed lower F0 ($F_{1,15}$ = 59.117, P = 0.000). Jitter and Shimmer of participant's voices were not significantly different under any of the measured conditions.

5.3 Discussion

Emotion and pain perception are strongly related. We studied the influence of self-perceived role-identity, and its associated emotional status on both, subjectively and objectively assessed pain perceptions. We used role-play strategies to implicitly induce two antithetic role identities.

Heroes/heroines tolerated more heat and gave these stimuli higher pain scores in the sensory subscale of the MPQ, and associated affective pain ratings were not altered. Heroes/heroines showed higher pain intensity ratings and unchanged pain unpleasantness scores. These results suggest that the hero/heroine identity can attenuate affective components of pain perception. Faint-hearts showed higher affective MPQ ratings together with less pain tolerance after role induction. Only faint-hearts revealed significant affective MPQ scores, suggesting that this identity can amplify affective and sensory components of pain perception. Control conditions showed a lower pain tolerance with unchanged subjective pain ratings. Thus, role-playing strategies targeting emotions can modulate pain perception.

We also assessed the influence of self-perceived role-identity and its associated emotional dimension "arousal" on acoustic vocal parameters and on skin conductance level (SC). SC of participants correlated during both role-playing stories (Fig. 6); this suggests similar levels of attention throughout role conditions. Higher stimulus-related SC peaks after the hero/heroine role induction probably resulted from the increased pain intensity perception at higher tolerance values. Since stimulus-related SC peaks did not decrease in the faint-heart and control conditions, we conclude that these participants stopped the pain stimuli at lower heat temperatures due to truly role-induced decrease in pain tolerance, and not due to different motivation. In contrast to previous reports (Mendoza 1998; Johnstone and Scherer 2000), vocal parameters did not allow for final conclusions. Lack of sensitivity and specificity (Zyski 1984; Ludlow 1987) may explain our results.

Heroes/heroines attributed more meaning to pain, and this correlated with more pain tolerance only of heroes and heroines. Faint-hearts showed less pain tolerance. Indeed, the faint-heart role was written free of passages containing tasks or motivations that would make pain meaningful and suitable. Thus, pain was better tolerated as role-identity conferred pain a meaningful and suitable character. Moreover, 58% of the freely named adjectives and phrases at the end of the hero/heroine role-playing story described an emotional state best fitting the role-identity of a hero facing pain. Similarly, after the faint-heart condition, 89% of participants' descriptions were appropriate to a faint-heart facing pain. Importantly, the terms "hero/heroine" or "faint-heart" were never explicitly mentioned. As revealed in a group of individuals unaware of this study (see Methods), 64% of the synonyms pertaining to a hero-identity facing pain, and

73% of those corresponding to a faint-heart identity facing pain matched those named by the participants. All synonyms of role players were found to have valence and arousal scores in the ANEW-catalogue and were congruent with two antithetic emotional states: a high-valence-high-arousal state in the case of a hero-identity and a low-valence-high-arousal state in the case of faint-hearts. Seemingly, our story lines induced the intended identities and associated emotions, and this may have altered pain perception.

Role and control conditions did not alter VAS unpleasantness. These scores increased over time, presumably after repeated noxious stimuli. Because VAS pain scores of heat pain have been shown to be stable over a time of 0 to 60 minutes (Granot, Sprecher et al. 2003), it is possible that the repeated completion of VAS resulted in higher ratings.

Attention can influence emotional components of pain perception (Bantick, Wise et al. 2002; Villemure and Bushnell 2002). Negative emotions can increase pain-directed attention (Rainville, Bao et al. 2005), and emotional salience of stimuli facilitates attention (Phelps 2006). Emotional vocal stimuli have a strong impact on brain dynamics, and attention magnifies this effect (Grandjean, Sander et al. 2005). If the hero condition had a higher cognitive load capturing more attention, a pain stimulus would be then less of a distraction, resulting in higher tolerance values. Highly demanding tasks might distract attention from pain causing lower subjective intensity values (Veldhuijzen, Kenemans et al. 2006). Interestingly, we observed a significant increase and not a decrease of pain intensity ratings for heroes/heroines.

The hero/heroine role gave rise to a wide array of terms corresponding to both positive and negative cognitions and emotions. This may, again, suggest a more complex cognitive load. This incongruence might be more apparent than real: While a brave attitude refers to confident behaviour in the face of dangers and is related to actively face and endure anything threatening (1989), this may not liberate the individual from antagonistic and concomitantly acting cognitions and emotions: the capacity to overcome dangers and the associated fears and worries confers on a person the qualification of a hero/heroine. Alternatively, the knowledge on cognitions and emotions related to a fainthearted, as for example fear and helplessness, might be rather common to humans, increasing the description's certainty for such a role.

Anxiety-induced hyperalgesia has been reported (Rhudy and Meagher 2000), whereas highly arousing negative affective states can attenuate pain (Janssen and Arntz 1996). If anxiety were involved in our results this would agree with the antithetic tolerance values of heroes/heroines and faint-hearts. If fear mediated our effects, attenuated instead of exacerbated pain perception would be expected during the faint-heart condition. The faint-heart story may have lowered subjects' motivation. Nevertheless, participants did not prefer one role to the other and SC correlated during both role-playing stories.

For every participant we used one out of two conditions to control for the effects of listening to a spoken text, answering questions, and for the speaker's voice. Pain tolerance was comparably lower after the faint-heart and control conditions. It is probable that hearing a hardly understandable scientific text or waiting blindfolded without knowing what will happen next led to unpleasant affective states promoting a low pain tolerance. In addition, MPQ and VAS scores for control conditions remained unchanged. Therefore, only a change in self-perceived role-identity resulted in measurable differences in the perception of sensory and affective pain components together with pain tolerance.

The interaction of self-perceived role-identity and gender on pain perception was insignificant. For pain tolerance, the variable of interest, we showed like others (Fillingim, Maixner et al. 1998) that for induced heat pain, men have, overall, higher pain tolerance. Like others (Yosipovitch, Meredith et al. 2004), we did not see gender differences in pain threshold, a marker we used to determine the turning point from warm into pain perception. Thus, different aspects of pain experience may lead to diverging results among genders.

Our data do not permit direct insights into action mechanisms. It is unlikely that results were influenced by hormonal status because the same individuals experienced both roles. Moreover, circadian factors were controlled. Future studies including analysis of cortisol levels may indicate to which extent role-induced functional modulation of the hypothalamic-pituitary-adrenal (HPA) axis was involved in these results. This is thinkable, as stress activates the HPA-axis (Glaser and Kiecolt-Glaser 2005).

The inclusion of comparable role-play strategies may limit the adverse effects of pain on endocrine and immune function on skin wound healing (Kiecolt-Glaser, Page et al. 1998). Also caregivers may benefit from training protocols using role-play strategies targeting self-enhancement and positive emotions related to the social meaningfulness of the work they do. This may reduce their short and long term risk of health deterioration (Kiecolt-Glaser, Page et al. 1998; Glaser and Kiecolt-Glaser 2005; Tosevski and Milovancevic 2006).

Neuroimaging studies may show whether empathizing with an archetype whatsoever, activates anterior insular-, and cingular regions of the brain, like during empathic pain (Singer, Seymour et al. 2004), or whether specific forms of empathy (e.g., role-empathy vs.- pain empathy) are differently associated to more affective (Singer, Seymour et al. 2004) or more sensory (Avenanti, Bueti et al. 2005) patterns of activity. Such studies may address the question as to whether during pain under a new role-induced identity, a global or a partial activation of the pain matrix occurs, and whether dynamic changes in the activity of the endogenous opioid system can be observed (Apkarian, Bushnell et al. 2005; Sprenger, Berthele et al. 2005).

Our data suggest an important role of self-perceived role-identity, and its associated emotional status, on pain perception. Whether the observed effects will last longer when role-induction sessions extend over several days is an open question. The small sample size and the specialized nature of the participants involved leave open the question as to whether our findings could be generalized to pain populations. Nevertheless, this data should be at least of heuristic value. Modulation of self-perceived role-identity in emotionally meaningful settings, may contribute to a beneficial influence on pain management.

6 Salivary Alpha-amylase is a Potential Biomarker for Acute Heat Pain Perception, Positive Arousal and Stress.

Background: Salivary Alpha-amylase is a non-invasive biomarker of human responses to stressful events. It has been proposed that Alpha-amylase levels reflect activity of the sympathetic system. Although previous work suggests that Alpha-amylase activity increases with mild and strong stressors, little is known about its activation by means of positive arousal or pain. *Objectives:* The objective of the current study was to explore the effects of acute heat pain stimuli, and of positive and negative affective picture viewing, on Alpha-amylase levels. In addition, we assessed the effects of a financial risk task on Alpha-amylase. *Methods*: Heat pain tolerance and threshold were measured on the forearms of 27 volunteers. To induce emotions, the International Affective Picture System (IAPS) was used. Risk behaviour was measured with a new, custom-made Risk Task (RALT). Saliva samples for Alpha-amylase measurements were collected at the beginning of the experiment and at four counterbalanced conditions: directly after pain measurement, during positive and negative picture viewing and during RALT. Participants completed self-reports on emotion's induction and pain perception. *Results:* Alpha-amylase levels correlated with VAS intensity and valence ratings of acute heat pain stimuli. Moreover, positive and negative picture viewing increased Alpha-amylase levels. Alpha-amylase levels during positive picture viewing correlated with SAM self reports of intensity and valence, which was not the case for negative picture viewing. Time of sample collection had no effect on Alpha-amylase levels. *Conclusion:* Alpha-amylase appears to be an objective and non-invasive biomarker of pain intensity and valence ratings. Furthermore, Alpha-amylase appears to be a useful index of positive arousal, at least under the present conditions. [6]

[6] The work described in this chapter has been done in collaboration with the following people: Roberto La Marca, Victor Candia, Gerd Folkers. A journal paper is to be submitted.

6.1 Introduction

Lang et al. proposed that the neural mechanisms of human emotion and motivation are preserved in the human brain in sub-cortical and deep-cortical structures that are supposed to have a two-factor motivational organization, in the form of an *appetitive* and a *defensive system*. These two brain systems respond to appetitive or aversive stimuli. So far, emotions are considered to be action dispositions preceding stimuli and determining the general behaviour strategy in response to these stimuli (Lang 1995).

Each of these two motivational systems can vary in terms of *activation* and *arousal*. Human arousal can be measured by physiological activity in muscles and glands (Lang, Bradley et al. 1998). The assessment of biological analytes in saliva has enabled researchers to measure processes in a minimally invasive manner in ecologically valid social contexts and in special populations like amongst young children. Alpha-amylase (sAA) is one of the most important enzymes in saliva accounting for 40% to 50% of the total salivary gland-produced protein. sAA hydrolyzes the a-1,4 linkages of starch to glucose and maltose. sAA is known to be mainly involved in the initiation of the digestion of starch in the oral cavity. Because sAA is a key component in the extraction of caloric value from foods, it is possible that sAA would increase during all periods of intense energy consumption. However, sAA has also been shown to have an important bacterial interactive function (Scannapieco, Torres et al. 1993). Recently, sAA has been used as a marker for sympathetic nervous system (SNS)-activation. Studies on animals and humans indicate that the Autonomic Nervous System (ANS), and in particular the SNS plays a powerful role in the secretion of sAA with contributions of both its alpha-, and beta-adrenergic mechanisms (Nater and Rohleder 2009). In their review, Nater et al. suggest that sAA might be regarded as an immediate and indirect indicator of SNS-activation, particularly for the sympathetic adrenal medullar system (SAMS) (Nater and Rohleder 2009). The ANS controls the function of the inner organs. Its function is largely independent of will and is thought to consist of two, functionally mostly independent systems, the SNS and the parasympathetic nervous system (PNS). SNS is responsible for increased performance and stress, and the PNS has been made responsible for physiological activity under rest. Most organs are under both SNS and PNS control, with mostly antagonistic effects (Silbernagl 1991). The relationship of SNS-activation with the activation of the Hypothalamus-Hypophysär-Andrenal Axis (HPA-Axe) with its marker cortisol is presumed to be additive (Ehlert, Erni et al. 2006; Nater, Abbruzzese et al. 2006; Nater, La Marca et al. 2006) or interactive, though both models have their limitations (Fortunato, Dribin et al. 2008).

Increases in sAA-levels have been shown after strong stressors like the Trier Social Stress Test (TSST) but also after mildly physiologically and psychologically stressful tasks, like aversive picture viewing (van Stegeren, Rohleder et al. 2006; van Stegeren, Wolf et al. 2008), the cold pressure test (van Stegeren et al. 2008), or a stressful video game (Skosnik, Chatterton et al. 2000). However, recent findings suggest that SNS-activation underlies both withdrawal and approach behaviours (Fortunato, Dribin et al. 2008). To our knowledge, no study has yet examined the effects of pain tolerance, acute heat pain or positive pictures on sAA-levels.

We hypothesized that 1) intensity and valence ratings of heat pain perception will correlate with sAA-levels. Moreover we hypothesized that 2) viewing highly arousing pictures with positive valence (e.g., erotic and team sport scenes) will induce emotions congruent with functional goals related to approach behaviours. In particular, we hypothesized that the observation of this pictorial material will activate the appetitive system leading to high SNS-arousal as shown in high sAA-levels. Conversely, we hypothesized that 3) viewing highly arousing pictures with negative valence (e.g., pictures of injuries, human catastrophes and attack scenes) will alead to defensive responses with functional goals related to defending oneself or others against harm, also leading to high SNS-arousal and high sAA-levels.

6.2 Results

The ANOVA for Alpha-amylase was significant for the within factor *Condition* ($F_{1,25}$ = 7.235, p = 0.000; Figure 16). After Bonferroni correction, post-hoc *t*-tests revealed that the Alpha-amylase levels during negative and positive picture viewing were significantly higher than during RALT measurements (RALT vs. IAPS negative: *t* = 4.741, p = 0.000: RALT vs. IAPS positive: *t* = 3.126, p = 0.004). In addition, Alpha-amylase levels during negative picture viewing were significantly higher than during pain measurements (pain vs. IAPS negative: *t* = -4.886, p = 0.000). While the remaining post-hoc comparisons did not survive Bonferroni correction they revealed a trend for Alpha-amylase levels being significantly lower, both after pain measurement and during RALT compared to the beginning of the experiment and during positive and negative picture viewing (start vs. pain: *t* = 2.829, p-uncorrected = 0.009; start vs. RALT: *t* = 2.715, p-uncorrected = 0.012; pain vs. IAPS positive: *t* = -2.703, p-uncorrected = 0.012). The ANOVA for the time of Alpha-amylase collection (1^{st}, 2^{nd}, 3^{rd}, 4^{th}, 5^{th} measurement) was not significant ($F_{1,25}$ = 1.719; p = 0.167).

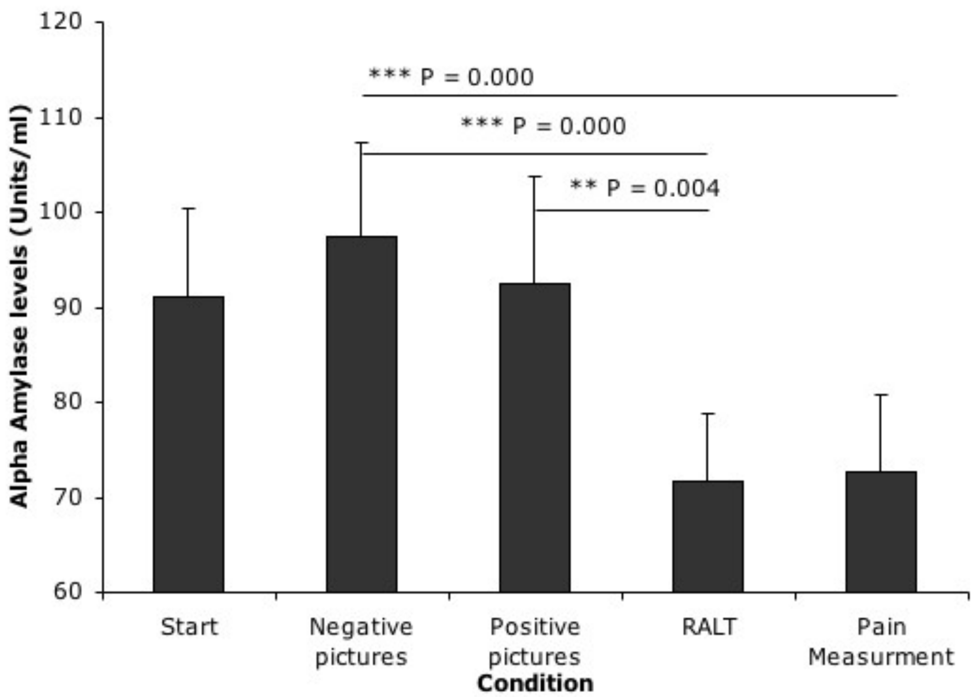


Figure 16 Mean levels of Alpha-amylase in saliva (Units/ml) during each new condition of the experiment. Start = beginning of the experiment; negative pictures = during negative picture viewing; positive pictures = during positive picture viewing; RALT = during RALT; Pain = directly after pain measurement; Bars depict mean values and their standard error (s.e.).

6.2.1 Subjective pain ratings

The non-parametric Spearman Rank correlation revealed a significant correlation between the increase of VAS intensity scores and Alpha-amylase levels after pain measurement ($\rho = 0.594$, $p = 0.003$. $R^2 = 0.3655$, Figure 17). Moreover there was a significant correlation between the increase of VAS valence ratings and Alpha-amylase levels after pain measurement ($\rho = 0.502$, $p = 0.012$, $R^2 = 0.2912$). For VAS intensity and valence ratings, some ratings could not be included, as participants clicked on the wrong space on the computer screen.

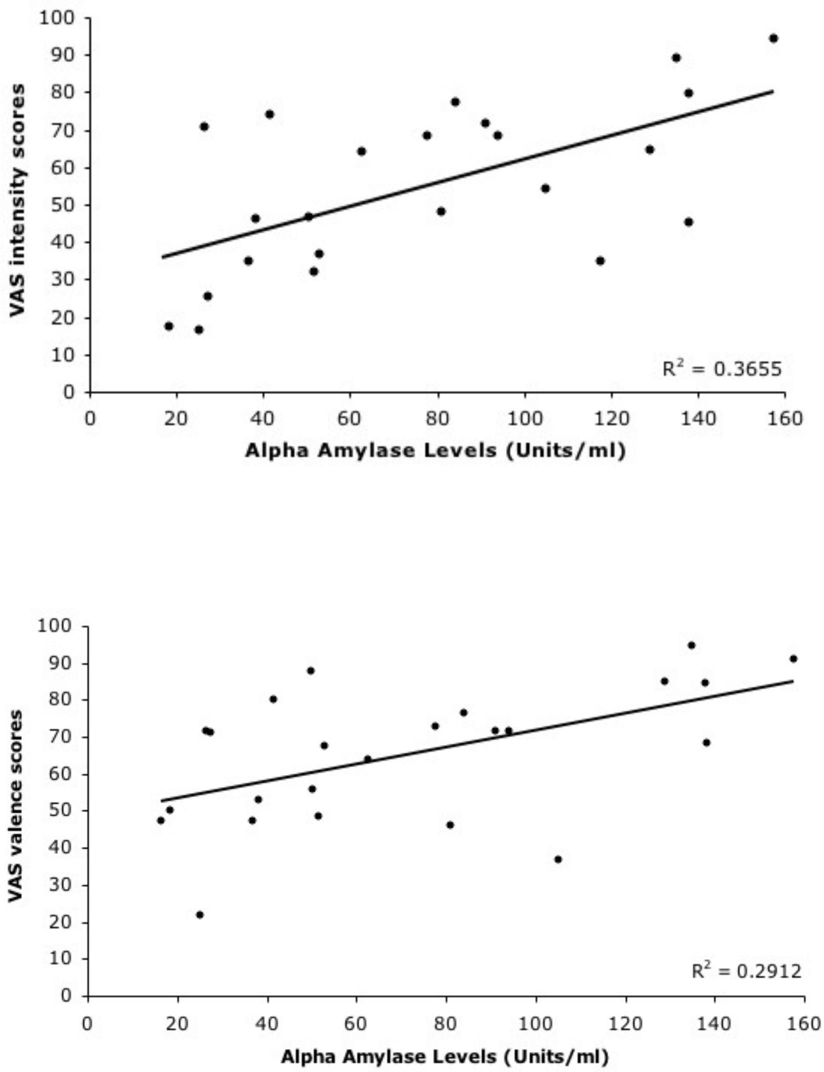


Figure 17 Significant correlations of VAS intensity (upper panel) and valence (lower panel) scores with corresponding Alpha-amylase levels in saliva directly after the pain measurement. Both intensity and valence VAS subscales correlated significantly with Alpha-amylase levels.

6.2.2 Subjective ratings of emotions

As SAM-scores reach only from 1 one to a maximum of 9 scores, we used a logarithmic fit to better describe the observed non-linear relationship. The logarithmic regression (Figure 18) was significant for the increase of SAM-intensity ratings of positive pictures and the corresponding Alpha-amylase levels during positive picture viewing ($F_{1,23}$ = 12.012, p = 0.002, R^2 = 0.39). Moreover it was significant for the increase in SAM-valence ratings of positive pictures and the corresponding Alpha-amylase levels during positive picture viewing ($F_{1,23}$ = 15. 77, p = 0.605, p = 0.001, R^2 = 0.44). However, no such correlation was seen for negative pictures (intensity: $F_{1,23}$ = 0.722, p = 0.408; valence: $F_{1,23}$ = 0.772, p = 0.389). Some ratings could not be included in the analyses, as they participants clicked on the wrong space for ratings on the computer screen.

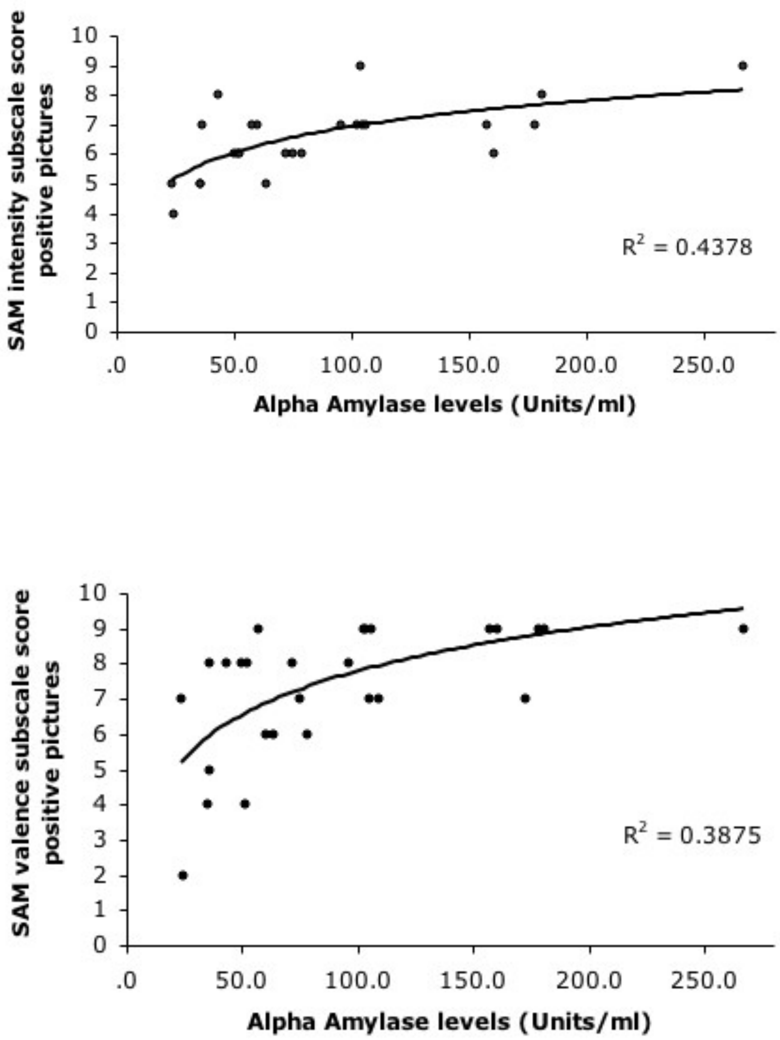


Figure 18 Significant logarithmic fits between the increase of SAM-intensity (upper panel) *and valence* (lower panel) ratings of positive pictures and corresponding Alpha-amylase levels during positive picture viewing.

6.3 Discussion

AA-levels correlated with the corresponding VAS for pain intensity and valence of acute heat pain stimuli, suggesting that sAA is a potentially objective correlate of pain intensity and valence ratings. In addition, average sAA-levels of all participants during picture viewing were significantly higher than during RALT and during pain measurement, irrespective of pictures' valence. This result suggests that sAA-levels depended on the arousal level and not on the valence of pictures. Moreover sAA-levels during positive picture viewing revealed a significant logarithmic relationship with SAM scores of intensity and valence. In contrast, SAM scores of negative pictures did not reveale such a relationship with sAA-levels. Time of saliva sample collection had no effect on sAA-levels.

To our knowledge, there is no evidence on the repercussion of acute subjective pain ratings on sAA-levels. In addition, the effect of acute heat pain perception on sAA-levels has not been assessed so far. Subjective VAS-intensity and valence pain ratings of acute heat pain correlated with their corresponding sAA-levels, suggesting that this biomarker is an objective predictor of pain intensity and valence.

Only few studies examined the relationship of sAA using subjective pain ratings, and this was done in patients suffering from *chronic* or cancer pain (Shirasaki, Fujii et al. 2007; Arai, Matsubara et al. 2009). Along the line of our research, these authors observed an inter-individual correlation of sAA-levels with VAS pain ratings or verbal pain intensity ratings of chronic pain, when using scales ranging from 0 to 10 (Shirasaki, Fujii et al. 2007; Arai, Matsubara et al. 2009). Only one study analyzed the effect of an *acute* cold pressor task on sAA-levels (van Stegeren, Wolf et al. 2008). While participants had to place their arms for 3 minutes in cold water at a temperature of 3°C, participants pain perception was not measured, neither by means of pain tolerances nor through subjective pain. However, it is highly probable that participants were under acute pain states. Cold pressor stress was accompanied by a large increase of sAA-levels from 40 to 120 Units/ml roughly 10 minutes post stimulus onset. Interestingly, and in contrast to the latter result, we observed that sAA-levels 3 minutes after heat pain measurement onset were as low as during RALT baseline. While these results are counterintuitive (one would expect heat pain stimuli to be strong stressors immediately triggering observable higher sAA-levels), it has been shown that a peak in sAA-level can be measured only about 10 minutes after stimulus onset. Consequently, we infer two potential reasons for the observed low levels of sAA-concentration: samples were from before the expected peak. Alternatively, as auditory cues indicated participants the starts of threshold and tolerance measurements, it is likely that volunteers were in a higher state of attention than 10 minutes after the less complex cold pressor task.

Higher states of attention can be accompanied by increased PNS, as demonstrated by others (Moses, Luecken et al. 2007; Wu and Lo 2008) and this may in turn decrease sAA-concentration. Even though, the effect of attention on sAA has not been analyzed so far, our results suggest that already 3 minutes after stimulus onset sAA-levels may achieve a concentration level high enough to serve as a marker of subjective pain intensity and valence ratings.

The effect of positive IAPS pictures on sAA-levels has not been analyzed so far. Our results revealed that during viewing of pictures with positive valence, mainly erotic pictures, sAA-levels of all participants were significantly higher than during RALT at baseline. In addition, sAA-levels were not significantly different from pictures with negative valence. Interestingly, sAA-levels during positive picture viewing correlated with SAM-scores of intensity and valence.

So far, most studies have focused on the effects of negative stressors on sAA-levels. However, seminal work suggest that SNS-activation underlies both approach and withdrawal behaviours. For example, SNS-activation is necessary to modulate energy resources that facilitate approaching as well as withdrawing from stimuli. Since an individual's interpretation of ANS arousal importantly depends on social context (Schachter 1964), SNS-activity may relate to overall arousal as the joint activation of both, approach and withdrawal behaviours (Nigg 2006). Besides, a shorter pre-ejection period of the heart, the time between onset of ventricular contraction and opening of the semi lunar valva, has been associated with high SNS activity along with reward seeking and approach behaviours (Beauchaine 2001). Moreover, sexual arousal induced by erotic stimuli is mostly accompanied by SNS-activity (Meston 2000), and SNS activity leads to orgasm and ejaculation together with PNS activity that leads to vassal dilatation in the genitals (Silbernagl 1991).

Most suggestions on the interaction of positive arousal with higher sAA-levels stem from experiments observing basic sAA-levels among participants. For example, Fortunato and co-workers showed a connection between sAA-baseline concentration and positive affect in toddlers. Though, task-specific affective behaviour could not be correlated to SNS-activity since post-task samples were taken approximately 1 hour after pre-task samples (Fortunato, Dribin et al. 2008). Moreover, basic sAA-levels correlated with positive affect and approach whereas low levels of sAA have been reported to correlate with aggressive behaviour (Gordis, Granger et al. 2006). Still others reported a trend towards a positive association of sAA with positive mood (Nater, Rohleder et al. 2007). In addition, athletes with higher sAA-levels had higher interest in performance and team bonding (Kivlighan and Granger 2006).

To our knowledge, only one study has so far observed intra-individual differences of sAA-levels induced by positive conditioning. In contrast to our results, viewing of erotic films did not increase sAA-levels *per se* but only in interaction with moderate levels of physical exercise (Hamilton, Fogle et al. 2008). Since our volunteers regarded themselves as being strongly moved by pictures, it might be the case that higher levels of arousal are pivotal to demonstrate changes in sAA-concentration.

AA-levels during pictures' viewing with negative valence (e.g., injury and attack scenes) of all participants were significantly higher than at RALT-baseline measurements. In contrast to positive pictures, SAM-scores of negative pictures did not correlate with sAA-levels.

To our knowledge, only few studies examined the effect of negative affective pictures on sAA-levels (van Stegeren, Rohleder et al. 2006; van Stegeren, Wolf et al. 2008): negative IASP picture viewing for 45 minutes resulted in an increase of sAA-levels from 40 (at baseline) to 120 Units/ml (directly after picture viewing). In line with these results, we observed a significant increase of sAA from about 70 to 100 Units/ml in comparison to levels during a stress-free intervention like RALT. It is tempting to speculate that this difference may have been larger with longer times of picture viewing. This appears also likely, because a concentration peak has been reported after around 10 minutes post stressor onset, while the saliva sample we collected were taken just 3 minutes after picture presentation. Fear reaction in rodents leads to activation of the defensive system accompanied by SNS-activation, autonomic arousal, hypoalgesia, and an increase of heart rate, blood pressure, and stress hormones (LeDoux 2000). The amygdala is the key site of the defensive system of motivation and emotion; its downstream structures are implicated in different defensive behaviours, some of which are also active during appetitive motivation (Lang 98). Our design was not set up to analyze possible correlations between an activation of the defensive system of the human brain accompanied by SNS-activation during negative affects and sAA-levels. The latter remains to be analyzed in future studies.

The first sAA-sample was collected about 10 minutes after volunteers entered the laboratory and were informed that they would face pain. It is likely that values obtained for this measurement mainly reflect a natural level of anticipatory stress more than a true baseline. The laboratory environment and the situation were novel and they may have included some anxiety in the light of the forthcoming pain measurements.

Consistent with this interpretation, volunteers in this series gave highest nervousness (RU) and highest bad mood (GS) ratings in MDBF immediately after base line data records. Similarly, other authors did find an increase in SNS and a decrease in PNS activity already during the evening prior to a public appearance, when people were informed that they would have to give a speech the next day (Hall, Vasko et al. 2004). Nater et al., found an increase of sAA-levels already at the announcement of the TSST (Nater, La Marca et al. 2006).

In contrast to the beginning of the experiment, samples of sAA-levels during RALT were collected about 10 minutes after stimulus onset and at least 13 minutes apart from the last stimulus. We assume that if factors like psychological stress or exercise (Nater and Rohleder 2009) have influenced sAA-responses, they did so to a lesser degree during this condition. Consequently, we conclude that this condition probably measures a true sAA-baseline and infer that it reflected the SNS-activity at work during this test.

The attained samples reflect sAA-levels of volunteers by the time of intervention during each specific run, when participants first entered the laboratory, and during one measurement in each of the four blocks (during positive and negative picture viewing, directly after pain measurement and during RALT). The succession of these four measurements was counterbalanced across experimental runs. Between collections of each sAA-sample there was an interval of about 20 minutes. To counteract for potential confounding effects of interventions on sAA-levels, we collected these samples before their expected peak. Since our experimental design involved a tight succession of interventions, it was not possible to control every single intervention regarding the reactivity pattern of sAA following novelty or stress. Some authors have recommended the use of at least three measuring points: a baseline before stress onset, a peak measurement about 10 min after stressor onset, and a new baseline about 20 minutes after stressor onset (Rohleder and Nater 2009). For this reason, we cannot completely decide whether the sAA-levels we measured were the result of the arousal of the specific interventions or whether they also reflect the effects of preceding interventions within a timeslot of about 20 minutes. Nevertheless, as the stressors occurred ca. 20 minutes apart from each other, we strongly believe that our measurements reflected sAA-levels of a single stressor and infer that all samples were more or less independent from each other. Since sAA-samples during picture viewing and pain perception were collected only about 3 minutes after stressors' onset, we suppose that peak level of sAA was still not reached by this time.

Conclusion

According to studies on chronic pain, our results are the first suggesting that sAA is a marker valuable for the objective assessment of pain intensity and valence during states of acute pain. Besides, our results suggest that sAA is a potential biomarker appropriate to objectively index also positive stress, as sAA seems to indicate the intensity and valence of positive arousal.

7 A New Tool to Measure Behaviour under Risk in Financial Decisions: The Randomized Lottery Task (RALT)

Background: The lottery mechanism has been widely used as an underlying concept for designing decision tasks under the influence of risk to investigate aberrations of Expected Utility Theory (EUT) (Kahneman 1979; Schubert 1999; Fehr-Duda 2006). However, existing risk tools show potential for improvement. *Objectives*: An improved lottery experiment should close the following gaps: handle the phenomenon that a problem, presented repeatedly to a participant, may result in different preferences, referred to as "preference switch" (Starmer), or as within-participant variability. Moreover, risk measures should be revealed through data analysis, rather than through conscious expression during the task to omit self-adaptation and prevent framing effects. Besides, the experimental layout and analysis should support nuisance control techniques. *Methods:* The Randomized Lottery Task (RALT) measured risk behaviour of 27 participants during four counterbalanced conditions: positive, negative, and two control conditions. For each condition, participants made their choices for 50 fully randomized binary winning lotteries. Finally participants completed a set of winning lotteries on option sheets (Fehr-Duda 2006) and subjective reports on financial risk taking. *Results:* We introduced the *preference function* as a new risk metric. With a decrease of guaranteed payoff, it depicts besides indifference points all probabilities of the participants decision. Moreover, with increasing *winning probabilities* participants risk proneness decreased. Besides, we observed sex differences at all winning probabilities and depending on the guaranteed payoff: women were more risk-averse than men and used a wider interval for their preference switch. Finally, *slow decisions* were more risk averse than quick decisions, and with *accumulated playtime*, participants were more risk averse.

Conclusions: RALT is a highly standardized and improved lottery experiment procedure that is close to the ideal observational process and avoids self-adaptation. It is the first risk-tool for decisions under probability related risk that 1) considers within-agent variability by following a general linearized model approach; 2) measures analysis-revealed, rather than consciously expressed behaviour and 3) is based on an experimental layout and analysis that support nuisance control techniques. We propose that RALT allows a closer measurement of risk behaviour and its influencing factors. [7]

[7] The work described in this chapter has been done in collaboration with the following people: Hans Rudolf Heinimann, Victor Candia, Gerd Folkers. A journal paper is to be submitted.

7.1 Introduction

Decision-making is the process of choosing a preferred option or course of action from among a set of choices. In some decisions contexts, the availability of the chosen option is certain, but other decisions are taken under risk: Decisions are "*risky*", were the probabilities and the outcomes are known in contrast to "*uncertain*", where only the outcomes are known and to "*ambiguous*", where both probability and outcome are unknown. In decisions under risk, a person begins at the information gathering stage and has to consider both the desirability of the potential outcome as well as their probability of occurrence until the final act of choosing. Events that are going to happen in the future may be characterized by two properties, the utility of the prospect, and the probability with which this prospect will become reality.

The conception of *Expected Utility Theory* (EUT) (Von Neumann 1944), a rational choice theory, is based on a priori considerations. Its rationality assumptions claim that agents will always favor that alternative out of a set of choices, which has the highest utility. This "Homo Oeconomicus" logically and unemotionally aims at maximizing his own utility, while having a consistent system of preferences and complete information about options and consequences. EUT neglects other sources of influence, such as emotional disposition, framing, or the social construct of probability. Though, research over the last four decades has demonstrated, mainly based on experimental evidence that people make decisions that are inconsistent with the normative predictions of EUT.

The lottery mechanism has been widely used as an underlying concept for designing decision tasks to investigate aberrations of EUT (Kahneman 1979; Schubert 1999; Fehr-Duda 2006). To study individual risk behaviour with winning lotteries, participants have to choose from two choices, A) a lottery with an expected utility EV [1], and B) a guaranteed payoff i.e. a cash amount that can be earned with certainty. When the lotteries risk premium (RP) [2] is highly negative or highly positive, behaviour can be predicted with high probability. Participants will choose the guaranteed payoff for highly negative RP and the risky prospect for highly positive risk premiums. Both choices are probable in between. However, so far the direct outcomes of the lottery mechanism, namely the risk premiums of indifference points, have been characterized with a single parameter, such as the mean or the median, resulting in data loss. Moreover, tasks represent a "dual task" situation were data capture requires *cognitive capacity* e.g. by the duty to write the results on option-sheets; This might cause a framing effect and influence behaviour (Schubert 1999; Fehr-Duda 2006). Moreover, the used lotteries omit principles of *nuisance control*, as they are not fully randomized.

The design of a standardized, non-complex risk task to simulate choice behaviour of an individual agent is a major challenge in behavioural experimentation. Hereby, the key is to answer the question «what is the most reliable and valid approach to measure risk-averse or risk-prone behaviour». As a consequence, experimentation has to be based on a standardized decision making task with clearly defined outcomes, a stimulation mechanism to control the factors that might affect decision behaviour, and a strategy to cope with uncontrollable, sometimes unknown factors of influence.

An improved lottery experiment procedure should close the following gaps: 1) handle the phenomenon that a problem, presented repeatedly to a participant, may result in different preferences, referred to as "*preference switch*" (Starmer) or within-participant variability. Moreover, 2) It should be as close to "*real-world-behaviour*" as possible so that the measure of indifference between a risky prospect and a guaranteed payoff is analytically revealed, rather than consciously expressed during the task. In addition, it should be the only mental task a participant has to cope with during the experiment in order to omit self-adaptation and prevent framing effects. Besides, 3) the experimental layout and analysis should support *nuisance control* techniques following the basic rules of experimentation, namely randomization, replication, and error control (Montgomery 1996).

Although the study of decisions under risky information has been an interdisciplinary project involving economics, psychology, statistics and sociology, standard risk tools still have their limitations. We presume that the RALT will add accuracy in order to depict decision making during risk scenarios because it is a tool that depicts participants' preference switch, is closer to real-world behaviour and supports nuisance control.

7.1.1 Expected Utility Theory

Assuming that a prospect may be characterized by an outcome z, and the probability p that z will be realized, the expected utility (EV) of a lottery [1] may be characterized as follows.

$$EV(p;z) = p(z) \cdot u(z) \qquad [1]$$

EV (p;z)	=	expected value of utility of z
p (z)	=	probability that z will occur
u (z)	=	utility of z
z	=	outcome

The *risk premium* (RP) [2] has been an important metric to characterize aberrations of individual risk behaviour from rational behaviour by mere calculation. It is the difference between the expected value of a risky prospect and a guaranteed payoff that an agent is indifferent to [2]. It has been used to characterize phenomena such as risk-aversion, risk-proneness, or sex differences in decision-making under risk.

$$RP = EV(p;z_1) - CE(z_2) \qquad [2]$$

RP	=	risk premium
EV (p;z1)	=	prospect
CE (z2)	=	sure cash payment/guaranteed payoff
p	=	probability that outcome z1 will be realized
z1	=	possible outcome of the lottery
z2	=	cash amount for sure

Consequently, three categories of risk behaviours can be defined, depending on the position of participants' indifference point (Q50) to the RP of the lottery.

Risk-neutral	Q50 = 0	$EV(p;z_1) = CE(z_2)$,
Risk-averse	Q50 > 0	$EV(p;z_1) > CE(z_2)$,
Risk-prone	Q50 < 0	$EV(p;z_1) < CE(z_2)$.

Risk premium metrics have been widely used to investigate abnormalities of EUT, such as the *certainty effect*, or the *reflection effect* (Kahneman, Tversky 1979). The certainty effect refers to the phenomenon that people overweight outcomes that are considered certain, relative to outcomes which are merely probable, whereas the reflection effect implies that people are risk averse in the positive (gain) domain whereas they are risk seeking in the negative (loss) domain (Kahneman, 1979).

7.1.2 Levels of observational processes

Observation broadly refers to the process of data collection in both observational and experimental studies. An ideal observational process would never influence the behaviour of the phenomenon being investigated. However, participants have their own “observational system”, the senses, to capture stimuli from the outside world. These stimuli feed back to their behaviour, causing biases, such as the framing effect (Tversky and Kahneman, 1986) that is assumed to control the representation of options, in conjunction with the nonlinearities of value and belief. As a consequence, one should neutralize framing effects by excluding possible effects of participants reasoning, habits, and expectancies on the task. On the other hand, behavioural tasks should be highly standardized and close to behaviour. There are several levels of observational studies, covering the whole range from "real-world behaviour" to "self-reported correlates" of risk taking, which may be arranged by the degree of closeness to real-world behaviour as follows:

1. *Observation of real world behaviour*. Preferences derived from this type of study are called "revealed". However, real-world tasks are mostly non-standardized, complex, and self-adapting. This is why they are only feasible for highly standardized tasks, such as messenger services (Fehr and Goette, 2007) that can be studied in *field experiments*.
2. *Observation of revealed "laboratory-world" behaviour* is stimulated and analytically revealed by a highly standardized *game task,* such as the balloon analogue risk task BART (Lejuez, Read et al. 2002; Lejuez, Aklin et al. 2003), or the stoplight task SLT (Greenwald, Johanson et al. 2006). This type of process causes participants to focus on the task while data capture happens subconsciously.
3. *Observation of expressed "laboratory-world" behaviour*, is stimulated by highly standardized behavioural tasks, but consciously expressed by the participants. This type of dual task situation has been widely used in behavioural economics, capturing data with option sheets that have to be filled in by participants (Fehr-Duda 2006).
4. *Self-reported behaviour*, such as cigarette smoking, alcohol consumption, gambling for real money, crossing the street. Self-report assessment is usually transformed into data by questionnaires. Preferences derived from this type of study are called "expressed".
5. *Self-reported correlates of behaviour* by using artificial assessment scales, such as the sensation seeking scale, the impulsiveness scale, the self-esteem scale, etc.

An *ideal observational process* should meet three criteria. First, it should be as close to “real-world-behaviour” as possible, to exclude possible framing effects. Second, it should be a highly standardized task to avoid self-adaptation. Third, the consequences should be revealed rather than expressed to prevent conscious modification. Behavioural experiments have to consider trade-offs between “closeness to real-world-behaviour” and “high degree of standardization”. The level 2 of our above classification weights up the two criteria against each other and corresponds to the level of observation, we pursue in this study.

7.1.3 Standard tasks for decision studies

Table 4 presents an overview on standard tasks for the three categories of decisions under risk: (1) decisions under ambiguity, (2) under uncertainty, and (2) under probability related risk.

Studies on decision behaviour under probability related risk (Kahneman 1979; Schubert 1999; Fehr-Duda 2006) have been mainly based on a level of observation including aspects of both revealed and expressed outcomes. For choice assessment, authors mostly used the lottery mechanism presented on option sheets. However, this approach seems to have a potential to influence participant's behaviour and to omit principles of nuisance control: in option sheets the data capturing process requires cognitive capacity that may cause a framing effect. Accordingly Ergonomic studies of human behaviour have shown that "dual task" situations develop interaction effects.

Nuisance control has to be considered in data analysis with nuisance factors and nuisance covariates being analyzed by general linear models. However, the direct outcomes or metrics of decision studies, namely the risk premiums, have so far been characterized with descriptive location parameters, such as the mean or the median. Those location parameters have then been used to estimate the weighting function parameters (Kahneman, Tversky 1992). Kahneman and Tversky were aware of the lack of nuisance control as they mentioned that individual data reveal both nuisance and individual differences, resulting in a between subject correlation (median cash equivalents vs. probability) of 0.4, which is fairly low. In contrast to this descriptive approach we will depict within and between subjects variability.

It is worth mentioning that some authors do not distinguish between the different categories of decisions under risk. Since 1999, several tasks for decisions under *uncertainty* were designed, such as the "hidden token task HTT" (Rogers, Owen et al. 1999), or the "balloon analogue risk task BART" (Lejuez, Read et al. 2002). These tasks are highly standardized and controlling for "dual-task" effects. Unfortunately, the used terminology is not always clear.

Table 4 Standard tasks for decision behaviour under risk are based on an observational level, which has aspects of both revealed and expressed outcomes (level 3). To our knowledge, there exists no task for probability related risk that measures behaviour on level 2. All mentioned tasks do not fulfil full randomization, one of the basic principles of experimental design.

Risk Tool	Authors	Type of uncertain behaviour	Level of observation	Mechanism	Metric
BART Balloon Analogue Risk Task	(Lejuez, Read et al. 2002)	Uncertainty	[2] Re-vealed	Balloon pump-up, reward linearly increases with n of pumps, burst ->0 reward	Number of pumps without burst for a sequence of balloons
SLT Stoplight Task	Greenwald (2006)	Ambiguity	[2] Re-vealed		
HTT Hidden Token Task	Rogers et al. (1999)	Risk	[2] Re-vealed	6 boxes, split in two colors, 1 hidden token, win-loose point	% Of choices of the most likely outcome
WinLot Winning Lotteries	(Kahneman and Tversky 1979) Schubert (1999) Fehr-Duda (2006a).	Risk	[3] Mixed revealed / ex-pressed	Lottery mechanism	Risk Premium at Point of Indifference
VAS Screening		Risk	[5] Ex-pressed	Self-assessment	VAS Score

7.2 Implementation

The experimental layout and the manner in which data are captured define the power and reliability of the statistical inference. The guiding idea of statistical experimentation was to follow a “backwards” approach. At first, the conceptualized hypothesis was tested with a statistical model, then an experimental layout was designed that best fits to the model.

7.2.1 Conceptual model

The lottery mechanism has been widely used in experimental economics. It usually consists of a set of *n* pair-wise choice problems. For each of them the participant has to state a preference. The series of binary choices usually consists of a risky prospect and a guaranteed payoff. A rational agent who decides by calculation would behave as follows: if the guaranteed payoff is bigger than the expected value of the prospect, there is always a preference for the guaranteed payoff. If the expected prospect value of the risk option is bigger than the guaranteed payoff, the risky prospects will always be preferred. There is exactly one point, the indifference point, at which option choice is indifferent to the agent.

To depict the "preference switch" or within-participant variability, we conceptualize our new approach in Figure 19, which shows the widely used approach on the left, and our new concept on the right. The results of this type of experiment can be represented in a coordinate system with the x-axis depicting risk premium, and the y-axis for the probability with which the risky prospect is preferred (see circles in Figure 19). We propose that human decision agents show *two types of deviation*:

First, the point of indifference may be systematically negative (called risk prone), or systematically positive (called risk averse); the indifference point lies on the turning point of the preference function (Q50). That is to say that the indifference point indicates when both options have the same value to the agent, so his/her probability for risky choice is 50%. If a participant decided rationally, by pure calculation, he would calculate the expected value of utility of the lottery and feel no bias toward option A or B, when the lottery had the same expected utility as the guaranteed payoff. His/her risk functions would have then an indifference point at a lottery’s RP of zero.

Second, one can observe choice options for which agents give different responses in independent, repeated judgments. This is particularly true for risk premiums with risky prospect rather close to zero for which agents "*switch preferences*" in repeated questions. This behaviour is depicted by the curved preference function that depicts a probability distribution of choice. Q10 and

Q90 are the preference points on the risk function at 10% and 90% probability of risky choice. They display participants' action tendencies. The more curved the risk function, the less predictable is the behaviour of participants at small and high guaranteed payoffs.

The standard approach to deal with the first type of deviation, risk proneness and risk aversion, has been to estimate a location parameter (Figure 19, left) at which agents sharply switch from preferring the guaranteed payoff to the risky prospect. Up to now, within-agent variability has been neglected. Our approach considers within-agent variability by introducing the probability *distribution function* of choice (Figure 19 right). We will systematically follow a general linearized model approach, based on the following subject matter model.

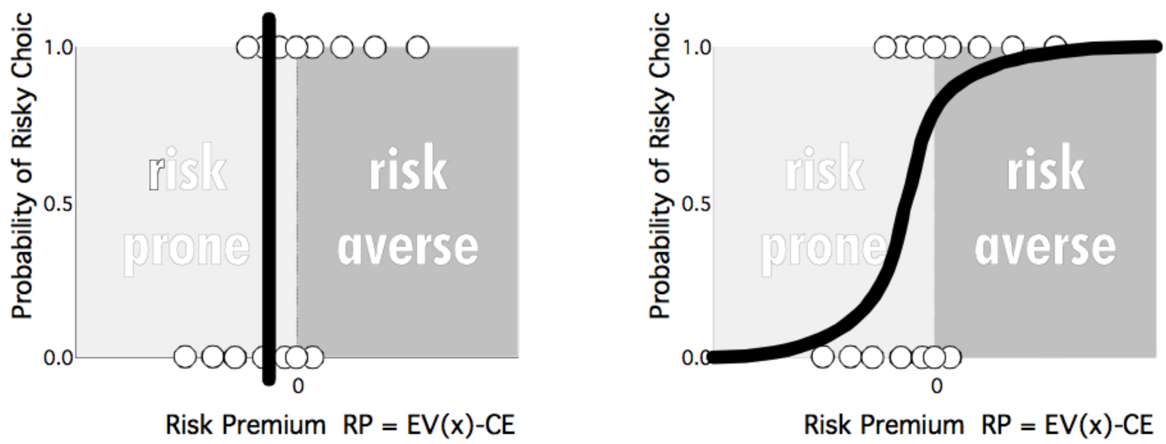


Figure 19 Representation of within-subject variability during a decision under risk. Previous studies characterized the distribution of risk premiums with a single location parameter (left). Our new approach characterizes within-subject variability by means of a probability distribution function (right). Circles represent the preferences in a set of pair-wise choices, a risky prospect and a guaranteed payoff. X-axis: Risk premium (RP) in Swiss Francs, y-axis: Probability of risky choice.

Nuisance is controlled by (1) fully randomizing both risk premium and the probability of the lottery, (2) by blocking with the factor SEX, and (3) by measuring possible nuisance factors, such as decision time (Rogers et al.).

7.2.2 Design of RALT

Our implementation of the lottery mechanism considers three parameters, (1) the maximum possible outcome of the risky prospects, (2) its winning probability and (3) the guaranteed payoff. RALT presents a sequence of 50 lotteries on a computer screen. Each of the 50 single choice pairs is presented graphically with the risky prospect (option A) on the upper and the guaranteed payoff (option B) on the lower part of the screen (Figure 20). The risky prospect has a randomly ascribed probability to win 50 CHF (15% in the Figure) or to win nothing with the corresponding probability (85% in the Figure). The guaranteed payoff is a randomly ascribed amount of money between 0 and 50 CHF (in the present case 1 CHF). The participant has to state his preferences by clicking A or B and proceed to the next pair of choices. As no feedback on decisions is given, players cannot adapt their strategies over time or learn. So, each decision is a single strategy that leads to a particular outcome, whose payoff value is only revealed at the very end of the game. As a consequence, this task is a realization of a non-cooperative situation, where each player acts independently on independent decisions.

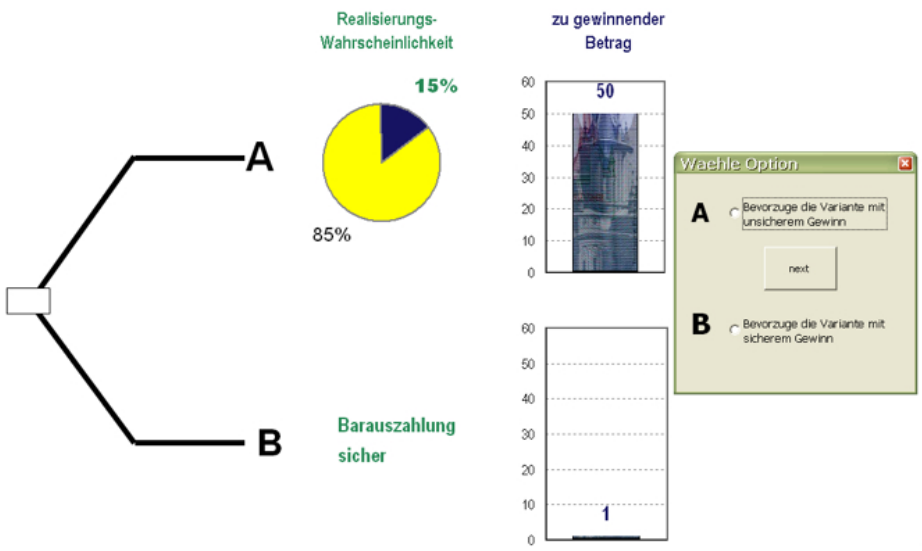


Figure 20 The user interface of the randomized lottery task RALT. The lottery mechanism presents a series of 50 binary choices between a risky prospect (option A) and a guaranteed payoff (option B). The risky prospect is characterized by a probability to win 50 CHF, whereas the guaranteed payoff is an amount of money between 0 and 50 CHF that can be earned for sure. The participant has to select the preference for each pair of options.

The winning probability and the guaranteed payoff were fully randomized and equally distributed in the interval between zero and one. Guaranteed payoff was randomly distributed between zero and the maximum outcome (50 CHF). Moreover, to neutralize artifacts, there was a constraint in that the expected value (EV) of the risky prospect should be distributed evenly around a RP of zero. If a participant would choose fully randomly between options A and B, this would therefore have no effect on the resulting risk metric, the point of indifference. To achieve this distribution of EV, and to prevent artificial trends, we used logarithmic transformation following an idea of Tversky and Kahneman (1993).

To achieve unconscious data capturing, the RALT system automatically captured and stored the following values for each choice: (1) the winning probability of the risky prospect, (2) the sure cash equivalent of the guaranteed payoff, (3) the risk premium of the risky prospect, (4) the participants preference, and (5) the time required to make the choice. Both the user interface and the data capture procedure were implemented with VBA (visual basic for application) and a spreadsheet program (Microsoft EXCEL).

7.2.3 Experimental procedure

The randomized lottery task RALT captured the raw-data of single and independent behaviors. This was the foundation for the analysis with the generalized linear model. 27 participants completed four RALT during four conditions: (1) positive, (2) negative, (3) neutral before negative, and (4) neutral before positive. For each condition, participants made 50 fully randomized binary decisions. Nuisance control was based on blocking for sex, and on capturing the decision time for each choice as a covariate. Four RALT were followed by one set of option-sheet based lotteries (Fehr-Duda 2006) to capture a “traditional” risk measure. After finishing the series of binary choices participants completed a self assessment on risk taking consisting of two 10 -cm visual analogue scales (VAS) for (1) financial risk taking and (2) financial self-efficacy with end values of 0 indicating *“not at all”* and 10 *“very strong”*. Participants were informed, that they would be paid for one of their independent choices. The validity of this commonly used experimental procedure, where participants play multiple rounds with one round being randomly selected for payment, was recently tested. Laury et al. did not observe differences between paying for 1 out of 10 rounds or for all 10 rounds, when payments were low (Laury 2006).

7.2.4 Statistical analysis

Data were analyzed with the software package R, using the following strategy:

- Estimating the effects of correlating factors and covariates and their statistical significance (*glm* and *anova.glm* procedures).
- Analyzing non-linearity of time variables via power transformation, because it is well known that learning effects are highly non-linear (REF?) (*glm* procedure).
- Analyzing the interaction of dependent factors and covariates (*glm* procedure).
- Exploring model results graphically (*plogis* and *curve* procedures).

7.3 Results and Discussion

7.3.1 Fitting a generalized linear model

We fitted several models, aiming at finding a model that was simple and explained as much of the variation as possible. Participant's binary response required a special treatment for analysis. Generalized linear models (GLMs) transformed the response variable by using a so-called link function, which is the logit function for binary responses. The error *e* followed a binomial distribution.

$$g(\eta) = COND_i + SEX_j \cdot rp_{ijk} + p_{ijk} + t_{ijk}^{0.05} + tacc_{ijk}^{0.05} + \varepsilon_{ijk} \qquad [3]$$

n	linear predictor	
g()	logit function	
$COND_i$	emotional conditioning	[factor, i=3 levels]
SEX_j	biological sex	[factor, J=2 levels]
rp_{ijk}	risk premium	[CHF[1]]
p_{ijk}	probability of lottery	[0…1^{-3}]
t_{ijk}	time required for one decision	[sec]
tac_{cijk}	accumulated time from start	[sec]
ε_{ijk}	residual error	

Our analysis showed that the interaction of SEX and risk premium explained a much higher share of data variability than both variables together. Moreover the time for one decision and the accumulated playtime were both highly non-linear.

Deviance (Table 5) has a similar role like residual variance from analysis of variance and is used to measure the explanatory power of model components. The interaction of SEX and risk premium had the biggest influence, followed by the probability of the lottery, decision time, emotional conditioning, and accumulated time from the start of the experiment for each single participant. Expected utility theory predicts that the risk premium of the risky prospect is of big influence, while sex, the probability of a lottery, and the time used for a single choice can be neglected. Our data provide clear evidence that predictions of expected utility theory were violated. However, the model explained only about 40% of the overall (null) deviance, something mainly attributable to between-subject variation.

Table 5 Analysis of deviance of the generalized linear model [1]. Deviance is a metric for statistical dispersion, based on log-likelihood theory.

	Df	Deviance	Residual Df	Residual Deviance
$t^{0.05}$	1	287.9	5399	7198
p	1	475.6	5398	6722
COND	3	41.1	5395	6681
$tacc^{0.05}$	1	18.5	5394	6663
SEX·rp	2	2121.4	5392	4541

Table 6 Parameter estimates for the generalized linear model [1]. (***) Indicates that the estimates are significant at a level of less than 0.001.

	Estimate	Std. Error	z value	Pr (>lzl)
$t^{0.05}$	7.55	1.14	6.61	3.99e-11 ***
p	-3.55	0.15	-24.44	< 2e-16 ***
COND (negative)	-13.75	1.94	-7. 10	1.26e-12 ***
COND (neutral)	-13.66	1.92	-7.12	1.12e-12 ***
COND (positive)	-13.64	1.93	-7.05	1.74e-12 ***
tacc $^{0.05}$	4.83	0.90	5.36	8.25e-08 ***
SEX·rp (female)	0.14	0.01	19.95	< 2e-16 ***
SEX·rp (male)	0.28	0.01	25.85	< 2e-16 ***

7.3.2 Exploring the model

7.3.2.1 Winning probability.

The binary response of participants depended significantly on the winning probability in the risky prospect (option A) (Figure 21). The higher the winning probability, the bigger was the RP of participants' preference functions. Positive risk premiums referred to risk-aversion, whereas negative premiums represent risk-proneness. Small probabilities - in our case 5% chance of winning - resulted in more risk prone behaviour, illustrated by a shift of the preference function to the left. Large probabilities - 95% chance of winning - resulted in more risk-averse behaviour, represented by a shift of the curve to the right. On average, participants' behaviour was risk-averse.

This "*probability effect*" is also described by prospect theory, whereby humans tend to overestimate rare and to underestimate frequent probabilities. In line with these observations, winning probability had an effect on intra-individual variation of risk behaviour, as small winning probabilities caused more risk prone behaviour than large winning probabilities. However, and in contrast to prospect theory, most participants were so risk-averse that also during 5% winning probability their whole preference function remained in the risk-averse domain.

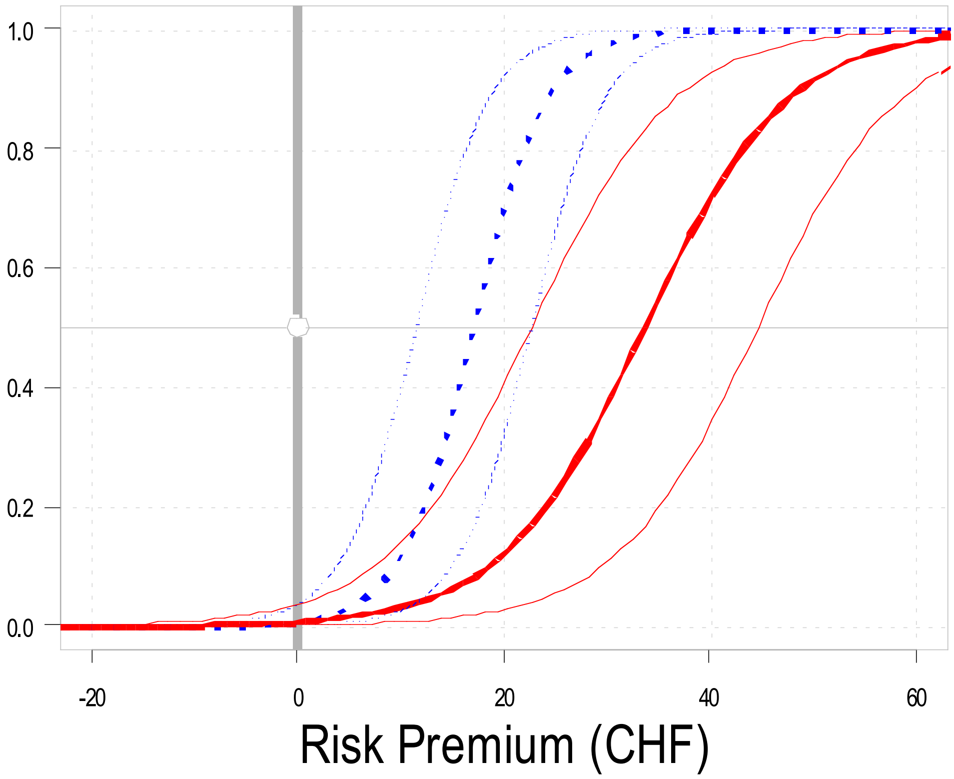


Figure 21 Influence of risk premium, biological sex, and probability of the random prospect on risk behaviour. Read lines represent women and blue lines men. For each sex the thick line represents behaviour at a 50% winning probability, whereas the thin lines show behaviour at the 5% chance level (left) and for the 95% level (right), respectively. X-Axis: Risk premium (RP) in Swiss Francs, Y-Axis: Probability of risky choice.

7.3.2.2 The preference switch

We observed a significant effect of the guaranteed payoff in option B on risk behaviour. The preference switch occurred with in intervals by switching from the sure choice (represented by a probability of risky choice that equals zero in Figure 21) at higher certain payoffs – to the risky choice (represented by a probability of risky choice that equals one in Figure 21) at lower certain payoffs.

To the best of our knowledge, this is the first approach that quantitatively describes the "*preference switch*" effect that has been documented in the economics literature.

We call the behaviour within the intervals at very low and high RP of the lottery "*acategorial*" and the behaviour outside them "*categorial*". We propose that an acategorial state of behaviour is a state at which the participant – during repeated choices – will choose both the sure and the risky option according to a binomial distribution. Within the state of "acategoriality" a preference function had the following explanatory power. On the left side of the interval, where the probability of the risky choice was 5%, a participant chose the risky option with a chance of 5% and the sure option with a chance of 95%. At the point of inflection there was 50% chance of choosing one or the other, the risky and the safe option. The point of inflection is therefore is a possible measure for the *point of indifference* that has been determined in previous behavioural studies for decisions under risk (Schubert 1999; Fehr-Duda 2006).

7.3.2.3 Biological sex.

We observed a significant behavioural difference between women (red lines, Figure 21) and men (blue lines), indicating that women were more risk-averse than men, represented by higher RP. Moreover the preference switch was dependent on sex of participants, as women revealed a curved risk function whereas the risk function of man was flatter, with sharper reversal points. More precisely, switching from the sure choice (probability of risky choice equals zero) to the risky choice (probability of risky choice equals one) occurred smoothly within the RP interval (-10, 40) for men and in a larger interval (-10, 70) for women. This indicated women's risk aversion at lower guaranteed payoffs than men. The evidence indicates that women's risk behaviour depends more on the guaranteed payoff than is the case for men.

Women have been known to be risk averse also in other domains, they take less hazards in crime, health or sports (Byrne 1992). However, surprisingly little work has been done on specific sex and gender differences in financial decision-making. Only a few laboratories used real monetary incentives. Studies on field data concluded that women are relatively more risk averse than men, whereas laboratory experiments with quite similar designs using winning lotteries on option sheets (see Table 4) partly rendered inconclusive results probably because results depend on the mix of lotteries used in the experiment (Fehr-Duda 2006). Women seemed to be less sensitive to probability changes and tended to be more risk averse in large and medium probabilities of gain than men. Croson et al. proposed that a lack of reciprocity might lead to this behaviour (Croson Rachel 1999). Fehr-Duda et al. observed that women were particularly pessimistic when winning gambles were framed in investment terms. In contrast to this, Schubert et al. observed no sex differences in contextual decisions. However, in abstract gambling decisions females were more risk averse (Schubert 1999).

Like others (Croson Rachel 1999; Schubert 1999; Fehr-Duda 2006), our results show that women are more risk averse than men in financial decisions. More precisely, women were risk averse not only at large and medium winning probabilities of winning lotteries, as previously shown by Fehr-Duda et al. but also at small winning probabilities. So, in comparison to men, women were risk averse during all winning probabilities. In contrast to Schubert et al. and in accordance to Fehr-Duda et al., we observed these sex differences in contextualized decisions: at the beginning of our risk tasks, we asked participants to imagine an a bank investment. Moreover, we show that there are indeed sex differences in the preference switch depending on payoff in option B.

7.3.2.4 Buridan's donkey and decision speed

The binary response of participants depended significantly on the time needed for a decision. Figure 22 shows that decisions taking around *two seconds* (thick lines) had lower RP than decisions taking around *13* seconds (thin lines). For decisions taking longer, behaviour was more risk averse. So, the RP of these decisions were further apart from rational behaviour than in quick decisions. For decisions under ambiguity, Rogers et al. observed an increased decision time when participants were confronted with a choice between a likely reward with reduced outcome in comparison to an unlikely reward (Rogers, Owen et al. 1999).

The "reflection effect" of irrational choice by long, rational pondering has been described before: *Buridans donkey* is a paradox that refers to a hypothetical situation wherein a donkey, placed exactly in the middle between two stacks of hay of equal size and quality, will starve to death since it cannot make any rational decision to start eating one or the other. Though, in contrast to long reflection, intuitive decisions or "*Bauchentscheidungen*" are based on only one good reason. They have been shown not only to save time but also to produce better results than decisions made after long reflection (Gigerenzer 2007). Accordingly, Blaise Pascal, the French scholar wrote in the 17th century, "*The heart has its reasons which reason knows nothing of*". Our results seem to follow this line of reasoning.

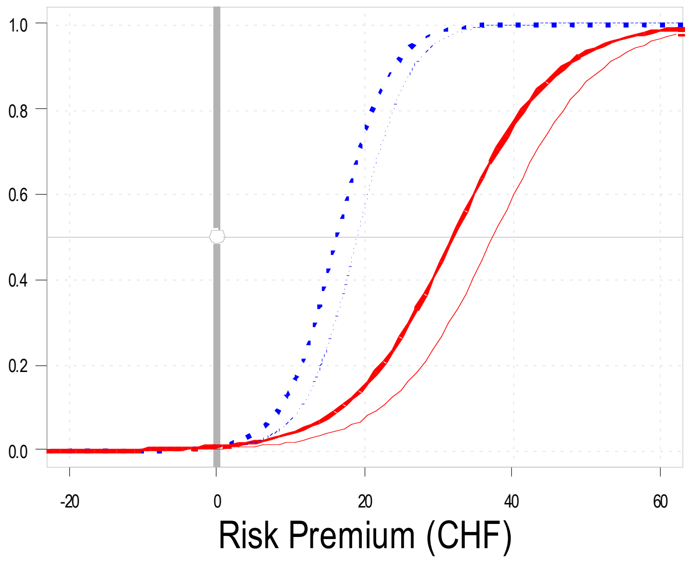


Figure 22 Influence of decision time on risk behaviour. Read lines represent women and blue lines men. The thick lines depict decisions taking around *two seconds*; and the thin lines depict decisions taking around *13 seconds*. X-Axis: Risk premium (RP) in Swiss Francs at 50 % winning probability, Y-Axis: Probability of risky choice.

7.3.2.5 Accumulated playtime.

The binary response of participants depended significantly on the accumulated playtime. The longer the accumulated playtime, the bigger was the participants risk premium.

7.3.3 Correlation with other risk tasks

Spearman Correlations of the same metric, the indifference point (Q50), of two different risk tasks, the RALT and winning lotteries on option sheets (Fehr-Duda 2006) revealed a significant correlation at 10% ($\rho = 0.61$), 25% ($\rho = 0.64$), 50% ($\rho = 0.56$), 75% ($\rho = 0.67$), winning probability (Figure 23). These results allow a comparison of RALT with an established risk task used by Fehr-Duda et al. and Schubert et al.

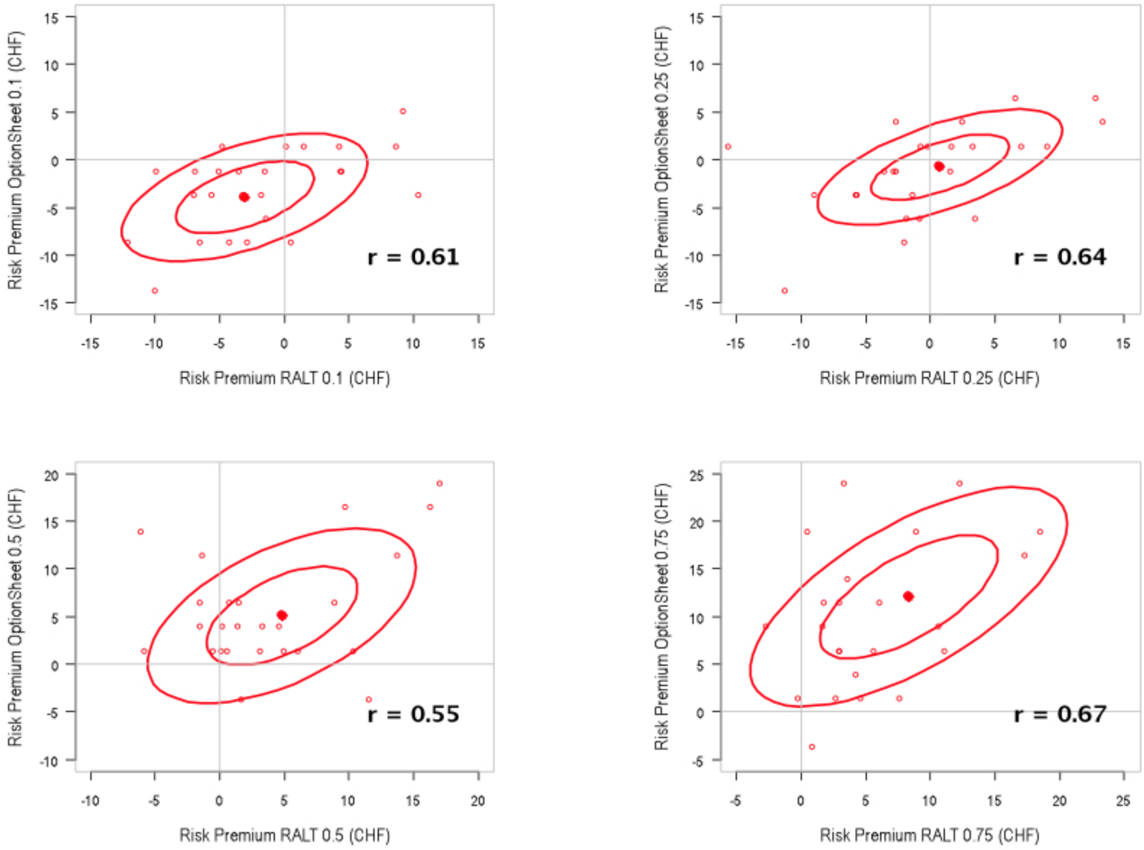


Figure 23 Correlations of indifference points between RALT and option sheet risk premiums (RP) at indifference points (Q50) at 10, 25, 50, and 75% winning probability. The circles are ellipses of the same probability that depict a two-dimensional probability distribution of the correlations. Flatter ellipses indicate higher correlations. X-Axis: RALT RP in Swiss Francs, Y-Axis: Option Sheet RP in Swiss Francs.

Besides, Spearman Rank correlation showed a significant positive correlation between the self-assessment concerning financial risk taking and RALT measures at 90 and 95% winning probability, at three preference points with highest correlations at Q95_25 (ρ = -0.41*, P = 0.039). Moreover there was a significant correlation with financial self-efficacy at 50% winning probability at two preference points with highest correlations at Q50_25 (ρ = -0.43*, P = 0.031).

7.3.4 Conclusion

We conclude that RALT is a highly standardized an improved lottery experiment procedure that is closer to ideal observational process and omits self-adaptation. It is the first risk-tool for uncertain decisions under risk that 1) considered within-agent variability by introducing the *preference function* as a new risk metric, following a general linearized model approach avoiding data loss. Preference functions are risk measures that depict participants' action tendencies beside their indifference point. Moreover, RALT reveals behaviour rather than consciously expressing it and permits an experimental layout and analysis that support nuisance control techniques. We conclude that RALT allows a closer measurement of risk behaviour and its influencing factors.

8 Calmness and Appreciation of Security and Control predict Risk Taking in Lotteries.

Background: Monetary preferences vary among individuals. One reason may be a difference in risk propensity, the degree to which people find risk attractive. Risk propensity is personality specific. In the effort to find predictors for inter-individual variation of monetary risk behaviour mostly single personality characteristics and self reported correlates have been reported so far. Theoretical risk tools and physiological correlates may offer new prognostic alternatives. E.g. pain perception has been related to personality aspects like self-perceived role-identity and a determined identity might result in a particular risk-taking tendency. Therefore, pain may serve as a new marker for a physiological objectivation of risk behaviour. *Objectives:* The current study sought to identify personality characteristics that may explain the inter-individual variation of risk behaviour in financial decisions under uncertainty and risk. *Methods:* Risk behaviour was measured with the standardized lottery task RALT (Randomized Lottery Task). Questionnaires on self-perceived role-identity were assessed. Heat pain tolerance and threshold were measured on the forearm. Positive and negative affective pictures were used to induce antithetic emotional states. Emotion induction was quantified by means of Alpha-amylase levels and self-report. Variables that had the highest correlation with RALT risk premium were considered for principal component analysis (PCA). For a model-based prediction of risk-behaviour based on PC1 and PC2 we fitted several models, to find a simple model, which could maximally explain variation. *Results:* The motivational force for risk aversion occurs with a role-identity that can be described by 1) *appreciation of security and control* and 2) *calmness*. To specify, risk aversion in RALT correlated with a focus on the security of a decision, high self-efficacy, low feminine and high masculine gender role, low narcissism, low social externality, and low pain tolerance. Furthermore it correlated with high calmness and low emotional arousal levels during positive picture viewing and pain measurements. The opposite was true for risk proneness.

Conclusion: Stimuli like risk tasks to measure financial decision behaviour undergo a cognitive-affective appraisal. This appraisal is influenced by acute role identities. Our results allow a physiological objectivation of risk behaviour. Risk behaviour is consistent for the domains of money and pain, at least under the current conditions. We suggest that monetary risk preference can, to a certain extent, be predicted by personality characteristics.[8]

[8] The work described in this chapter has been done in collaboration with the following people: Hans Rudolf Heinimann, Victor Candia, Gerd Folkers. The journal paper is to be submitted.

8.1 Introduction

Risk propensity, the degree to which people find perceived risk attractive, has been shown to be personality specific. Sitkin et al. define *risk propensity as* "the tendency of a decision maker either to take or avoid risks", or as the summation of the reported risk taking behaviour of an individual across situations and time (Sitkin 1992). Risk propensity differs between individuals and it probably leads to inter-individual differences in risk taking. However empirical evidence shows that, even when having general and consistent views about risk, it is possible to be risk seeking in some areas of life and risk averse in others. Sitkin and Weingarts interaction model of risk taking concludes that both situational characteristics as well as person-centered characteristics like age, gender, culture, genes and personality influence risk taking (Sitkin and Weingart 1995). They propose that the *perception of risk* is domain specific, as it is influenced by situational characteristics, whereas *risk propensity* as an individual characteristic may be consistent across multiple decision domains. Weber et al. investigated risk taking in five domains including financial decisions. Results showed that while the degree of risk perceived in a situation can vary according to the personality characteristics and be highly domain-specific, the risk propensity remained stable across situations (Weber 1997; Weber 2002). Recently Nicholson et al. introduced a new scale, the Risk Taking Index, a self assessment scale to measure overall risk propensity concerning six domains of finance, recreation, health, career, safety and social domains (Nicholson 2005) and concluded that risk propensity is strongly rooted in personality.

In an effort to find personality characteristics that predict for inter-individual variation of monetary risk behaviour mostly single and self-reported correlates have been reported so far. Physiological correlates and game theoretical risk tools may offer new predictor alternatives. Here we focus on three potentially influencing factors on risk behaviour *1) self-perceived* role-identity*,* its 2) *emotional arousal* and its 3) *pain perception,* one potentially associated physiological factor.

Role identities, here defined, as the way people perceive themselves are associated with emotions. Emotions probably reflect ancestral neuro-genetic memories that link up with capacities to learn about environmental contingencies (Panksepp 2006). This means that people seem to have chronic - e.g. personality related - dispositions to specific emotions. Self-perceived role identities have been shown to influence risk behaviour: some people seem to focus rather on the potential and others on the *security* of a decision (Lopes and Oden 1999). In one recent study, *narcissism* has been shown to correlate with self-reported aggressive investment strategies (Foster 2009, in press). *Self-efficacy,* a measure for the belief in one's own capacity to perform (Bandura

1977) was positively correlated to effort and performance in a stock investment simulation (Seo 2009). According to stereotypes, biological *sex* and gender roles act a part: women are risk averse in many domains, they take less hazards in health, sports (Byrne 1992) and also have been shown to be more risk averse in financial decisions under risky information (Schubert 1999; Eckel 2003; Fehr-Duda 2006). The effect of these components of role-identity on a standardized tool measuring financial decisions under risk has not been assessed yet. Moreover, *pain perception* has been related to personality aspects like self-percieved role-identity. We hypothesise that personality specific risk propensities in the domains of money and pain are similar, and that pain perception may serve as a new marker for a physiological objectivation of risk propensity. An individual sensitive to negative emotions (like for example to those created by noxious painful stimuli) is likely to have an emotional background leading to particular risks taking which can be objectively depicted by means of RALT (Randomized Lottery Task). To our knowledge, relationships of pain perception and risk behaviour in financial decisions have not been assessed in the same group of volunteers.

For some people sensations and risks are attractive because they are stimulating, exciting. Subjective and physiological *arousal* has been shown to have an effect on gambling (Dickerson 1987). Accordingly, research on arousal shows that increased arousal can restrict attentional capacity (Mano 1992) and increase risk taking (Mano 1994). Impulsivity and sensation seeking correlate to risk taking in monetary matters (Zuckerman and Kuhlman 2000; Martins, Tavares et al. 2004) (Wong 1991). Ku et al. propose a competitive arousal model of decision-making which suggests that factors that induce arousal will result in impaired decision-making processes and outcomes (Ku 2004).

We focus on the inter-individual variability of risk behaviour assessed by our improved lottery task RALT. We hypothesize that self-percieved *role-identity* and its *emotional arousal* has an important effect on risk behaviour in finance and may account, to a certain degree, for the reported variation of inter-individual risk behaviour. It is assumed that risk aversion will correlate with a role-identity that can be described by 1) *an appreciation of security and control*. More precisely, a role identitiy that focuses on decision's security, shows high self-efficacy, low narcissism and fatalistic externality scores, is compatible with a female gender role and has low pain tolerance and threshold. Moreover, we hypothesize that risk aversion will be related to 2) high *calmness*; characterized by high calmness ratings throughout the experiment, low levels of emotional arousal during positive emotional stimulation, and 3) to subjective pain ratings. In contrast, exactly the opposite will be the case for risk-proneness. Consequently, risk propensity should not be domain specific but a general trait, mirrored in different domains.

8.2 Experimental Verification

For more experimental details, see Chapter 3.

To measure and predict inter-individual variability of risk behaviour we used the following strategy:

- A 25 x 40 correlation matrix was created. Each personality characteristic was correlated with 5 preference points (Q) at 5, 10, 25, 50 and 75% probability for the risky choice option A and 5, 10, 50, 90, 95% winning probability (P) in option A.
- Psychological and physiological correlates of RALT RP ($\rho < -0{,}4$; $\rho > 0{,}4$) at several winning probabilities in the risky option A, and at several preference points (Q) with low inter correlation were identified.
- These parameters were used for a first principal component analysis.
- Determinant parameters with highest factor loadings and an equal distribution around zero were identified.
- Determinant parameters were used for a second principal component analysis.
- The factors of PC1 and 2 were interpreted.
- A model-based prediction of risk behaviour grounded on PC1 and PC2 was done.

8.3 Results

8.3.1 Principal component analysis

19 variables that had the highest correlation with RALT risk premium were considered for principal component analysis (PCA). Variables optimally depicting differences in personality characteristics that had long arrows in the two-dimensional space and the same angle around zero, depicted by the green lines. Seven determinant factors that optimally depict differences in personality characteristics with an optimal separation effect were identified. They had high factor loadings and the same angle around zero. They were used for a second PCA; Table 7 gives the factor loadings and Figure 24 shows the projection of the determinant variables on PC1 and 2.

Table 7 **Matrix of factor loadings, 7 variable alternatives**. Mapping of 7 variables on principal component (PC) 1 and 2. PC1 depicts four variables, (1) self efficacy, (2) female traits, (3) safety seeking, and (4) pain tolerance; whereas PCA2 aggregates 3 variables, (5) calmness, (6) reaction to emotionally positive stimulation by picture viewing, and (7) McGill pain perception.

Personality Characteristics	PC1	PC2
Pain tolerance negative condition	-0.55	-0.07
Mc Gill Pain rating control condition	-0.12	-0.64
Calmness rating (MDBF)	-0.10	0.54
Arousal rating positive stimulation (SAM)	0.18	-0.34
Safety seeking	0.43	0.28
Feminity (BSRI)	0.48	-0.31
Self efficacy (FKK)	0.48	0.06

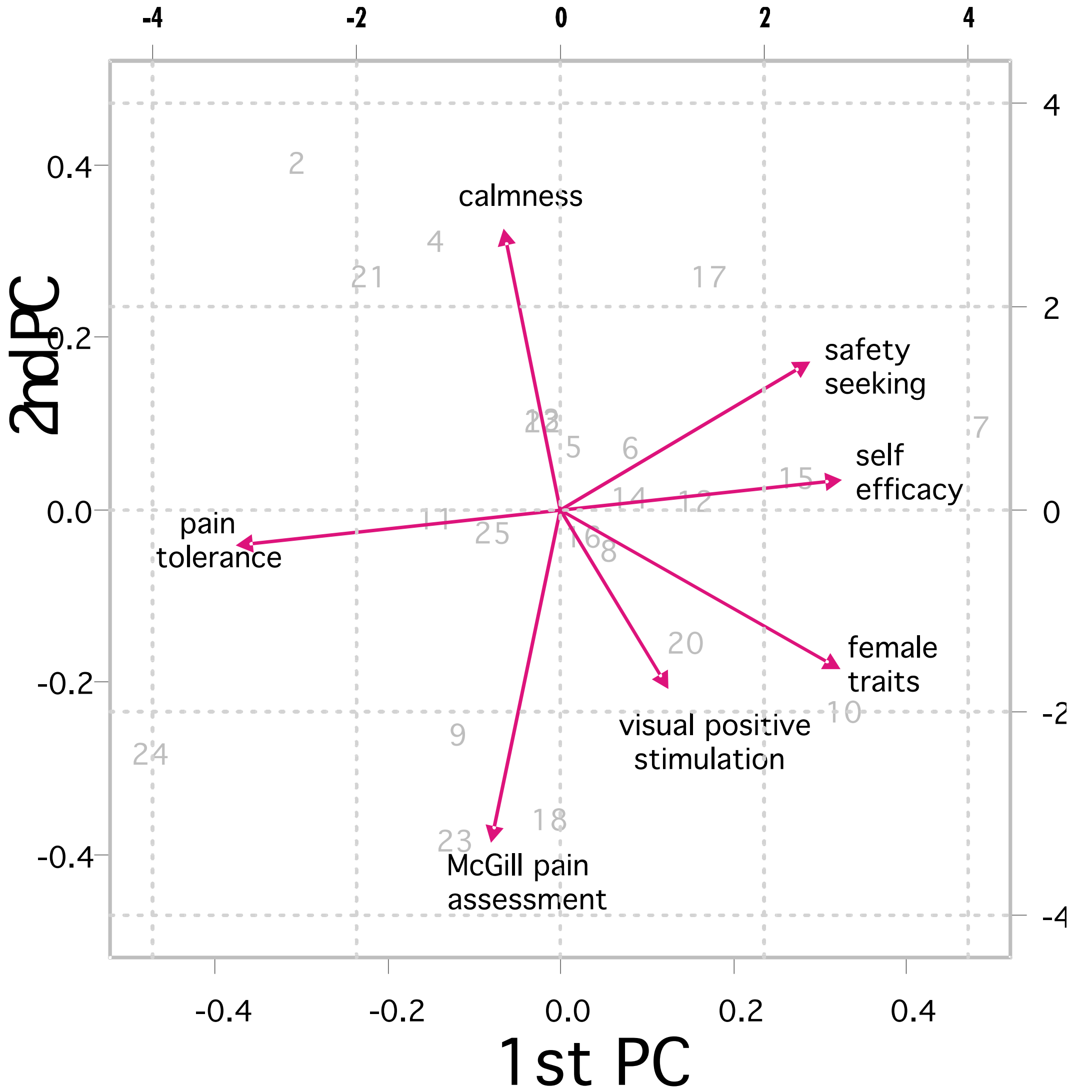


Figure 24 Projection of the seven personality characteristics that optimally depict differences in personality characteristics with highest correlations with RALT RP on the first two principal components (PC). Grey numbers represent volunteers.

8.3.2 Model based prediction of risk behaviour

For details on the generalized linear model [3] based on RALT raw data see Chapter 7.3.1. We fitted a model based on PC1 and on PC2 instead of RALT raw data. The analysis of deviance (Table 8) indicates that the interaction of SEX and risk premium had the biggest influence; followed by the probability of the lottery, decision time, PC1, emotional conditioning, accumulated time and PC2. Table 9 gives the parameter estimates fot the generalized linear model.

Table 8 Analysis of deviance of the generalized linear model based on PC1 and PC2 [7]. Deviance is a metric for statistical dispersion, based on log-likelihood theory.

	Df Deviance	Resid.	Df Resid.	Dev
NULL			4400	6099.7
I(time^e)	1	197.3	4399	5902.4
Probab	1	501.0	4398	5401.4
COND1	3	19.0	4395	5382.3
I(acc_time^e)	1	13.1	4394	5369.3
hk72_PC1	1	25.8	4393	5343.5
hk72_PC2	1	12.4	4392	5331.1
premium:factor(SEX)	2	2004.9	4390	3326.2

Table 9 Parameter estimates for the generalized linear model [3]. (***) Indicates that the estimates are significant at a level of less than 0.001.

	Estimate	Std. Error	z value	Pr(>|z|)	
I(time^e)	3.68	1.31	2.8	0.00492	**
Probab	-4.44	0.18	-24.8	< 2e-16	***
COND1neg	-9.10	2.24	-4.1	4.99e-05	***
COND1neut	-8.72	2.22	-3.9	8.56e-05	***
COND1pos	-8.72	2.24	-3.9	9.66e-05	***
I(acc_time^e)	4.68	1.07	4.4	1.31e-05	***
hk72_PC1	-0.15	0.03	-5.2	2.21e-07	***
hk72_PC2	-0.18	0.03	-5.4	5.85e-08	***
premium:factor(SEX)0	0.17	0.009	18.5	< 2e-16	***
premium:factor(SEX)1	0.30	0.012	24.2	< 2e-16***	

Based on the parameter estimates of Table 9 we examined the effect of PC1 and PC2 on risk behaviour. High positive scores of both PC1 and PC2 resulted in a decrease in risk proneness (Figure 25).

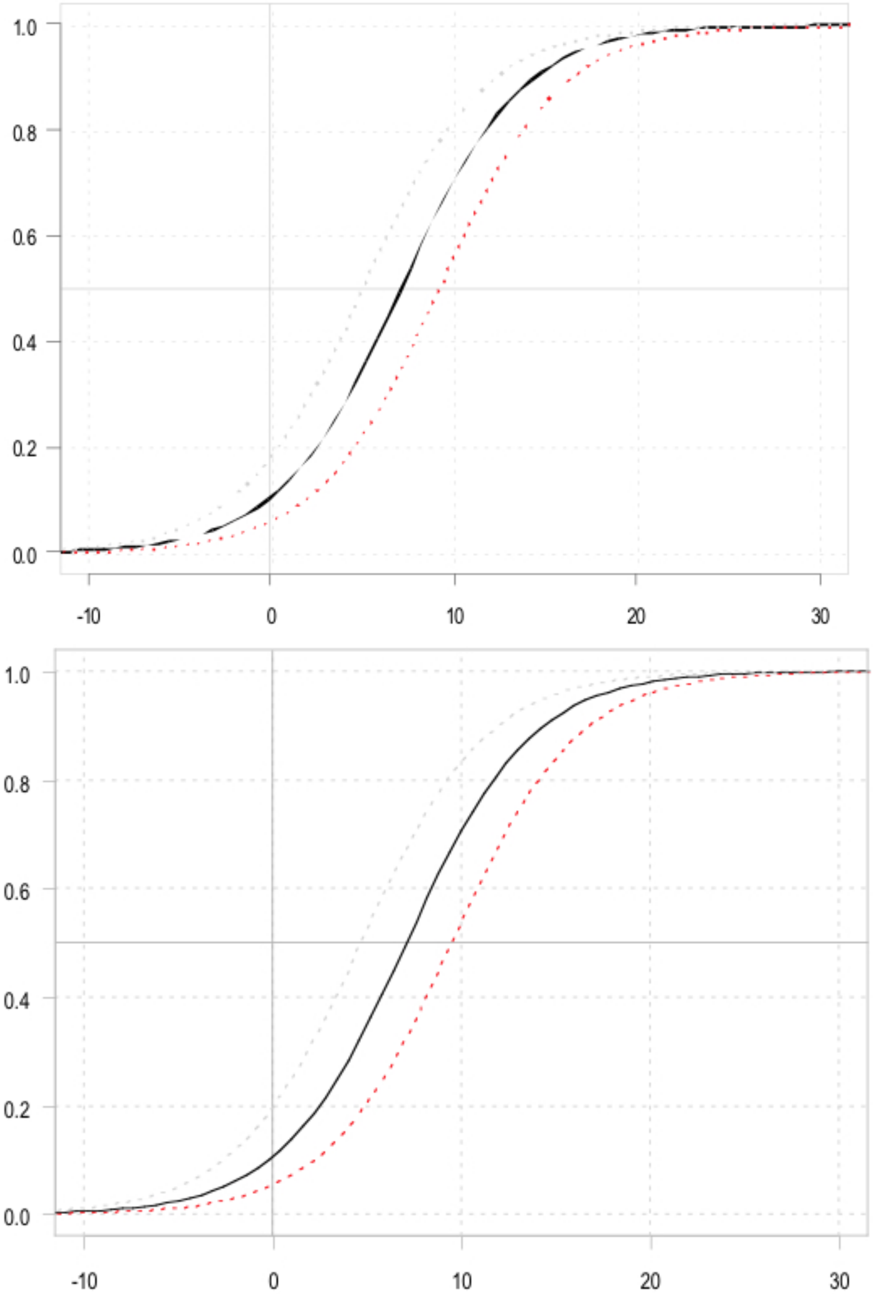


Figure 25 **Effect of 1st PC (above) and of 2nd PC (below) on risk behaviour**. Based on [1] with parameter estimates of Table 2. High positive scores of PC 1 and PC2 result in the dotted, red line, inferring a decrease in risk proneness. High negative scores lead to an increase in risk proneness.

8.3.3 Correlates of RALT risk premium

Pain tolerance

Spearman rank correlations showed a significant negative correlation between the increase of pain tolerance, pre and post picture viewing, and the increase of RALT risk premium (RP) at all measured 40 preference points of 90% and 95% winning probability in option A.

Table 10 gives an example for the highest correlations at the preference point at 95% winning probability in option A and 90% probability of risky choice (P95 Q90). The Grubbs test detected a significant outlier for P95 Q90 at a significance level of 0.05 (critical value of $z = 3.14$, z of outlier $= 3.55$, $P < 0.05$). When the outlier was excluded, correlations remained significant (see Table 10) so, in further analysis the Grubbs outlier was not excluded. Spearman correlations were not significant when women and men were analyzed separately.

Table 10 Example for the highest of several correlations of risk behaviour and pain perception. Spearman Rank correlations between RALT RP at P95 Q90 and pain measurements were significant for all participants. Correlations were not significant when women and men were analyzed separately. *: Correlation is significant at the 0.05 level; **: Correlation is significant at the 0.01 level.

t	Control condition 1	Control condition 2	After positive pictures	After negative pictures
All participants	ρ = -0.56** P = 0.00 (Figure 26)	ρ = -0.54** P = 0.01	ρ = - 0.61** P = 0.00	ρ = -0.50* P = 0.01
Participants without Grubbs outlier	ρ = -0.51* P = 0.01	ρ = -0.52** P = 0.01	ρ = -0.58** P = 0.00	ρ = -0.44* P = 0.31
Women	ρ = -0.51 P = 0.09	ρ = -0.01 P = 0.97	ρ = -0.24 P = 0.46	ρ = -0.30 P = 0.33
Men	ρ = -0.42 P = 0.16	ρ = -0.30 P = 0.33	ρ = -0.37 P = 0.21	ρ = -0.27 P = 0.93

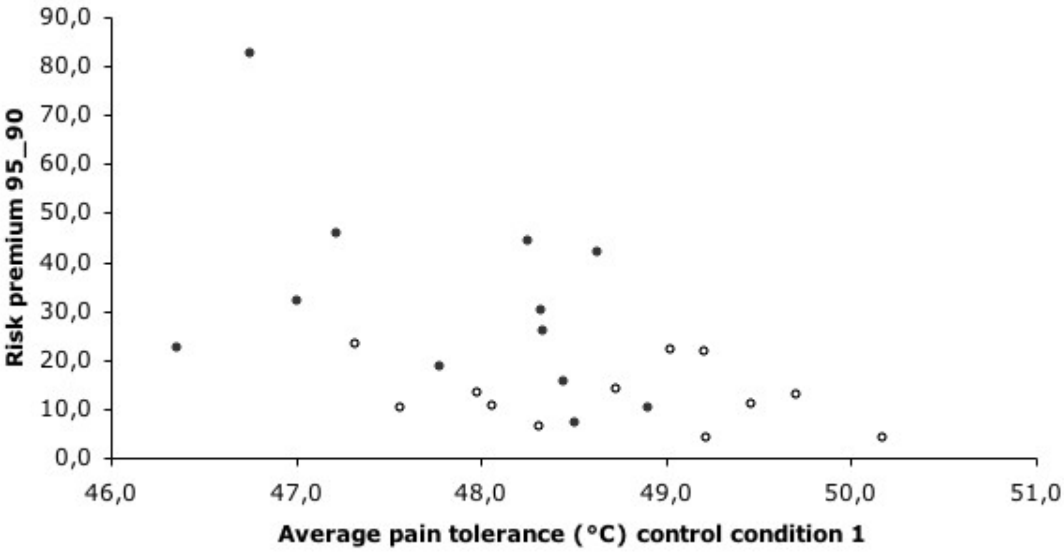


Figure 26 Example for the highest of several significant negative correlations of RALT risk premium of women (black) and men (white) at P95 Q90 (95% winning probability in option A and 90% probability of risky choice) and mean levels of pain tolerance in the control condition.

VAS-intensity-score

The Spearman Rank correlations revealed a significant negative correlation of *VAS-intensity* pain score during control conditions and RALT RP at 5 and 10% winning probability at 5 preference points. The highest of several correlations appeared at P5 Q25 (ρ = - 0.51*, P = 0.01).

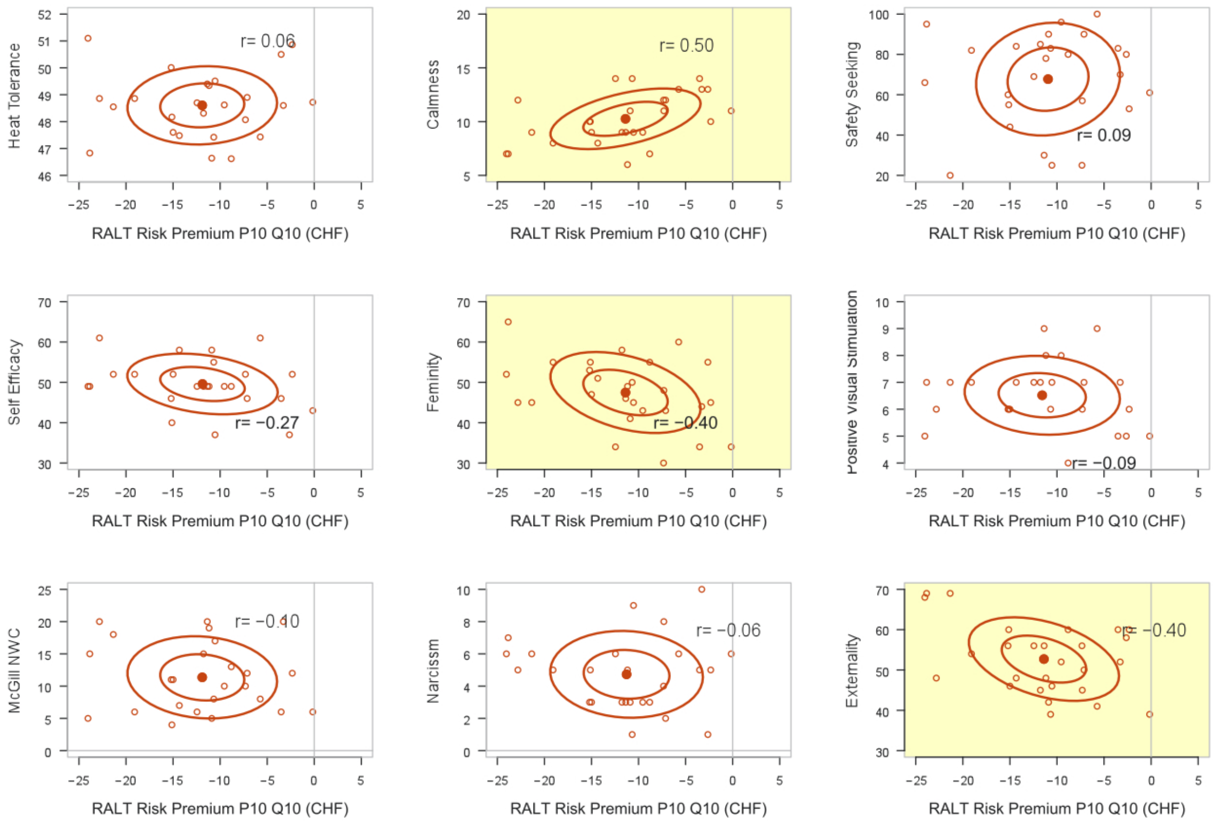
MPQ subscales

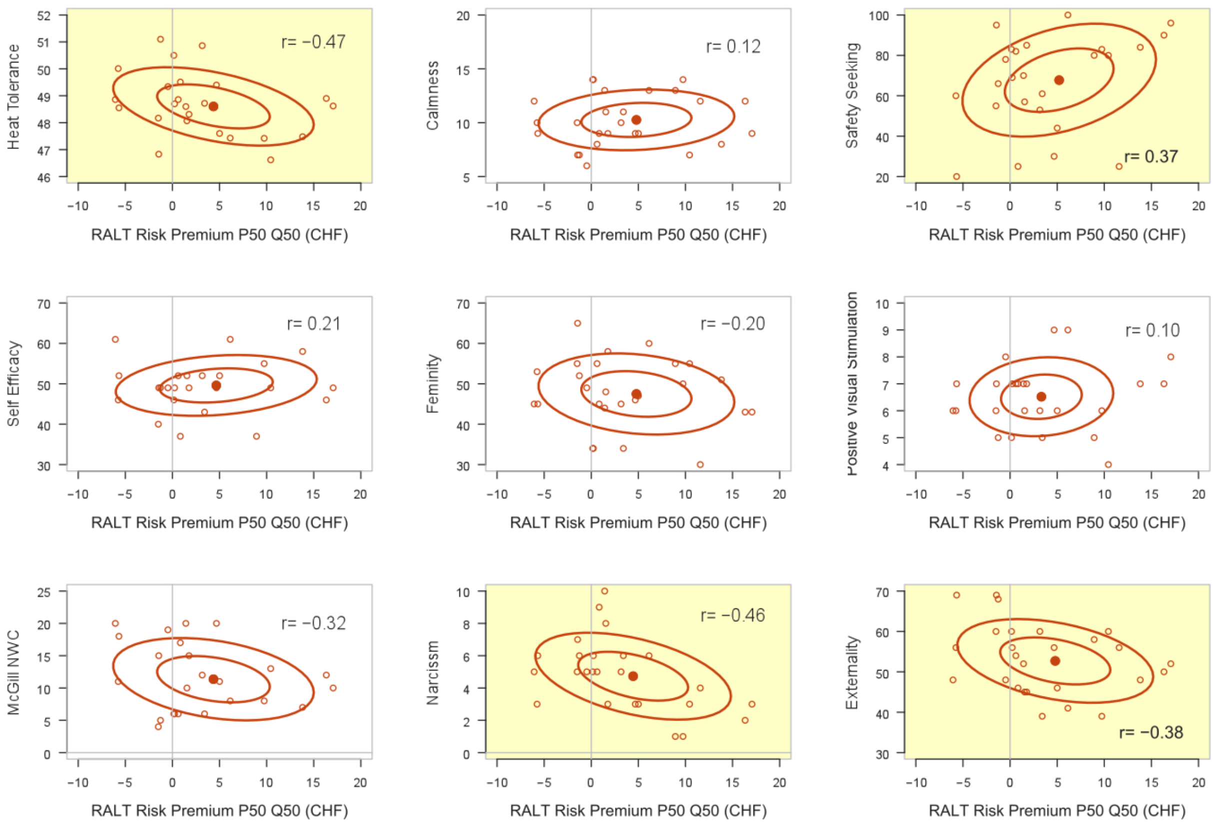
Spearman Ranks correlation was significant for *MPQ* pain ratings of the subscales S, A, T, and NWC during control, negative and positive condition and RALT RP at 90 and 95% winning probability at 38 preference points. The highest of several correlations appeared at P90 Q10 (NWC subscale during control condition: ρ = -0.47*, P = 0.02; T subscale during negative condition: ρ = -0.47*, P = 0.02; sensory subscale during positive condition: ρ = -0.55**, P = 0.01; affective subscale during control: ρ = -0.47*, P = 0.02).

Self assessed personality characteristics

The Spearman Rank correlation revealed significant negative correlations between the increase of *SAM intensity scores of positive pictures* at 5%, and 10% winning probability and 4 preference points with the highest correlation at P5 Q50 (ρ = -0.43*, P = 0.02). Moreover Spearman Rank correlations were significant between RALT RP and BSRI *feminity* and *masculinity* subscale scores at 5%, and 10% winning probability and 3 preference points each with the highest correlation at P5 Q25 for feminity (ρ = -0.44*, P = 0.02) and P5 Q75 for masculinity (ρ = 0.39*, P = 0.05). Moreover Spearman Rank correlations were significant for RALT with *NPI* score at 50%, 90% and 95% winning probability at 9 preference points with the highest correlation at P90 Q50 (ρ = -0.55**, P = 0.00) and with the FKK subscale of *social externality* at 5%, 10% and 50% winning probability at 4 preference points with highest correlations at P10 Q75 (ρ = -0.43*, P = 0.03).

Spearman Rank correlations were significant between RALT RP and FKK subscale of *internality vs. externality* at 50% winning probability at two preference points (P50 Q90: ρ = 0.48*, P = 0.02) and of *self-efficacy* (P50 Q90: ρ = 0.41*, P = 0.04). Moreover, there was a correlation with the *MDBF R/U* subscale for calmness at 5% and 10% probability of risky choice at 5 preference points with highest correlations at P10 Q10 (ρ = -0.51**, P = 0.01). Besides, correlations were significant between the self-assessment on *focus on the security of a decision* and RALT measures at 50, 90 and 95% winning probability at 12 preference points with the highest of several correlations at P95 Q25 (ρ = 0.60**, P = 0.00).


Heat Tolerance
r= 0.06
RALT Risk Premium P10 Q10 (CHF)
Calmness
r= 0.50
RALT Risk Premium P10 Q10 (CHF)
Safety Seeking
r= 0.09
RALT Risk Premium P10 Q10 (CHF)
Self Efficacy
r= −0.27
RALT Risk Premium P10 Q10 (CHF)
Feminity
r= −0.40
RALT Risk Premium P10 Q10 (CHF)
Positive Visual Stimulation
r= −0.09
RALT Risk Premium P10 Q10 (CHF)
McGill NWC
r= −0.40
RALT Risk Premium P10 Q10 (CHF)
Narcissm
r= −0.06
RALT Risk Premium P10 Q10 (CHF)
Externality
r= −0.40
RALT Risk Premium P10 Q10 (CHF)


Heat Tolerance
r= −0.47
RALT Risk Premium P50 Q50 (CHF)
Calmness
r= 0.12
RALT Risk Premium P50 Q50 (CHF)
Safety Seeking
r= 0.37
RALT Risk Premium P50 Q50 (CHF)
Self Efficacy
r= 0.21
RALT Risk Premium P50 Q50 (CHF)
Feminity
r= −0.20
RALT Risk Premium P50 Q50 (CHF)
Positive Visual Stimulation
r= 0.10
RALT Risk Premium P50 Q50 (CHF)
McGill NWC
r= −0.32
RALT Risk Premium P50 Q50 (CHF)
Narcissm
r= −0.46
RALT Risk Premium P50 Q50 (CHF)
Externality
r= −0.38
RALT Risk Premium P50 Q50 (CHF)

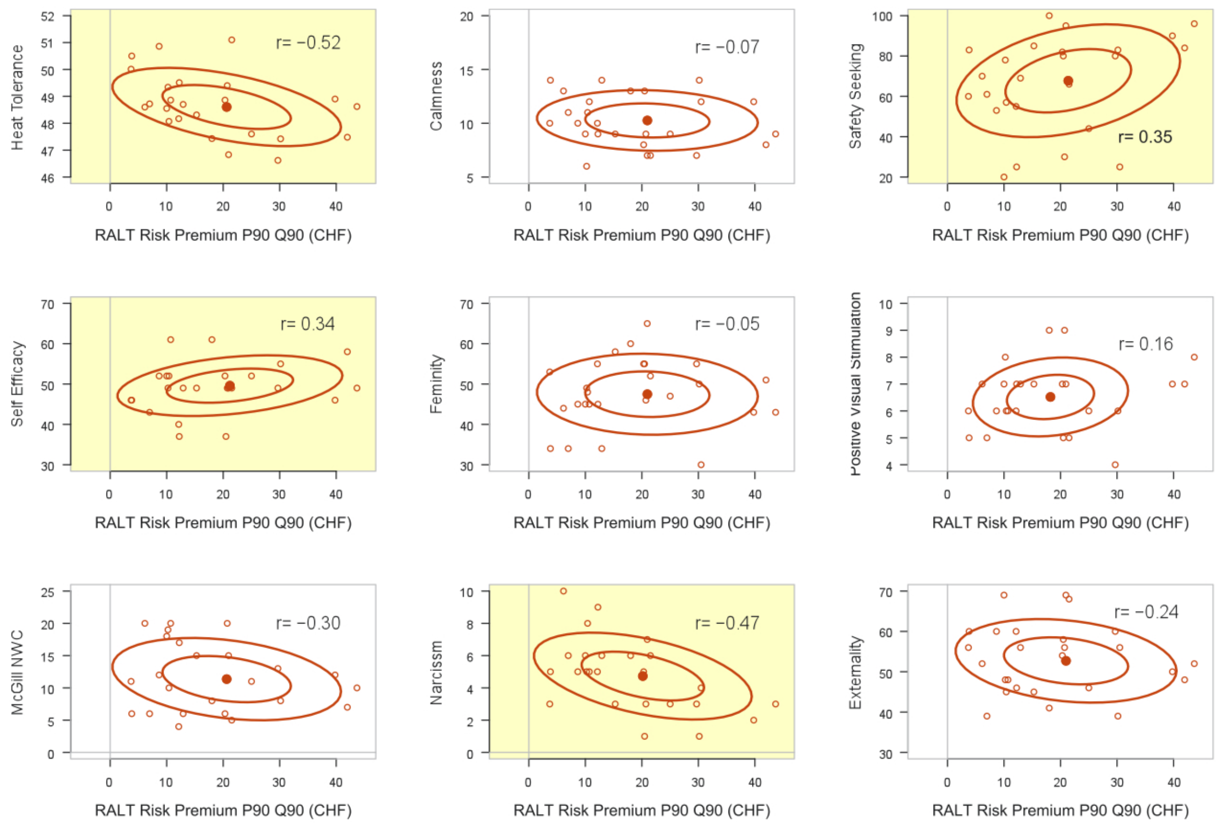


Figure 27 Example for correlations of the determining parameters with RALT risk premium at P10 Q10, P50 Q50 and P90 Q90. Not all determinant parameters correlate significantly with all of these risk measures, the significant correlations are colored yellow. The red circles are ellipses of the same probability that depict a two-dimensional probability distribution of the correlations. Flatter ellipses indicate higher correlations.

8.4 Discussion

To predict *inter-individual variability of risk behaviour* psychological and physiological correlates of RALT RP were assessed. Two principal components were identified. They indicated that the motivational force for risk aversion can be best described by two personality characteristics: 1) *appreciation of security and control* and 2) *calmness*. Accordingly, model-based prediction of risk behaviour, which was purely based upon PC 1 and 2 by omitting raw data for RALT, revealed that high scores in both components occurred with a decrease in risk proneness.

At least for the presented experimental set up, risk behaviour was personality specific. Risk aversion went together with role identities best described by the appreciation of security and control and emotional calmness. An appreciation of security and control was characterized by low pain tolerance and high scores of self-efficacy, feminity, and safety seeking (PC1, Figure 24). Moreover, low arousal of volunteers was associated with risk aversion in RALT and was characterized by low emotional arousal during positive picture viewing, low pain ratings and high calmness ratings (PC2, Figure 24). In contrast, risk proneness went together with forced risk seeking and emotional arousal.

Risk-averse behaviour in RALT went together with high scores of *self-efficacy* and *internality vs. externality* and low scores of *social externality*. Self-efficacy is a measure for ones belief in owns capacity to perform (Bandura 1977). Similar high levels of internality vs. externality indicate high control and autonomy. On the other hand, social externality relates to the general expectation that events depend on non-personal circumstances, such as fate, luck or chance High scores in this measure indicate a strong dependence on others. Self-efficacy has been recently shown to be positively correlated to effort and performance in a stock investment simulation (Seo 2009). Vancouver et al. proposed that self efficacy might create a positive motivation by directing high resources towards goals (Vancouver, More et al. 2008).

High scores in feminine gender role correlated significantly with risk proneness at very low winning probabilities in option A. Nevertheless, feminity had high factor loadings on PC1 indicating risk aversion (Figure 25). Moreover, risk prone behaviour in RALT appeared with high scores of male attributes in BSRI. High male scores projected negatively on PC1 indicating risk proneness. In line with our results, women have been shown to be more risk averse in financial decisions under risky information (Schubert 1999; Eckel 2003; Fehr-Duda 2006). In general, the expression “gender” is often used as a synonym for biological sex. However, some authors clearly differentiate between sex and gender where sex indicates physiological characteristics that divide cases into male and female. Gender, however, connotes complex attributes that culture ascribes to each of the sexes and is socially constructed. Meier-Presti et al.

observed in one recent publication the effect of gender and biological sex on risk taking in four different investment scenarios. In line with our results, high values of maleness in BSRI went along with higher financial risk taking, independently of biological sex. Identification with the female gender role, however, did not have an effect on risk taking (Meier-Pesti 2008). This was not the case for our volunteers, as female gender role had high factor loadings on PC 1, indicating that participants with high estimation of security and control were more risk averse than those with low factor loadings.

Risk prone behaviour correlated with a low focus on decision's security. People seem to have chronic – e.g. personality or gender related - dispositions to specific emotions. Some seem to focus rather on the potential, others on the security of a decision (Lopes and Oden 1999).

Pain tolerance was measured four times per participant. All four measurements correlated negatively with all 5 RALT preference points at 90 and 95% winning probability. Risk prone participants at high winning probabilities had higher pain tolerances. An increase of 1°C in pain tolerance occurred with about 10 CHF decrease in risk premium. This effect was independent of the emotional state during pain measurement; we observed highest correlations for pain tolerance after positive picture viewing.

Money and pain: Risk taking is influenced by emotions; they influence the subjective utility of a decision, anticipate feelings about the outcomes and the likelihoods of an outcome (Katz 1999; Loewenstein, Weber et al. 2001). One possible explanation for the correlation of pain tolerance and decision behaviour under financial risk may be that both are mediated by emotions. An individual that is sensitive to negative emotions will likely have an emotional background that can be characterized by a careful consideration of risks and potential losses. Pain tolerance, or the readiness to endure pain, involves a forced risk taking, as pain functions as a warning of tissue damage because enduring heat pain may result in body damage. To a certain degree, pain perception can even be equalized with a sensitivity to negative emotion, since brain regions of pain and emotion are closely connected (Eisenberger 2003; Vogt 2005) and states of emotion and pain interact closely (Kut 2007). Accordingly, the sensitivity to pain as a negative emotion could indicate the strengths of emotional effects on risk behaviour.

Outlier: Figure 26 depicts the highest of several correlations of RP with pain tolerance. One outlier at high RP and low pain tolerance was detected by the Grubbs test. Table 10 depicts the correlations of all four measurements with RALT RP with and without the outlier. The volunteer represented by the outlier did not show abnormalities in behaviour during the other tests. When the outlier was excluded, correlations remained significant.

Distribution of RP: Our volunteers have not been selected depending on their risk behaviour but represent the monetary preferences of a randomly selected group of students. Their RP was not evenly distributed, as they were risk averse during all win probabilities. Figure 26 depicts the distribution of RP at 95% winning probability in the risky option; most participants have a risk averse RP in between 0 and 50 CHF. We believe that a pre-selection of participants covering the full range from (-80) to (+80) CHF may improve the knowledge on the nature of the correlation between RP and pain tolerance. Nevertheless, such a selection would imply an artificial set of volunteers.

Sex Differences: When men and women were analyzed separately, the correlation was not significant any more. A reason for this may be the rather small amount of volunteers and the fact that volunteers risk behaviour was not evenly distributed.

Risk prone behaviour in RALT went along with high scores of narcissism in NPI. High narcissism scores projected negatively on PC1 (Figure 24). So far, a recent study has shown, in congruence with our results that narcissists report a preference for aggressive (high risk/high reward) investment strategies. Participants had to choose between 5 different aggressive funds for each of the four scenarios in order to find their risk tolerance, i.e. the “maximum amount of uncertainty that someone is willing to accept when making a financial decision” (Foster 2009, in press). These results of high risk/high reward strategies are in accordance to Campbell’s agency model that depicts that narcissists are strongly motivated by reward and weakly motivated by punishment (Campbell 2006).

Risk prone behaviour occurred with low *calmness ratings*, high *arousal ratings of positive pictures* (sports and erotic scenes) and *higher pain ratings* of Mc Gill pain questionnaire (S, T, NWC) in all conditions, and on VAS intensity in the control condition. In line with our results, various studies indicate that a preference for arousal might go together with a preference for risk: research on arousal shows that increased arousal increased risk taking (Mano 1994). Moreover impulsivity and sensation seeking have been shown to be a highly consistent predictor of various kinds of risk behaviour including compulsive gambling (Zuckerman and Kuhlman 2000; Martins, Tavares et al. 2004) and of self- assessed risk taking in everyday monetary matters (Wong 1991). Accordingly, risk takers may be strongly driven by reward and engage in behaviours without proper regard of the consequences, rather than being deterred by potential negative outcomes. A biochemical model of risk taking holds that neural correlates for financial risk taking may have dopaminergic pathways, as risk taking is positively associated with reduced dopamine availability in the synaptic cleft and increased sensitivity of dopamine receptors (Chen 1999): risk seeking and response disinhibition have been shown to be associated with the 7R allele of the dopamine receptor D4 gene (DRD4). It is possible that individual variation of risk preferences in financial decisions may therefore be mediated by allelic variants of DRD4. The authors observed a significant correlation between the presence of the 7R allele and risk taking under risky information in one decision with real monetary profit. Further studies including gene tests may indicate to witch extend DRH4 modulation of personality characteristics was involved in these results.

Conclusion

Nicholson et al. introduced a new scale, the Risk Taking Index, a self assessment scale, to measure overall risk propensity concerning the six domains of recreation, health, career, finance, safety and social issues (Nicholson 2005). They proposed as a motivational force for risk taking high sensation seeking and openness with low neuroticism, agreeableness and conscientiousness. They conclude that some people are consistently risk takers or risk averse while others exhibit domain specific patterns of risk behaviour. In our study, similar personality characteristics predicted inter-individual variation of risk behaviour. Moreover, risk preference was not domain specific for money or pain. Our results add psychological and physiological factors and a theoretical risk tool to self-reported correlates of personality characteristics. To a certain degree, they allow predictions on risk behaviour.

9 Affective Pictures and their Associated Emotions Influence Pain Perception and Risk-behaviour during Lotteries

Background: It has been proposed that emotions developed from primitive reactions that facilitate survival. Previous work suggests that active emotions react to aversive and appetitive stimuli and sometimes unconsciously influence motivation and behaviour. It is known that cognitive and affective appraisal have an effect on pain perception, and also risk behaviour. *Objectives:* The present study assessed how positive and negative affective pictures frame behaviour by investigating how they affect 1) heat pain perception, and 2) risk-behaviour during lotteries. *Methods*: Heat pain tolerance and threshold were measured on the forearm of 27 volunteers. Risk behaviour was measured with a new custom-made Random Analogue Risk Task (RALT). Emotion induction was quantified by means of salivary Alpha-amylase (sAA)-concentration levels and self- reports. *Results:* Concerning pain perception, negative picture viewing led to stress-induced analgesia, while positive picture viewing also resulted in an increased heat pain tolerance and pain threshold in all participants. With RALT, negative picture viewing went together with risk-averse financial behaviour of men, whereas positive picture viewing resulted in a trend towards more risk-prone financial behaviour. In accordance, higher arousal ratings after positive picture viewing correlated with risk-prone behaviour in all participants. Positive and negative picture viewing increased sAA-levels, which appear to be a good index of arousal.

Conclusion: Apparently, under the present conditions, negative affective states prime the decision-maker to focus on the problem and increase conservative behaviour, as they result in an attenuation of pain perception and in risk-averse behaviours during financial lotteries, especially by men. In comparison to this, positive affective states prime the decision-maker on potential gains and result in reduced pain perception and risk-prone behaviour during lotteries. We presume that the defensive respectively the appetitive system of emotion and the sympatic nervous system (SNS) were activated as indicated by increased sAA-levels. Under given conditions, decisions made within the context of monetary gambles, but also during pain, are modulated by emotions in order to maximize ruin avoidance.[9]

[9] The work described in this chapter has been done in collaboration with the following people: Hans Rudolf Heinimann, Peter Krummenacher, Victor Candia, Gerd Folkers. A journal paper is to be submitted.

9.1 Introduction

Decision-making is the process of choosing an option or course of action from among a set of options (Shafir 2008). It permeates all aspects of our life, including decisions on which stock to buy, which job we take or on how much pain we endure until we resort to painkiller. Here, we focus on decisions within two particular contexts: pain perception and financial risk. *Pain* can be defined as a "defensive behaviour" (Rhudy and Williams 2005) that is accompanied by pain perception, here defined as the product of the brain's abstraction and elaboration of a nociceptive input (Basbaum 2000). Pain helps organisms to avoid actual or potential tissue damage and its neurocircuitry is thought to be part of a defensive system (LeDoux 2000). So a high readiness to endure pain involves forced risk taking. Concerning *financial risk* we focus on uncertain decisions based upon risky information were the probability of outcome is known, as it is the case in for example insurance issues or in the stock market.

In line with previous research, Lang et al. proposed that emotions are the products of Darwinian *evolution* (Lang 1995). It is assumed that emotions developed from primitive and reflexive reactions to appetitive or aversive stimuli that facilitated survival. As the authors propose, the neural mechanisms of human emotion and motivation are preserved in the human brain in sub-cortical and deep-cortical structures that are supposed to have a two factor motivational organization, in the form of an *appetitive* and a *defensive system*. Thus, these two brain systems respond to appetitive or aversive stimuli. We used the *International Affective Picture System* (IAPS) (Lang and Bradley 1997) to activate the antithetic brain systems of emotion in order to evaluate the effect of the antithetic goals of approach or defence behaviour in pain perception and risk behaviour. IAPS is a standardized set of picture stimuli that systematically varies along the two dimensions valence and arousal. For this study motivationally relevant pictures with similar normative arousal values were selected: highly pleasant erotic and sports scenes and highly unpleasant attack and injury scenes. The activation of the two emotional systems can be determined by arousal, the physiological activity in muscles and glands (Lang, Bradley et al. 1998) and by self report. The salivary enzyme *Alpha-amylase (sAA)* can be used as a marker for the emotional dimension of stress (van Stegeren, Rohleder et al. 2006; van Stegeren, Wolf et al. 2008) and immediate and indirect SNS-activation (Nater and Rohleder 2009). However, recent findings suggest that SNS-activation underlies arousal of both approach and withdrawal behaviours (Fortunato, Dribin et al. 2008).

In so far, emotions are considered to be action dispositions preceding stimuli and determining the general behaviour strategy in response to these stimuli. In general, emotions modulate and "prime", preset for activation other processing operations in the brain linked to the engaged motivational system, like connected memory associations or action programs. Scientist offer three different criteria to predict the effect of active emotions at work in the context of a financial decision: *valence* (Isen 1983), *appraisal* (Lerner and Keltner 2001) or *ultimate function* (Fessler 2004), or priming on *gain or loss* (Kuhen 08): in *their theory of motivational priming* Lang et al. suggest that negatively valenced emotion enhances defensive responses like escape or attack while inhibiting appetitive responses like eating or reproduction. Alternatively, positively valenced emotion enhances approach behaviours and inhibits defensive responses (Lang 1995). In their *appraisal* tendencies hypothesis, Lerner and Keltner (Lerner and Keltner 2001) argue that emotions that can be characterized by security and control and therefore favour the use of rules of thumb and risk seeking choices, whereas a lack of control leads to careful consideration of the facts and to risk averse choices. In their *evolutionary functionalist perspective*, Fessler and co-workers propose to identify the ultimate functional goals of emotions in order to predict the impact on behaviour (Fessler 04). The *anticipatory model of affect* adds to this that emotional cues that signal potential gains increase risk taking in behaviour, whereas cues signalling potential losses decrease risk taking (Knutson 2005). Independent research laboratories have presented increasing evidence in support of these priming theories of emotion within the domain of pain perception or risk behaviour. Nevertheless, results depend on the induced emotion and on the different methods of pain quantification.

Rhudy and Meagher propose that emotion influences *pain* through a *valence-by-arousal interaction*. Specifically, negatively valenced emotions (defensive activation) can enhance or inhibit pain, depending on the level of arousal that accompanies the emotion i.e., how intensely the negative emotion is experienced: Pain is enhanced with negative emotions that range from low to moderate arousal, but it is inhibited at higher arousal levels. Alternatively, positive emotions always inhibit pain, as long as minimal arousal is obtained (Meagher 2001). This theory is in congruence with experiments on the effect of IAPS picture viewing on cold pressor pain (de Wied and Verbaten 2001; Meagher 2001), pressure pain (Greenwald, Bradley et al. 1998; Arnold, Alpers et al. 2008), and electrical pain stimuli (Rhudy, Williams et al. 2005; Rhudy, Williams et al. 2006; Kenntner-Mabiala, Andreatta et al. 2008). So far, only one study has analyzed the effect of IAPS pictures on intensity and unpleasantness ratings using fixed thermal stimuli (Wunsch, Philippot et al. 2003). Nevertheless, in the mentioned studies the critical levels for a stress induced analgesia were not achieved and some studies revealed just part of the expected effects (Meagher 2001) (Arnold, Alpers et al. 2008). To the best of our knowledge, no evidence for effects of viewing positive and negative IASP pictures on heat pain tolerance and threshold has been presented so far. In general, pain stimuli are applied in fixed or ascending magnitudes, they can be assessed by threshold and tolerance measurements and subjectively characterized by pain scores (Granot, Sprecher et al. 2003). Participants decide when stimuli reach their threshold and tolerance and then stop the heat stimulation. It can be assumed that especially pain threshold and tolerance reflect the sensory experience provoked by a noxious stimulus more directly than subjective reports, because no time delay and no reflection veils the painful experience. For this reason, we focused on the frequently used heat pain stimuli when applied to the forearms.

Still authors consider *risk* as a "feeling". Active and passive emotional states bias estimations on the likelihood of various outcomes, anticipated feelings about the outcome of the decisions and the subjective utility of a decision thereby influencing risk behaviour (Katz 1999; Loewenstein 2003). To date, to measure risk behaviour, work on decision-making under risk conditions has been mostly focused on subjective estimations of likelihoods. Nevertheless, accounts of real-world behaviour suggest that emotions also shape the subjective utility of various outcomes independently of subjective estimations of their likelihood. So, to measure uncertain decisions under risk containing information, participants *risk premium* (RP) has been used. RP is defined as the amount of income that an agent is willing to spend in order to obtain an allocation with risk (Pratt 1964; Pratt, Raiffa et al. 1994). In other words, it is the difference between the expected value of an uncertain lottery and the certain value he is indifferent to. We focus on the effect of active emotions on decision behaviour within the frame of a risk context, here defined as financial decisions between a certain payoff (option A) and a risk option with an expected utility and a given occurrence probability (option B). So far, the few studies giving evidence for the effect of active emotions on risky information (Raghunathan and Pham 1999) (Mittal and Ross 1998; Nygren 1998; Fessler 2004) carry important limitations (see Chapter 6): they used non-randomized experimental designs, data recording under task-awareness conditions, and very few choices to depict risk behaviour. Moreover many tools do not use monetary incentives; if participants believe that their earnings do not depend on their own decisions, there is less incentive for them to make accurate decisions. To our knowledge, the effects of acute effective states, as induced by picture viewing on risk-behaviour in lotteries, have not been analyzed so far.

Although numerous hypothesis and models of decision-behaviour have been presented so far, there still is an absence of founded knowledge about their potential operating mechanisms. Building a bridge between the three research fields of emotion, pain and risk, might fortify our knowledge on the influences of emotions on risk behaviours.

We hypothesize that 1) viewing highly arousing pictures with negative valence (injuries, human catastrophes and attack scenes) will lead to defensive responses with functional goals related to defending oneself or others against harm and a priming on losses. Therefore it is expected that behaviour will be risk-averse and that depending on level of arousal, pain perception will be enhanced or inhibited. Conversely, we hypothesize that 2) viewing highly arousing pictures with positive valence (erotic and team sport scenes) will induce emotions congruent with functional goals related to approach behaviours and a priming on gains. It is expected that therefore pain perception of volunteers will be attenuated and that they will display risk-prone behaviour in RALT. Finally, the new risk tool RALT will be able to depict risk behaviour more precisely and the effects of active emotions, for the first time and without framing effects or methodological artefacts.

9.2 Results

9.2.1 Pain perception

Pain tolerance and Pain threshold

The ANOVA for pain tolerance was significant for the within subject factor *Time* ($F_{1,23} = 8.375$, $P = 0.008$, Figure 28). Pain tolerance increased significantly after viewing of both positive and negative pictures.

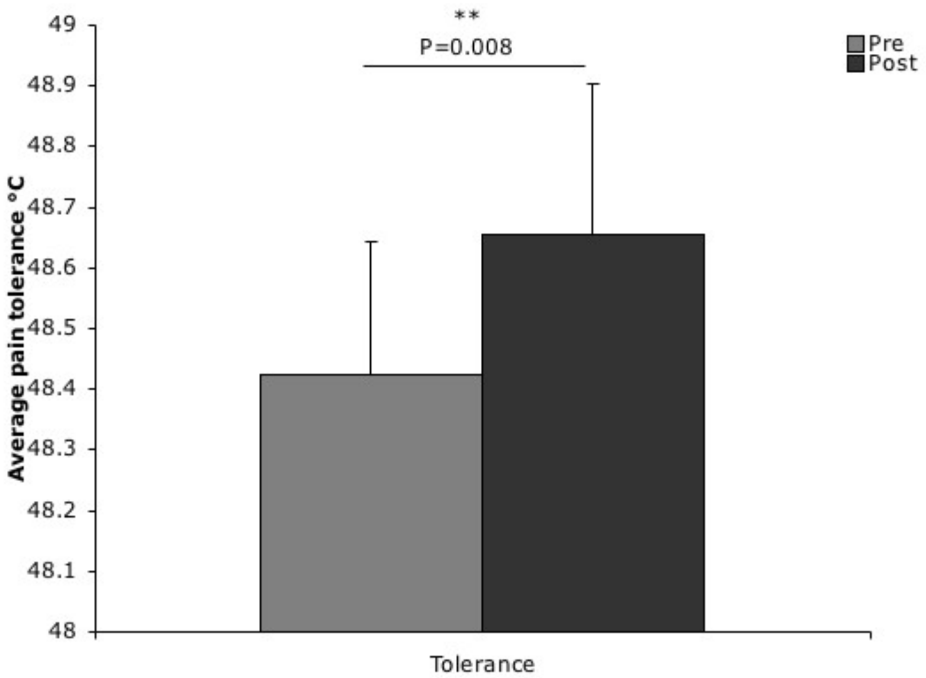


Figure 28 Mean levels of pain tolerance (°C) pre and post picture viewing. Positive and negative IAPS pictures both significantly increase pain tolerance. Pre = before picture viewing; Post = post picture viewing; Bats depict average values and their standard error of the mean (s.e.m.)

Furthermore there was trend in the interaction of *Time*Gender* ($F_{1,23} = 3.989$, $P = 0.058$) for pain tolerance, indicating that the effect of picture viewing was slightly stronger in men. The between subject factor *Gender* (Figure 29) revealed that overall men showed higher pain tolerances than women ($F_{1,23} = 16.466$, $P = 0.000$).

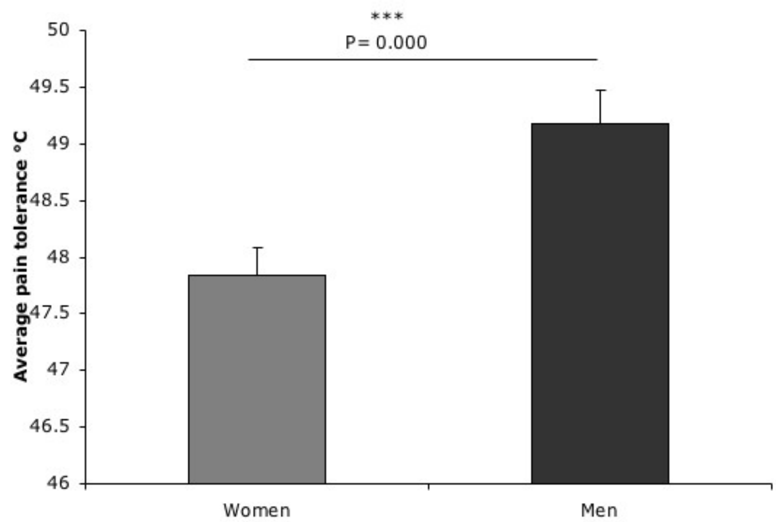


Figure 29 Mean levels of pain tolerance (°C) for men and women. Overall, men showed significantly higher pain tolerances than women. Bars depict average values and their s.e.m.

The ANOVA for pain threshold was also significant for the within subject factor *Time* ($F_{1,23}$ = 7.922 P = 0.010; Figure 30). Pain threshold increased significantly after picture viewing regardless of positive or negative valence. In contrast to pain tolerance, gender had no significant effect on pain threshold ($F_{1,23}$ = 0.097, P = 0.759).

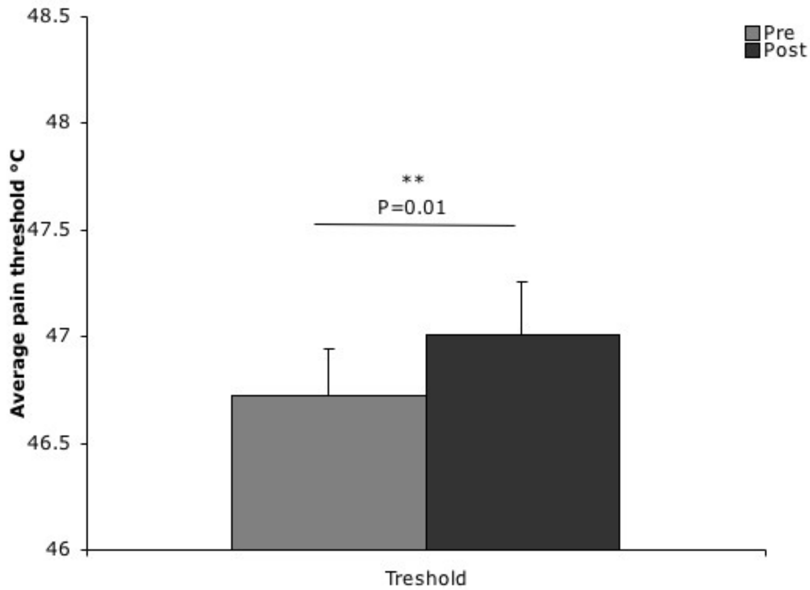


Figure 30 Mean levels of pain threshold (°C) pre and post picture viewing. Positive and negative IAPS pictures both significantly increase pain threshold. Pre = before picture viewing; Post = post picture viewing; Bars depict average values and their standard error of the mean (s.e.m.)

Mc Gill Pain Questionnaire (MPQ)

The ANOVA for the number of words chosen (NWC) was significant for the interaction *Emotion*Time* ($F_{1,23}$ = 9.903, P = 0.005). Post-hoc paired samples t-test revealed that after positive picture viewing NWC pain ratings were lower than during the control condition (t = -1.823, P = 0.042). Nevertheless, this value did not survive Bonferroni correction.

The ANOVA for the sensory and affective subscale of the MPQ was not significant for any interaction. Though the affective subscale revealed a trend for the interactions *Emotion*Time* ($F_{1,23}$ = 4.009,P = 0.058), as positive picture viewing decreases and negative picture viewing increases affective subscale scores in comparison to control conditions.

Visual analogue scale (VAS) for pain intensity and unpleasantness

The ANOVA for the VAS on pain intensity was significant for the factor *Time* ($F_{1,23}$ = 5.513, P = 0.028); VAS intensity ratings were higher after picture viewing. Though picture viewing did not change VAS ratings for unpleasantness. The between subject factor gender was also not significant (intensity: $F_{1,23}$ = 0.4276; P = 0.520; unpleasantness: $F_{1,23}$ = 0.076; P = 0.786).

9.2.2 Risk premium

Correlation of SAM-ratings with RALT

The nonparametric Spearman Rank correlation revealed a significant negative correlations between the increase of SAM-intensity scores of positive pictures and different RALT measures (Q5_50: ρ = -0.434, P = 0.024. R^2 = 0.3482; Q5_75: ρ = -0.403, P = 0.037. R^2 = 0.3996; Q10_25 ρ = -0.393, P = 0.043. R^2 = 0.2229; Q10_50: ρ = - 0.416, P = 0.031. R^2 = 0.367; Figure 31). No such correlations for pain tolerance were found during negative picture viewing and SAM-intensity ratings of positive pictures (ρ = 0.262, P = 0.261. R^2 = 0.0354).

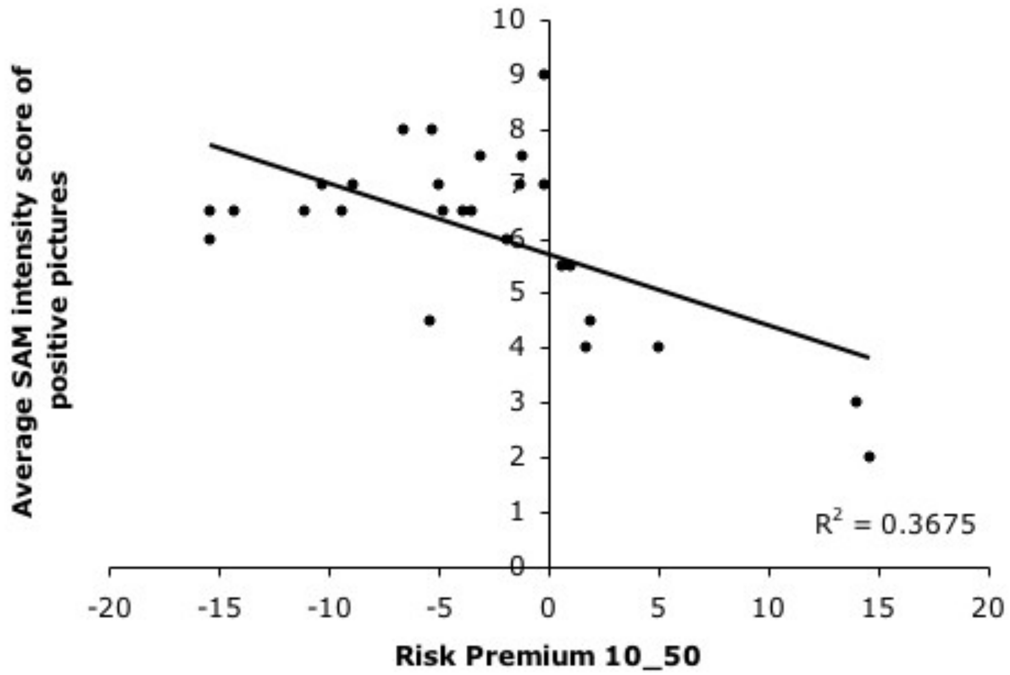


Figure 31 Example for the highest of several significant correlations of SAM-intensity scores of positive pictures with RALT risk premium of participants at Q10_50 (10% whining probability at the indifference point.

Correlation of self assessed hero identity with RALT. Spearman Rank correlations showed a significant positive correlation between the adaptation of a hero role-identity during negative picture viewing and RALT measures at Q 95_25: ρ = -0.459*, P = 0.042, R2 = 0.21)

Generalized linear model

We fitted several models and chose o model that was simple and explained as much of the variance as possible (see Chapter 7.3.1). Table 11 depicts the analysis of deviance of the generalized linear model. The interaction of SEX and risk premium had the biggest influence, followed by the factors probability of chance in option A and the condition (neutral, positive or negative). Table 12 shows the parameter estimates for the generalized linear model.

Table 11 Analysis of deviance of the generalized linear model [3]. Deviance is a metric for statistical dispersion, based on log-likelihood theory.

	Df	**Deviance Resid.**	**Df**	**Resid. Dev**
NULL			4800	6654.2
Probab	1	538.2	4799	6116.0
factor(SEX):premium	2	1840.6	4797	4275.4
factor(SEX):COND1:I(acc_time^e)	6	456.3	4791	3819.1

Table 12 Parameter estimates for the generalized linear model [3].

	Estimate	**Std. Error**	**z value**	**Pr(>|z|)**
Probab	-4.027445	0.164819	-24.436	< 2e-16
factor(SEX)0:premium	0.164499	0.008878	18.528	< 2e-16
factor(SEX)1:premium	0.263684	0.010891	24.211	< 2e-16
factor(SEX)0:COND1neg:I(acc_time^e)	0.696310	0.092830	7.501 6	34e-14
factor(SEX)1:COND1neg:I(acc_time^e)	1.278501	0.106219	12.037	< 2e-16
factor(SEX)0:COND1neut:I(acc_time^e)	0.634581	0.076033	8.346	< 2e-16
factor(SEX)1:COND1neut:I(acc_time^e)	1.547873	0.090068	17.186	< 2e-16
factor(SEX)0:COND1pos:I(acc_time^e)	0.660294	0.093685	7.048	1.81e-12
factor(SEX)1:COND1pos:I(acc_time^e)	1.618673	0.107825	15.012	< 2e-16

Concerning men, the generalized model of behaviour revealed a significant effect of negative picture viewing on risk-behaviour in RALT (Figure 32) during the first few decisions. For men, negative picture viewing leads to risk-averse behaviour in comparison to control condition. Moreover, concerning men, positive picture viewing leads to slightly more risk prone behaviour than during control condition. When all 50 decisions were taken into account we observed a tendency of negative picture viewing leading to risk-averse behaviour in all participants.

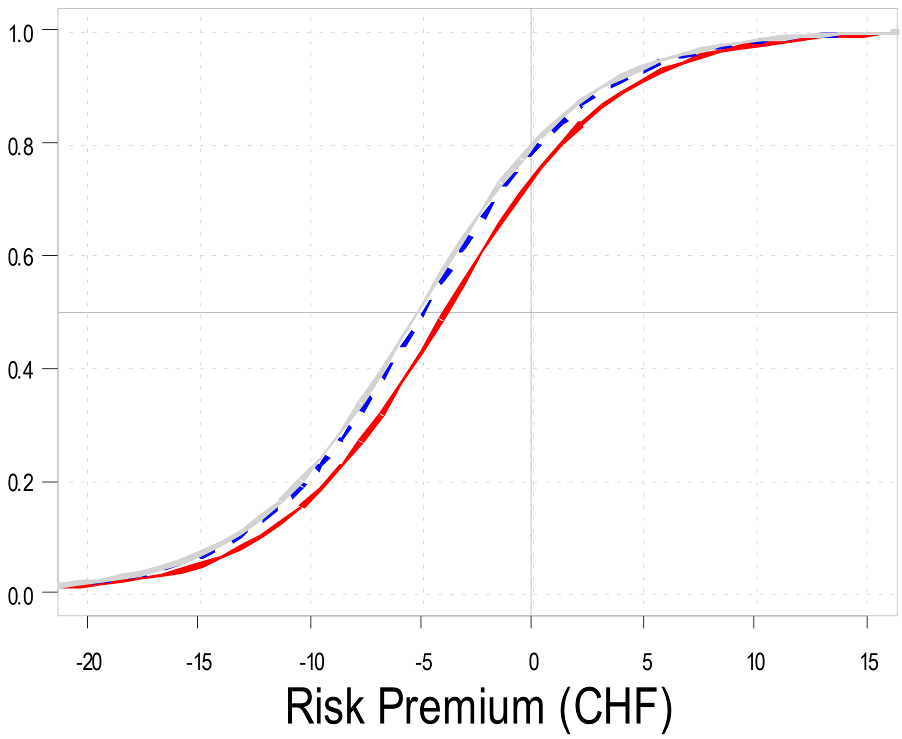


Figure 32 Effect of emotional stimulation on risk behaviour of men. Generalized model of behaviour during negative (red), neutral (blue), and negative (grey) condition. X-Axis: Risk Premium (RP) in Swiss Francs, Y-Axis: Probability of risky choice.

9.2.3 Mood

SAM scale on emotional state after picture viewing

The ANOVA for the SAM-ratings of emotional *intensity* after IASP picture viewing was significant for the factor *Valence of Pictures* ($F_{1,25}$ = 4.857, P = 0.038); negative pictures were rated as more intense than positive pictures.

The ANOVA for the SAM-ratings of emotional *valence* of the IASP pictures was significant for the factor *Valence of Pictures* ($F_{1,25}$ = 213.262, P = 0.000), this means that negative pictures of IASP were rated as significantly more negative in valence than positive pictures. Moreover, they were significant for the factor *Task* ($F_{1,25}$ = 7.663, P = 0.011), so that those pictures presented during risk blocks (i.e. between two risk tasks) were more negatively rated than pictures presented during pain blocks.

Furthermore, the ANOVA for the SAM-ratings of emotional valence of the IASP pictures was significant for the interaction *Task*Gender* (F = 4.310, P = 0.049). Post-hoc paired samples t-test and independent samples t-test did not survive Bonferroni correction yet they revealed a trend for women giving lower ratings after risk- than after pain blocks (women: pain - risk t = 2.823, P = 0.015) and lower ratings after risk blocks in comparison to men (risk women - risk men t = -2.184, P= 0.039).

Freely chosen words

Freely chosen words at the end of the positive and the negative condition indicated the emotional state of participants. In the positive condition, 94% of the adjectives were “Appropriate” to emotions present in a situation with appetitive and approach stimuli; whereas 2% were “Antonyms” and 4% were “Strange” adjectives. In the negative condition 98% of the adjectives were “Appropriate” present in a situation evoking defensive behaviour, whereas 2% were “Antonyms” and 0% were “Strange” adjectives. All synonym groups were represented by one of their synonyms that were found to have a number with valence and arousal scores in the ANEW-catalogue. The “Appropriate” synonyms were congruent with high-valence-high-arousal words, in the case of a positive condition, and with low-valence-high-arousal words, in the case of negative condition. [ANEW-numbers for the words representing the synonyms named by volunteers after the positive condition and its percentage of appearances, considering all 54 adjectives pertaining to this identity condition: 24 = aroused (20%), 48 = bored (2%), 135 = easygoing (4%),173 = freedom (6%), 200 = happy (37%), 221 = hungry (2%), 261 = lonely (2%), 323 = power (2%), 350 = relaxed (9%), 483 = warmth (2%), 630 = adventure (3%), 766 = good (11%). ANEW-numbers for the words representing the synonyms named by volunteers after the negative condition and its percentage of appearances, considering all 61 adjectives pertaining to this condition: 9 = aggressive (3%), 18 = angry (11%), 24 = aroused (3%), 124 = disgust (18%), 368 = sad (13%), 592 = fear (28%), 654 = beautiful (2%), 741 = evil (8%), 940 = pity (13%).]

Questionnaires on mood (MDBF)

The ANOVA for MDBF subscales RU (calm/nervous) was significant for the Factor *Time* (RU: $F_{1,25} = 884.535$, P = 0.000); RU ratings were higher at the end of the experiment. Accordingly, the ANOVA for MDBF subscales GS (good/bad) was significant for the Factor *Time* ($F_{1,25} = 101.828$, P = 0.000); GS ratings were higher at the end of the experiment as well. In contrast, the MDBF subscale WM (awake/tired) was not significant for the factor time ($F_{1,25} =$ 1.881. P = 0.182).

Moreover, GS subscale was significant for the factor *Valence of Block*Gender* ($F_{1,25} = 6.870$, P = 0.015). Nevertheless, post-hoc paired samples t-test (women: GS positive vs. GS negative: t = 2.799, P = 0.016) and independent samples t-tests (GS positive women vs. Gs positive men: t = 2.372, P = 0.026) did not survive Bonferroni correction but revealed a trend, of women giving higher GS scores at the end of the positive blocks vs. control condition and also higher than males' after the positive blocks.

The WM (awake/tired) subscale of MDBF was also significant for the interaction *Valence of Block*Gender* ($F_{1,25} = 5.390$, P = 0.029). Independent samples t-tests revealed that women gave significantly lower ratings after the negative block than men (t = -2.740, P = 0.011), Conversely, post-hoc paired samples t-test were showing a trend for women giving insignificantly lower ratings after the negative than after the positive block (women: positive vs. negative: t = 2.444, P = 0.031).

In contrast, the RU subscale was not significant for the interaction *Valence of Block*Gender*.

Conversely, the between subject factor *gender* showed that women gave higher calmness ratings than men ($F_{1,25} = 4.427$, P = 0.046).

9.3 Discussion

Our goal was to evaluate the effect of emotions on decisions under risk that promote the two opposite functional goals of defence and approach behaviour. So far, only few studies analyzed the effects of emotions on risk premium of lotteries (Mittal and Ross 1998; Nygren 1998; Fessler 2004). Moreover, there have been no experimental assessments of the effect of affective pictures on risk-behaviour in financial decisions within a risk context. Besides, risk behaviour has not been analyzed by means of a risk tool consistent with all the basic principles of experimental design (Montgomery 1996).

Our results show that negative picture viewing increased risk-averse behaviour in comparison to control conditions, especially in men. Moreover, positive picture viewing slightly increased risk-proneness in men. Besides, high arousal after erotic picture viewing correlated with risk-prone behaviour in RALT. Freely chosen words at the end of each picture viewing condition indirectly assessed which emotions were induced. We assume that pictures evoked different emotions, as all stimuli were described by synonyms of different emotions.

Our results indicate that negative picture viewing increased risk-averse behaviour in comparison to control conditions, especially in men. For negative picture viewing, 28 % of the used synonyms corresponded to fear, 18% corresponded to disgust and 13% of the synonyms corresponded do sadness. In congruence with our results, *anxious* and *sad* individuals (Lerner and Keltner 2001), and *disgusted* women (Fessler 2004) emerged as risk-averse. Moreover negative aroused feelings associated with an anticipation of loss (e.g. anxiety) turned out to activate anterior insula and to promote defence behaviour and risk aversion. In contrast to these and our results sad individuals have been shown to be risk prone in uncertain decisions under risk (Raghunathan and Pham 1999). However also 11% of synonyms expressing anger have shown to prime risk proneness in men, which was not the case in this study (Fessler 2004).

Positive picture viewing slightly increased risk-proneness only in men. Besides, SAM-intensity ratings for positive pictures revealed that participants with higher arousal ratings were more risk-prone at low winning probabilities on RALT, as compared to those participants giving low ratings for the same pictures. We hypothesize that the baseline of volunteers RP at low winning probabilities differs, and can be predicted to a certain degree by the SAM-intensity of positive picture ratings, at least under the present conditions. We suggest to analyze this effect in future studies. For positive picture viewing 37% of synonyms corresponded to being happy, 20% to being aroused and 11% to feeling good. In congruence with our results, Knutson et al. propose in their *anticipatory* model of affect that positive aroused feelings associated with anticipation of gain (e.g. excitement) activate nucleus accumbens and anterior insula and promote approach and risk taking behaviour. Authors state that casinos surround their guests with reward cues in order to prime risk-prone behaviour while a reverse priming is used by insurance companies (Kuhnen and Knutson 2005). Knutson et al. observed that erotic picture viewing increased risk-taking in an uncertainty task in men and was mediated by the nucleus accumbens (Knutson, Wimmer et al. 2008). As Knutson et al. repeated picture viewing and gambling task several times it is probable that not only anticipated but also active emotions were at work in their experimental design. Similarly, Isen et al. observed that people under positive affect display risk- proneness in a low-risk situation (Isen, Nygren et al. 1988). In congruence with Knutson et al., Kuhen et al. identified neural circuits in men and women linked to anticipatory emotions that may promote different types of financial choices. The authors infer that activation of the nucleus accumbens or the anterior insula predicts a shift in risk preference towards gain or loss. Recent findings provide the first direct evidence for the role of dopamine in the modulation of subjective hedonic expectations in humans (Sharot and Shiner 2009). In contrast to our results, positive mood resulted in risk aversion in lotteries in a study conducted by Mittal et al. (Mittal and Ross 1998)

Like others (Schubert 1999; Fehr-Duda 2006), our results show that *women* were more risk-averse than men during all winning probabilities. Moreover emotion induction had no significant effect on women, though results reveal a trend for risk aversion after negative picture viewing. Women are reported to be more sensitive to negative stimuli (Rhudy and Williams 2005) and less sensitive to erotic stimuli. Probably this was also the case for our female participants. It is possible that due to the stronger intra-individual variation of risk behaviour of women the effect of emotion induction was not significant: women used a wider interval for their preference switch from the sure to the risky choice and preferred smaller certain payoffs than men. More precisely, switching from the sure choice (probability of risky choice equals zero) to the risky choice (probability of risky choice equals one) occurred in a larger interval for women (Discussion see Chapter 6). This indicates that women expect double reward in the risky option in order to choose it and that their behaviour is less predictive.

In part of the present work, the effects of antithetic pictures and their associated emotions on both, subjectively and objectively assessed pain perception has been studied. To our knowledge, this is the first attempt to assess the effects of IAPS picture viewing on heat pain tolerance and threshold. After both, positive and negative pictures, volunteers tolerated more heat, showed higher heat pain thresholds, and gave these stimuli higher pain intensity ratings. Nevertheless, sensory, affective, NWC-scores of MPQ and VAS pain unpleasantness ratings were not altered. Moreover, control conditions did not alter pain perception. These results were gender independent for pain thresholds and tolerances though overall, women had lower pain tolerances. In our study, we included only volunteers regarding themselves as empathetic, as being able to be strongly moved by pictures. Therefore, we presume that picture viewing had a strong emotional effect upon them. The *valence-by-arousal interaction* of pain and emotion (Meagher 2001) suggests that the effect of emotions with negative valence depends on the levels of arousal of volunteers. When a critical arousal level is achieved stressors can induce analgesia (Flor and Grusser 1999). On the other hand, positive emotions always inhibit pain, as long as a minimal arousal is obtained. Exactly this results' constellation was the one we observed.

We found that, after *positive and negative* IAPS pictures, volunteers tolerated more heat and had higher pain thresholds than in the control condition. Similarly, in previous work of this laboratory we showed that the adaptation to a positive hero-identity increased heat pain tolerance (Kut 2007). Along this line of results, mental arithmetic and noise led to stress induced analgesia with higher pain tolerance and threshold (Flor and Grusser 1999). Accordingly and right in another real-life domain, war veterans suffering from post-traumatic stress disorder (PTSD), who were re-exposed to a traumatic stimulus, demonstrated increased heat pain tolerance (Pitman, van der Kolk et al. 1990). Accordingly, fear (Rhudy and Meagher 2001) and noise stress (Rhudy, Grimes et al. 2004) increased heat pain thresholds. In contrast to these and our results and indicating lower arousal levels of the volunteers, the adaptation to a faint-heart identity decreased heat pain tolerance and threshold on the forearm (Kut 2007) and sad music decreased heat pain threshold (Wagner, Koschke et al. 2009). Thus, our results for pain tolerances appear to confirm that affective stimuli alter pain perception depending on their levels of arousal.

After both positive and negative picture viewing volunteers tolerated more heat and gave these stimuli higher pain intensity ratings, though sensory, affective, NWC-scores of MPQ and VAS pain unpleasantness ratings were not altered.

Results on subjective pain ratings differ depending on whether the authors use constant stimuli or changing stimuli (e.g. to measure thresholds and tolerances). Some authors have pointed out that pain ratings of heat pain threshold and tolerance should remain stable after stress induction provided that subjects use consistent criteria to indicate their pain threshold. They used VAS intensity and unpleasantness ratings that were unaltered by stress induction with a few exceptions (Rhudy et al. 2004; Rhudy and Meagher 2001). We infer that our subjects used consistent criteria to indicate pain threshold and tolerance as picture viewing modulated only intensity ratings, whereas sensory, affective, and NWC components of pain and pain unpleasantness remained unaltered.

In line with our results concerning *negative* conditioning, Rhudy et al. observed stress analgesia induced by loud noise or electrical shocks that increased radiant heat tolerance and threshold but mostly did not alter pain ratings (Rhudy and Meagher 2001; Rhudy, Grimes et al. 2004). However, authors that observed hyper- and not analgesia after the induction of negative emotions, give reports of amplified subjective perception of heat pain (Wunsch, Philippot et al. 2003; Kut 2007) (Villemure, Slotnick et al. 2003; Loggia, Mogil et al. 2008). Concerning positive conditioning and in line with our results the adaptation to a hero-identity increased pain tolerance along with pain intensity ratings, while other pain scores remained unaltered, implying a damped pain perception (Kut 2007).

Several authors analyzed the effects of IAPS on perception of other painful stimuli like for example *cold pressor pain* (Meagher 2001), *electro dermal stimulation* (Rhudy, Williams et al. 2005; Rhudy, Williams et al. 2006) and *pressure pain* (Arnold, Alpers et al. 2008). These results support the motivational priming hypothesis, though some authors reported only part of the expected effects of positive (Meagher 2001) or negative (Kenntner-Mabiala, Andreatta et al. 2008) pictures. These studies revealed a decrease of pain perception during and after positive picture viewing, and hyperalgesia during and after negative picture viewing. Therefore, they suggest that the critical arousal level necessary to trigger stress-induced analgesia was probably not achieved.

During pain measurements, volunteers were blindfolded and asked to focus their *attention* on pain perception. Attention can influence emotional components of pain perception (Bantick et al., 2002; Villemure and Bushnell, 2002). Negative emotions can increase pain directed attention (Rainville et al., 2005), and emotional salience of stimuli facilitates attention (Phelps, 2006). Highly demanding tasks might distract attention from pain causing lower subjective intensity values (Veldhuijzen et al., 2006). If the picture condition had a higher cognitive load capturing more attention, a pain stimulus would then be less of a distraction, resulting in higher tolerance values. Moreover, intensity ratings have been found to be higher with the attention focused on the pain and lower with attention focused on the pictures (Kenntner-Mabiala, Andreatta et al. 2008). Interestingly, we observed a significant increase and not a decrease of pain intensity ratings after picture viewing. Therefore we infer that the effect of antithetic pictures was not a mere result of attention.

The effect of affective pictures and their emotional dimensions “arousal” and “valence” was assessed directly after picture viewing with SAM-scores. In agreement with previous reports (Lang and Bradley 1997), SAM-valence ratings were high for positive-, and low for negative pictures. In contrast to predictions of Lang et al., SAM-intensity ratings were higher for negative pictures though pictures had the same IAPS-average arousal rating. Participants described themselves as sensitive to emotional pictures. It is possible and even likely that this was especially true for negative pictures. Besides, pictures shown during runs containing risk measurements had lower valence than pictures shown during runs containing pain measurements. Interestingly, there was a trend for women giving even lower SAM-valence scores for pictures after the risk blocks as men did. SAM-ratings of pictures were given not directly after picture viewing but a bit later, after pain measurement or RALT. Possibly, pictures were perceived as more positive in valence after a subjective pain experiences. Alternatively, it might be that though standard ratings of pictures shown in risk and pain blocks were equivalent, our participants experienced the pictures shown in the risk block as having a higher valence.

We wanted to evaluate the effects of two opposite functional goals, defence and approach behaviour. We assume that the pictures we used evoked different emotions. It is probable that this pictorial material induced at least a minimal level of arousal thus activating the appetitive or approach system (positive pictures) and the emotional defence system (negative pictures). We used freely chosen words at the end of each condition to indirectly assess which kind of emotions were induced. All synonyms of volunteers had valence and arousal scores in the ANEW-catalogue and were congruent with two antithetic emotional states: a high-valence-high-arousal state in the case of a positive conditioning, and a low-valence-high-arousal state in the case of negative conditioning. Viewing erotic and team sport scenes was accompanied by 96% words that can be described as being appropriate to an appetitive or approach situation: 37% of synonyms corresponded to being happy, 20% to being aroused and 11% to feeling good. Similarly, viewing pictures of injuries, human catastrophes and attack scenes was accompanied by 98% words that can be described as being appropriate to a defence situation: 27% of synonyms corresponded to fear, 13% to sadness and 11% to anger whereas 18% corresponded to disgust. Seemingly, IAPS pictures induced associated emotions, and this may have altered pain perception and risk behaviour.

At the very beginning of the experiment, volunteers gave lower calmness (RU) and mood (GB) ratings compared to the beginning of the much shorter second part of the experiment. After the first part of the experiment, thermodes for pain measurement were removed, and volunteers knew that the experiment would soon be over. It is possible that the mood of participants was enhanced. In general and compared to men, alertness ratings of women were significantly lower throughout the first part of the experiment. In addition, their calmness ratings were higher at the end of both negative blocks. Taken together, these results indicate that women were more tired during the full length of the experiment, remaining calmer than men after the two negative blocks. This result is surprising, since women have been reported to be more sensitive to negative emotions (Rhudy and Williams 2005) and to show higher endocrine stress levels (Kirschbaum, Kudielka et al. 1999; Nater, Abbruzzese et al. 2006). It is possible that the heterogeneous gender dissociations seen across studies, including those of our laboratory have been also the result of differences in methodology, the interaction of stress stimuli with the cognitive setting, or even both.

Conclusion

In line with previous research on IAPS, manipulation checks confirmed that the targeted positive and negative affective states were achieved. Positive and negative picture viewing increased sAA-levels, which appear to be a good index of arousal (see Chapter 7).

To our knowledge this is the first study to analyze the effect of active emotions on risk-behaviour by using a risk-task consistent with all basic principles of experimental design (Montgomery 1996). Moreover, as far as we know, the effect of affective and antithetic pictures on lotteries involving risk has not been analyzed so far. Our results are in line with other results obtained through methods of emotion-induction and risk measurement and indicate that negative stimuli increase risk-aversion in men, whereas positive stimuli increase risk-proneness during winning lotteries.

To the best of our knowledge, only one study by Wunsch et al. analyzed the effect of IAPS-pictures on subjective pain ratings (Wunsch, Philippot et al. 2003) but their effect on heat-pain tolerance and threshold has not been assessed so far. Our results on the effect of negative picture viewing on pain perception are in line with those of others observing stress-analgesia during such kind of stimuli (Pitman, van der Kolk et al. 1990; Rhudy and Meagher 2001; Rhudy, Grimes et al. 2004). Moreover, the observed inhibition of pain after positive emotion-induction is in congruence to our previous study (Kut 2007). As far as we know, only the latter study analyzed the effect of positive emotion-induction on heat pain threshold yet without any significant effects (Kut 2007).

9.4 On the emotional appraisal of risk

"Though the modern world differs profoundly from ancestral environments, there is no presumption that emotions currently enhance biological fitness—just as today our evolved preferences for fat and sugar lead to health problems despite having functioned effectively in an environment of caloric scarcity, so too may our emotions now often lead to fitness-reducing, rather than fitness-enhancing, outcomes." (Fessler 2004)

Do emotions help to decide properly; are they strategies of maximum ruin avoidance? Our study shows that positive emotional states prime risk taking whereas negative emotional states prime risk aversion in financial decisions. Our results are in congruence with observations in neuroscience by scientists like Knutson et al., but also with strategies used in casinos and insurance (Kuhnen and Knutson 2005). Casinos surround their guests with reward cues in order to prime risk-prone behaviours while insurance companies use reverse priming (see Chapter 9).

However it has been shown that in life threatening situations, constantly negative situations individual decision makers switch from risk-averse to risk-prone behaviour, and vice versa, the so-called "strategy of maximum ruin avoidance" (Müller-Herold 2000): Animal ecology and economic anthropology share a concern on how individuals make their living, allocate resources and deal with uncertainties. Review-research on birds and pastoralist nomads identifies behaviour strategies whose objective may be to maximize long-term survival, so that shortage of a determined resource does not lead to extinction. Individual decision makers react to chances depending on circumstances: They switch from risk-averse to risk-prone behaviour if things look bad, and vice versa, the so-called "strategy of maximum ruin avoidance" (Müller-Herold 2000). Such economies like those of hunters and gatherers, nomads and peasants do not only minimize but also accept a calculated risk. Two examples of natural risk investigations are *birds' decision models of feeding* and *pastoralist nomads*.

- One of the major breakthroughs in the investigation of natural risks was the observation that feeding animals are risk sensitive. In a celebrated paper, Thomas Caraco showed that small birds are not risk-indifferent but exhibit risk-avoidance when they expect to receive as much food as they need to survive the next night. However, the same animals exhibit risk preference when they are fed so little that they could not expect to survive the next night. In the experimental situation, the animal could obtain food in two alternative ways: by 1) a risky alternative that provides $m+d$ or $m-d$ units of food, and 2) a certain alternative that provides m units of food. This experimental setting has been called the "expected-energy-budget-rule": if the if expected daily energy budged is positive, avoid risk; but if the expected energy budged is negative, prefer risk in order to minimize energetic ruin (Caraco 1980).

- In a careful quantitative study, Ruth Mace observed the strategies for long-term household survival in the Gabra, a Cushitic, pastoralist-group in north Kenya. Rainfall is too low to support agriculture, the major threat for herding being drought. Herders' wealth depends on number of offspring. Breeding females demands much water transforming into a risk factor for herds' survival. Poor and wealthy households adopt different behaviours to maximize their long-term survival. Owners of large sheep herds are risk aversive and prefer a small short-term gain by actively reducing the number of breeding females by breeding-control practices. Most in contrast, herders with very small numbers of sheep, facing a loss of the last animals choose unrestricted reproduction (Mace 1993).

10 Synthesis and Outlook

The results of this thesis can also be seen under broader, more disputable aspects. The synthesis presents our results regarding *five major points* that seem important to me: 1) reproduction and 2) induction of emotions, 3) biological sex, 4) role identities and 5) the limits of reproducibility of human behaviour. They offer a new perspective, point out connections between the subprojects and can be read independently. This general discussion is based on several essays, magazine articles and interviews I was able to publish during my PhD.

Emotional states are *reproducible*, transferable between individuals and are not purely subjective as can be seen in our newly developed method of emotion induction, the role-play strategies (ARD 2008; Folkers and Wittwer 2006; Wittwer 2009; Wittwer 2007; Radiovorarlberg 2007).

Moreover *biological sex* and *role-identity* have an effect on behaviour, as on average women are more risk averse with pain and in financial decisions. We suggest that traditionally male gender roles like hero identities can mainly be of advantage in states of acute pain, though in financial decision they prime risk taking. High social appraisal of risky decisions is discussed as an important cause for wrong decisions and the settings that caused disasters like the financial crisis. We presume that there is a need for men and women with „mixed skills“ for many positions, including an ability to accept criticism and a less aggressive, more empathic and loyal guidance. Further research is required with respect to this point (SF1 2009; Wittwer 2009; Wittwer 2009).

Our results indicate that the study of the *limits of reproducibility*, the instability in human behaviour under risk and pain is of interest, as there is scope for the improvement of behaviour (Wittwer 2008). Ongoing research in this matter could help to integrate social sciences and natural sciences and improve economic and physiological concepts.

10.1 The transfer and the measurement of emotional states

10.1.1 The feline nightmare

For millions of years a noise in the darkness indicated feline man-eaters. Emotional states are *action tendencies* that prime behaviour in a very efficient way in order to survive in difficult situations, when there is no time to consider whether it is wrong or right to run. In this thesis, in appreciation of William James and Baruch de Spinoza, emotions are understood as a psycho-physiological process. They are triggered by a certain stimulus, e.g. by noise in the darkness, and lead to a change of the physiological state – cold hands, wide-open eyes, fast heartbeat and sweating. This change of physiology undergoes an appraisal and leads to specific behaviour, to run away or to fight. Often this process is accompanied by a subjective change of feelings, e.g. to fear, though emotions are not always conscious, sometimes we are not aware of them. We inherited our emotions, our maximum ruin avoidance strategies, as they reflect neuro-genetic memory, they are the product of a Darwinian evolution. It is assumed that they developed from primitive, reflexive reactions to appetitive or aversive stimuli that facilitated survival. Still we can influence emotions by training.

10.1.2 The subjective bat and the subjective bug

However, emotions are regarded as something inherently *subjective* and *individual*. To sense the fear of the other, one would have to be in his shoes. His fear cannot be measured or understood, as it is not objective. We know from the famous essay "Wie ist es eine Fledermaus zu sein?" (Nagel 1974) that it is impossible to feel like a bat, to consciously act like bat, and especially to share the experience of a bat. As the states of a bat will very probably be different from ours, they will be strange to us. Hence the situation of an internal observer with his own experience, the bat, and an external observer, a human researcher, with his measurements and interpretation of a bat's experience, might not match. Similarly Wittgenstein compares his own pain to a bug in a secret box, a thing, and a nothing. Everybody is talking about pain but everybody only knows his own bug in the box.

Our reality builds up from perception and interpretation. What happens when we see an insect? In contrast to the vision of a tick that has a light sensitive exoskeleton, human vision is the double interaction of light with an object, e.g. a bug, and of the reflected light within our eyes. Photons of a wavelength between 380 and 760 nm cause a change of conformation in photoreceptors of our retina and change their activity by a change of the conformational state of the molecule rhodopsin. This optic perception of data points is only one third of the information; a process called *back processing* inherently adds the other two thirds. So the questioning of the objectivity of our visual senses is legitimate.

Each human body as a chaotic system differs from the other, though it is genetically determined. Wine tastes differently after sucking a peppermint or accidentally having eaten a bug. So are there six and a half billion of individuals, each with his own, limited perception that is fundamentally different from his friend’s, neighbour’s, son’s or spouse’s? Do we not understand each other, because we are caught in the privacy of our own subjective states, incapable to translate them into appropriate signs or understand the signs of the others? So is the world around us and inside of us a mere construction, and if so, should we care? In everyday life we don't.

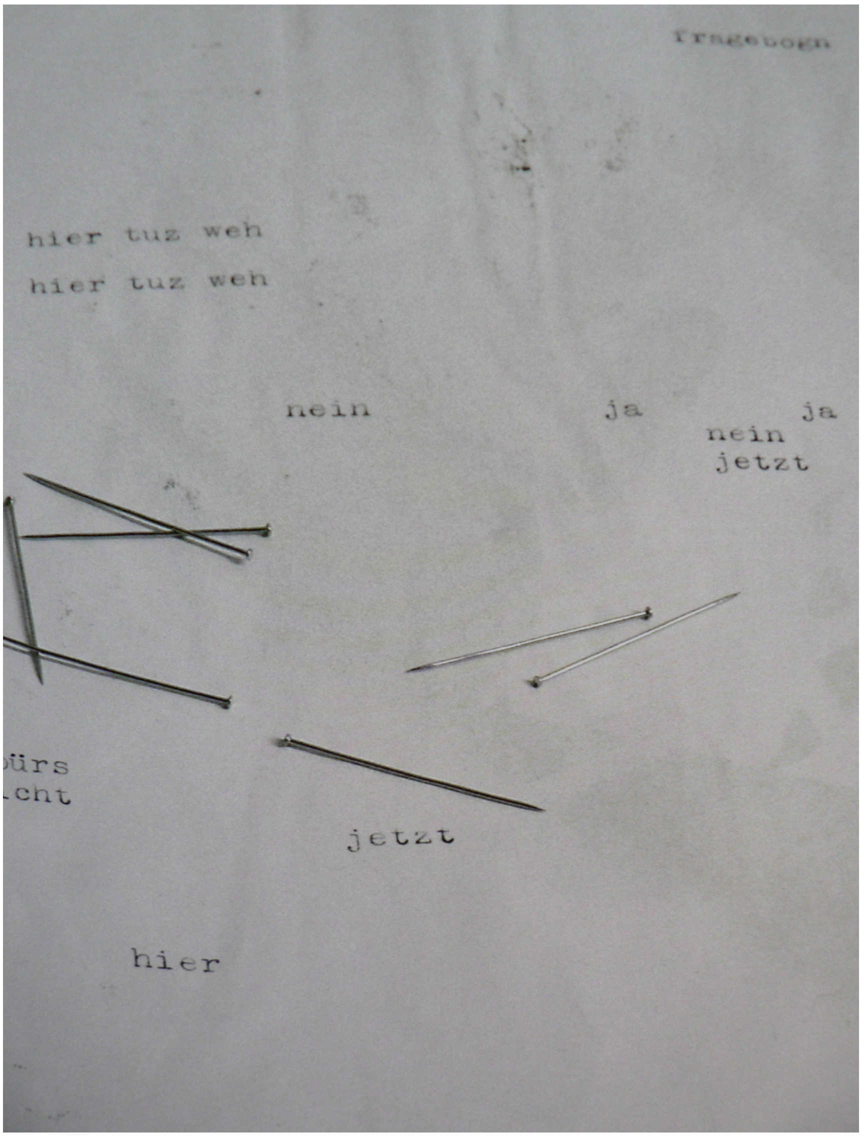


Figure 33 Is pain completely subjective or can we measure it? After intense discussions the artists Lutz & Guggisberg designed the “Fragebogn” (Das Schmerzphantom, 2008)

10.1.3 The reproducibility of emotional states

"*Esiste una enorme zona d`ombra in cui solo la letteratura e l' arti in genere possono penetrare*."

Javier Marías (Marías 2005)

Though subjective, mental and physical states can be shared. We hypothesize that literature, art and humanities allow this overlap. A change of mental states can lead to empirically observable effects as it is the case for the effect of role-identity or placebo on pain perception. We hypothesize that literature, arts and humanities are the media where the entanglement of internal and external properties is reflected: they allow persons A and B to share their inner worlds of experience. Artists are able to create physical representations of their inner experience, by a poem or a painting, as an expression that is both emotionally and cognitively shared by a larger number of people. Enjoying pieces of art and literature may serve as a proof to support this hypothesis. Reasons for difficulties in understanding might often be caused by scientific dialects or wilful establishment of differences in order to exert power.

Evolutionary processes suggest that the "processes of a cognitive rationality, which are so important for daily life and are an extremely costly part of life...", have a "functional role for the survival of an organism"(Searle 2005). It can be assumed that mental construction is accompanied by the ability of sharing emotions. Empathy and its benefit are reflected in the proverb: "Geteiltes Leid ist halbes Leid, geteilte Freud ist doppelte Freud." Studies recently published in Science by Tanja Singer show that empathy, the feeling of shared emotions is possible (Singer 2004). The firing of *mirror neurons* may be its neuro-physiological mechanism (Iacoboni and Dapretto 2006). The effect of a change of mental states can be empirically observed as it has been demonstrated e.g. for the *placebo effect (Wager 2004)* or as we have shown the effect of role-identity (see below) on pain perception. Hence the same set of emotions belongs to more than one person and emotions should not be personalized. From a pharmaceutical viewpoint, placebo therapy is a legitimate way to activate the bodily drug laboratory. *Placebo* includes all therapeutical interventions that are themselves physiologically inert but have positive physiological reaction. They strengthen processes of self-healing with pure context, like colour or shape of the drug, way of application or the therapeutical situation itself. 400 years B.C. Plato called the legitimate lie in medicine an ethical principle. Wagner et al. call the placebo effect an emotionally controlled cognitive process of recognition and intellectual anticipation of potentials (Wager 2004). (Folkers and Wittwer 2006)

10.1.4 How to visualize bodily and emotional states

What is a vision? «Vision» is derived from the "visio" (Latin, see, perceive) and stands for religious epiphanies and imaginations about the future. Before 1315 officially nothing was known about the anatomy and physiology of the human body. Everything known was deduced in analogy from animal anatomy, of dissections of goats and sheep. One reason for this was that in accordance with the doctrine of the church the human body belonged to god, the only difference with the animal being his soul. Autopsy carried out in renaissance revealed that it was wrong to assume that the inner structure of man corresponds to that of an earthworm. Mundius performed the first public and documented autopsy of a human in 1315 in Bologna, and published also a standard work on human anatomy. In the 19th century *endoscopes* were painfully introduced into orifices of the body, allowing the doctor a blurred view of it's functions. Almost a hundred years later, in 1895, Karl Roentgen discovered the X-rays, subsequently named after him. The fortitude of these rays, while permeating matter, was diminished, depending on the material. On photographical paper they show in white on black the form of bone and shoe. Immediately and specifically it was used to detect broken bones and the right shoe number, until about seven years later the correlation with skin cancer was identified and X-rays were used more carefully. 1957 saw the introduction of sonography, using the principle that sound outside of the interval of human hearing permeates water and sends back an echo when encountering a solid object. It is still claimed to be a completely harmless analytical method. Section, endoscopy and sonography only provide blurred visions of the human body's anatomy and function, short of information about it's actual emotional state. (Potter 2000)

In 1967 the engineer Godfrey Hounsfield developed the computer tomography (CT) for the company EMI. This method allows the combination of two to three dimensional pictures. Besides X-rays and sonography it is used with isotope and magnetic resonance tomography: radioactive elements are instable. When these decay, particles with high energy and or ionizing radiation are emitted. In a nuclear analysis (SPECT, PET) radioactive drugs distribute in the human body and show physiological processes. This method is especially effective for diagnostic purposes. The nuclear burden of one analysis is about the same as one year's natural exposure in Zurich. MRI uses the principle that protons in a magnetic field produce a tissue-dependent resonance. Functional MRI measures a correlation of neuronal activity and oxygen consumption. So far, no side effects are known.

Because modern imaging techniques like fMRI have their limitations, they were compared with phrenology and given the nickname "blobology": the measurement of voodoo correlations or artificial blobs (Vul and Harris 2008). Several limitations have been discussed: the temporal resolution is too slow for an observation in time. Besides, one cannot tell whether inhibiting or activating neurons are active in the process. In addition Feuillet et al. discovered that the correct anatomical design of a brain does not seem to be causal for a normal social living. Figure 34 depicts the MRI of a white-collar worker with a hydrocephalus, i.e. severely enlarged ventricles. (Feuillet, Dufour et al. 2007)

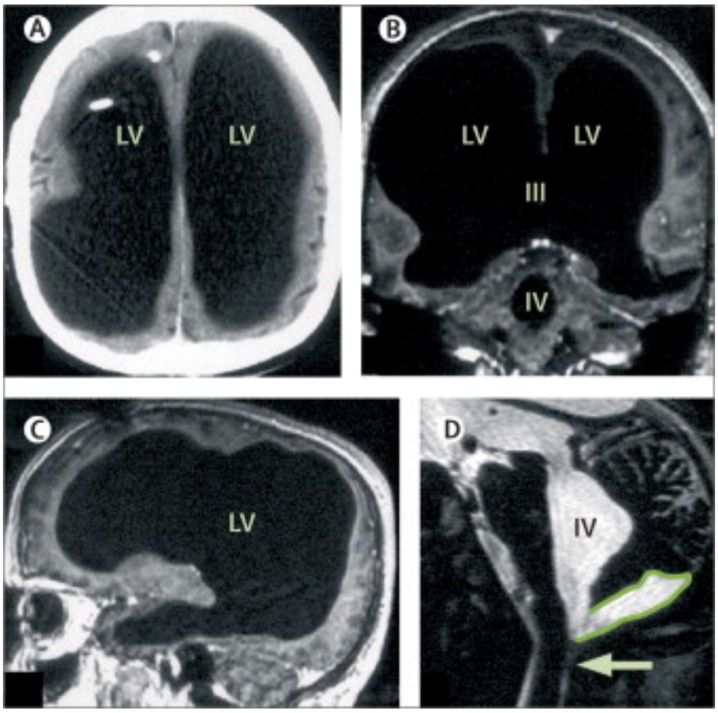


Figure 34 Massive ventricular enlargement in a patient with normal social functioning. V=lateral ventricle. III=third ventricle. IV=fourth ventricle. [i]

For our studies we decided not to use modern brain imaging techniques because to prove our hypothesis it was not necessary to depict brain activity. Only if we wanted to know more about the direct action mechanisms or the causal correlations of decision behaviour with specific brain areas, techniques like fMRI or TMS would have been needed. To measure the emotional states of our participants we recorded physiological data, as the activation of the emotional systems can be determined by arousal, the physiological activity in muscles and glands (Lang, Bradley et al. 1998) and their valence by self-report (Steyer, Schwenkmezger et al. 1997). We used the salivary enzyme *Alpha-amylase* (sAA) as a marker for the emotional dimension of stress (Nater and Rohleder 2009). Moreover we measured the participants' *skin conductance*, the electrical resistance of the skin depending on the amount of sweating, as it correlates with sympathetic activity and emotional arousal (Gomez and Danuser 2004; Kut, Schaffner et al. 2007). (Wittwer 2007)

10.2 The design of a new method of emotion induction

Since we agree that somehow emotions can be shared, these also can be specifically induced! At the outset of this thesis, our first challenge was to design a new method of emotion induction. To induce emotions, pictures, films, odours, music, mental, imagery, respiration and games are commonly used. So why did we feel the urge not to use an established method? This was due to the one and only basic requirement, which was to "analyze the effect of emotion on acute pain perception!" We, the PhD students, can only wonder about the visionary guidance; to find out what we knew the least about; about other motives we can only speculate. What is so interesting about pain and its emotional regulation to employ PhD students, besides the fact that we know little about it? Is this, because pain is rude to man, so individual that language fails to describe it properly, resists therapy and is something we all will encounter, sooner or later?

10.2.1 Why study the effect of emotion on pain?

"Divinum est sedere dolorem." Galen

As pharmacists, our natural goal in the study of pain was to relieve pain sensation, not to worsen it. Here the affective modulation of pain offers one big potential of relief. As a beginning, let us face three essential hypotheses on pain and emotion: (1) pain is not good; (2) pain is a negative emotion; and (3) emotions modulate pain. It is a fact that ignorance toward these three points has caused evitable pain. Still pain has a negative effect on lives of millions of people worldwide (Melzack 2008).

- Still a surprisingly great number of people in my surroundings think that pain medicine is "bad". Their statements concerning pain medication resemble the Cartesian view prevalent until about 150 years ago that pain is caused by god, thereby ennobling and improving mankind. Aspirin and co are for "pussies and half boiled eggs that take warm showers". The reality is much different, as acute states of pain not adequately treated can take a turn into chronic pain that has no physiological reason and that resists traditional pain therapy. So to relieve acute pain and prevent chronic pain, get advice of your pharmacist and take a pill. Paracetamol 500 mg can do no harm.
- One interesting thing about pain is that pain experts do not any more differentiate between the pain of a sore throat and that of a broken heart. Both can be described by a burning, stinging, tearing sensation, both are real states of pain. – Even in the official definition of the International Pain Society, pain is defined by an uncomfortable sensation that is

accompanied by tissue damage or can be described with words describing such damage (see also Chapter 2). Brain imaging studies support this hypothesis as negative feelings result in physiological activity in the pain matrix of the brain (Becerra, Breiter et al. 2001; Eisenberger, Lieberman et al. 2003; Singer, Seymour et al. 2004; Vogt 2005). This entanglement of acute pain and negative emotional states is especially important with pathological states of pain like chronic states of pain that cannot be cured by traditional pharmacotherapy.

- How does an acute state of pain originate, e.g. by a cut in the skin? Noxious stimuli on the skin cause inflammatory mediators to activate nociceptors, the receptors of pain sensation. Though nociception is not a one-way street conduction but a transport of electricity from nociceptors, over C and A fibres, and the spinal cord to the brain. Each stimulus is modulated on the level of the central nervous system e.g. by the sensory, affective and evaluative dimensions of the sensation (see Chapter 2). Here, at this point *affective modulation of pain* sets in, emotions influence the affective dimension of pain and this is one chance for cure. The direction to this effect can be predicted by a rule of thumb: arousing pleasant affective states reduce pain perception, whereas moderate unpleasant affective states exacerbate, strong negative affective states lead to analgesia (Meagher 2001). So next time you face the dentist, think about something nice or engage into real anger.

10.2.2 The essence of role identities in states of pain

There are two essentially different schools of acting, one established by Brecht, the other by Stanislavski. Brecht advised the actors not to experience emotions but just to act them, whereas the school of Stanislavski, nowadays dominant, lays the emphasis on empathy and real emotional states. As volunteers in our first study, we chose to select actors and role players, because they are used to change and adapt to new role-identities in a short time. Our first step was to find a way of emotion induction capable of inducing a specific role-identity. The self-perceived role-identity is the way of self-perception including e.g. body, talents, education, goals, and experiences. Literature on emotion induction indicates that games may be strong emotion inductors. So we searched role-play literature, but games like Dungeons&Dragons were not specific enough for our goals, as an empirical study requires each participant to be treated in the same way. Beyond that we found no role identities relevant to pain. Nevertheless a role player described the standard procedure to invent whole storylines and wrote some examples. The storylines involved a lot of fluorescent moss and dark corridors that seemed a little boring but gave an orientation what a role-play should be like. I was given the task to write our own role-play strategies, relevant to states of pain in a fantasy context involving heroes and faint-hearted princes (see Appendix).

So my question was: what do self-perceived role identities have in common that makes pain bearable?

- The martyr feels that his suffering is similar to the suffering of Christ. It is demanded by god and makes the maryr's religious belief stronger.
- Tibetan monks, also yamabushi in Japan, stand for hours under cold waterfalls in order to obliterate all bodily demands on the way to enlightenment.
- Victims of torture report that as soon as they accepted the pain and let themselves immerse in it, they were able to survive.
- The tortured Indians were not allowed to express their pain loudly; otherwise they would not be allowed to enter the eternal hunting grounds.
- The hero of real life. E.g. the "natural heroes" of Philipp Zimbardo (see 10.4.2).
- The fantasy hero. Heroes in the media like James Bond are often ego motivated sensation seekers. However they fight for mankind, their majesty and the Bond Girls.

All these roles have two factors in common, on one hand (1) *a strong character*, on the other hand (2) a *meaning* (in life) that gives pain a purpose though being uncomfortable. Accordingly, Victor Frankl, the inventor of Logotherapy said: "*Wer ein Warum zum Leben hat, erträgt fast jedes Wie."* Of course, one defines and searches for a meaningful self-perceived role-identity for a whole life. However, as a start and as a model, we aimed at showing the effect of a small, artificially induced identity.

10.2.3 The creation of a small, artificial role-identity

"Die Sprache ist das schärfste aller Schwerter".

Gerd Gigerenzer

As described above, the basic hypothesis for writing the role-plays was that known role identities facing bearable pain can all be characterized by a strong character who sees a point in pain, who has a meaning in life. The role-plays inducing such an identity would have to be reproducible and should induce the role-identity in a rather short time of about 10 minutes. As a blueprint, I used the commercial role-playing game DUNGEONS&DRAGONS, a fantasy strategy game with monsters and heroes from the 1970s. In these games, a narrator develops a fantasy world where the player and special rules determined the players' action. We hoped that the role players and actors could identify with a simplified role-play game with restricted scope of action.

I wrote four role-plays describing the two opposite roles hero/heroine and faint-heart for each gender, in order to improve role empathy of men and women (see Appendix). All role-plays had the same structure of a little drama. The identity of the main character whose identity should be adopted was characterized e.g.

by his body and his goal. The hero/heroine role-identity called for a winner image with strong personality and athletic build and the motivating task to save a princess. „*Dein Beil donnert gegen das Holz der Falltüre. Du spürst die Wucht des Schlages in jeder Faser deines Körpers. Du magst dieses Gefühl, du bist stark, du hast ein Ziel und wirst jedes Opfer bringen. Du wirst sie retten*“. In contrast, the faint-heart character was to personify a victim with a weak personality, and no task that motivated his/her suffering. „*Deine Nägel brechen, als du versuchst die Falltüre zu öffnen. Dein Herz klopft dir bis zum Hals, dein seidenes Gewand klebt am schweißgebadeten Körper. Ein Schluchzen entfährt dir.*“ Both roles started as robber-knights attacked a kingdom. While the faint-heart was threatened in his castle, the hero was on his way to liberate a princess. Both entered a fatal labyrinth. In contrast to the hero the faint-heart was violently forced into it, without any hope to escape. He resented his fate, and was plagued by fire, rats and vertigo. By contrast, in his search for the princess, the hero overcame these dangers. At six different moments, participants had to choose what to do or where to go within the labyrinth. However their choices did not affect the story. Both characters ended up facing a guardian, who unjustifiably punished the faint-heart and offered a deal to the hero: He was free to escape with the princess, provided he was willing to suffer for her. The volunteers received painful heat stimuli seconds after the main character of the story line suffered from pain. The pain test stimulus was incorporated in the hero and the faint-hearted condition alike. Most importantly, at this moment, the hero/heroine focused on the motivating task of saving the princess, while the faint-heart did not, thus experiencing emotionally unmotivated pain.

All story lines and the control text were spoken and recorded in a sound studio by a professional speaker, Rene Bill. Interestingly the role-play for the female faint-heart was an impossible challenge, even for a professional. It continued to sound like pulling one’s leg instead of inducing real sadness and tragic. After recording it several times I had to see it through with an audio processing software. By using many *fast breathes* and *breaks* I achieved the desired desperation.

10.2.4 The effect of the role-play strategies

Heroes suffer less

Language has been called the sharpest of all swords (G. Gigerenzer). Our results show that a mental state can be transmitted to another person by a literary text. This transmission is empirically observable by a change of pain tolerance and pain perception: a self-percieved role-identity of a strong character that gives a meaning to pain, increases pain tolerance and reduces suffering. Writing the role-play, I tried to catch specific emotions. Rene Bill, the professional actor and speaker put them into words. The volunteer willing to listen and to empathize will sense the emotion spreading over to him and observe how his pain is diminishing. Do these results have any implication? Are they important? From own experience we know how self-perceived role-identity allows us to tolerate pain more easily. For example, parents encourage their children to adopt a brave attitude and try to create a meaningful context in order to diminish unpleasantness during a painful medical intervention. This is the first empirical study depicting the effect of a change of role-identity on pain perception. This result is significant, as it indicates that a modulation of role identities in emotionally meaningful settings may complement traditional pain therapy. So far assistance of patients' role identities is not part of the education of medical personal, its cost is not covered by health insurance. However many nurses, pharmacists and doctors already try to assist patients by strengthening their role-identity and trying to prevent them from falling into victim roles, shedding tears and suffering, leading to give themselves up. A plausible setting would also be to apply the role-plays or similar radio plays in acute pain treatment of children. For future studies, Dr Kathi Thieme is planning to include the role-plays in an fMRI study on fibromyalgia patients.

10.3 The effect of biological sex and gender[10]: a hot topic

Why bother studying psychological and physiological differences of both sexes, one of the hottest topics in science? *In order to maximize equality of chances*. We suggest that a new idea of man would be desirable that respectfully takes into account differences.

The study of *genetically and hormonal causes* of physiological differences are of medicinal relevance to both men and even more to women in order to foster health. Still most drugs are only tested on men though the female body is significantly different – female hormones inhibit or override the reactions. As an example for psychological difference we observe *female sensitivity to negative emotions*. We suggest that it is one reason for psycho-physiological differences between both sexes. Above all other effects of biological sex, the empirical studies in this thesis observed *higher pain perception* and *higher risk aversion* in women. An observation of mechanisms could help decrease suffering and improve knowledge on decision behaviour. (Wittwer 2009)

[10] In this study we differentiate between biological sex and gender where sex indicates physiological characteristics that divide cases into male and female. Gender, however, connotes complex attributes that culture ascribes to each of the sexes and is socially constructed.

10.3.1 Basic physiological differences: sex chromosomes and hormones

Why make a physiological difference? What is the use of looking for physiological differences? What is the advantage of sexual reproduction by mating or self-fertilization in contrast to cloning? A male and female germ (Figure 35) melts to a zygote by a new combination of genes. This exchange of genetic material between two individuals allows the formation of highly variable, potentially beneficial combinations of genes. The best product survives stress and parasites and is selected to be dominant in the biotope. Experts suggest that the grand diversity of life on earth was possible because of sexual reproduction.

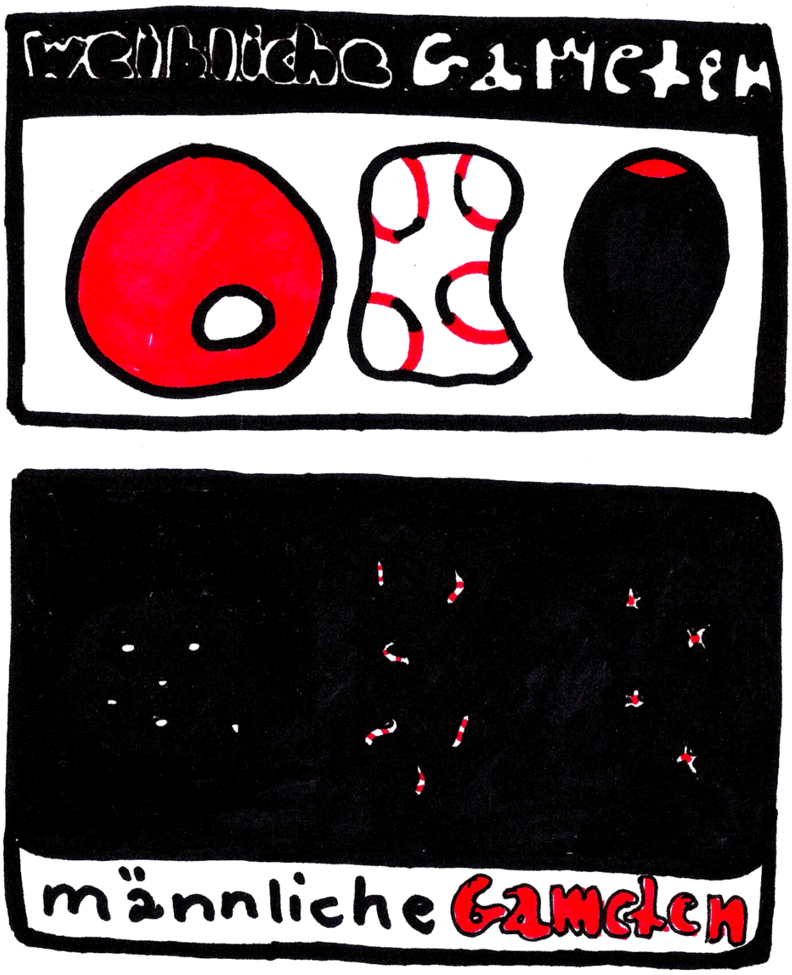


Figure 35 **The basic sexual difference.** Male and female germs differentiate in their size. The bigger germs are always female.

Several factors determine the sex of the descendant: age, temperature and the sex chromosomes. Until about 30° C the baby crocodile grows to be a female, from 34° C onwards, it surely will be a male. With turtles it's the other way round. In birds and insects the mother determines sex, by delivering a W- or Z-chromosome. What about mammals like men? If the male sperm holds a Y-chromosome, it will be a boy, if it holds an X-chromosome it will be a girl. As a consequence, female sex is in general not determined by the combination of the chromosomes but by the *size of the germs*: it always delivers the bigger germs that are fertilized by the smaller male germs. Each human cell holds 22 identical chromosome pairs, and one pair of sex chromosomes, in women two X, and in men an X and a Y-chromosome (Figure 36). As a consequence*, male and female cells differentiate*!

The genetic code on the chromosomes contains the information for the construction of proteins. The next step, from protein to living cell, is a topic of current research. However it seems proven that sex specific genetic expression and as a consequence also the sex hormones lead to sex differences and also to specific diseases.

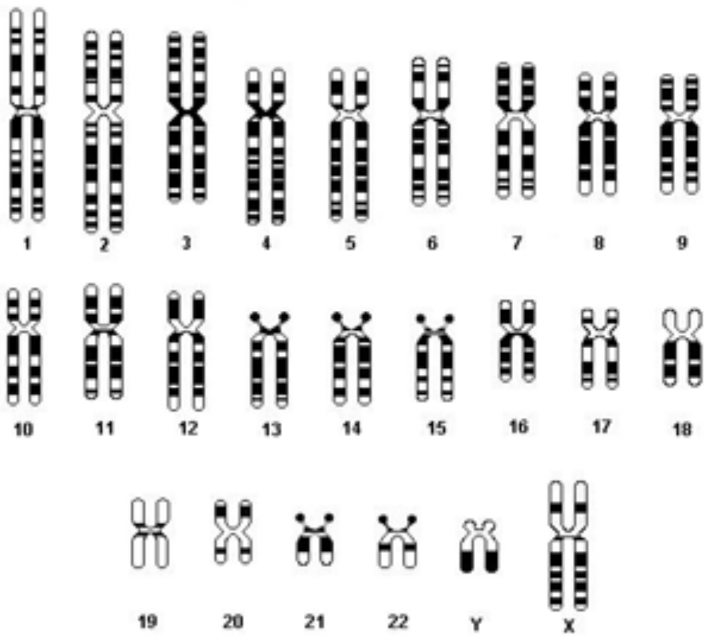


Figure 36 Chromosomes are the carriers of genetic information and cause all sex differences. The sex chromosomes Y and X that determine biological sex were discovered in 1905 by Nettie Stevens und Edmund Wilson with a microscope (Wilson 1911).[ii]

Broken or streamlined by evolution?

The Y-chromosome has been regressing since 300 million years, onto one third of the size and 5% length of the X-chromosome. At this time, the oldest known mammals called Morganucodontiden strolled over the earth (Gore 2003). 27 proteins are encoded, in comparison to 1500 proteins by the X-chromosome, with accumulated retroviral and inactive sequences. For the scientist Ian Craight, the Y-chromosome was “streamlined by evolution”, whereas for Germain Greer males are the product of a “broken” chromosome (Craig, Harper et al. 2004). A fact is that the genes on the Y-chromosome like SRY determine spermatogenesis and the development of the testicles (Hanley, Ball et al. 1999; Ostrer 2001).

However and surprisingly the X-chromosome is primarily responsible for sex differences (Skuse 2005; Davies, Isles et al. 2006) with the two factors *mosiacism* and *stronger female gene expression*: Mosaicism describes the fact that by chance one of the two X-chromosomes is expressed in each female cell to 80%, whereas the other is expressed to 20%. So both X chromosomes are equally active in women and protect them from mutation, whereas men have only one X-chromosome. As a consequence men are prone for more extreme gene variations ranging from giftedness to retardation.

The sex hormones oestrogen, gestagen and the androgens are active in both men and women. A sperm grows under high concentrations of estrogens, and women produce higher concentrations of androgens than of oestrogen in kidney and ovary (Burger 2002; Craft, Mogil et al. 2004). However sex differences stem from differences in hormone concentration, receptor distribution in special tissues, and the female variations of concentration before birth, due to puberty, menstrual cycle, pregnancy and menopause. The basic condition of a *foetus* is principally female: at an age of seven weeks the embryo swims with a milk line from upper arm to thigh in amniotic liquor. The standard condition of his brain is feminine (Arnold and Burgoyne 2004), the sexual organ is an undifferentiated gonad. Probably an androgen secretion in the tenth week from the Leydig cells on the testicles induces sexual dimorphism of human anatomy (McCarthy and Konkle 2005). Two further great testosterone secretions follow immediately after birth and one occurs during puberty (McIntyre 2006). High levels of androgens increase red blood cells, muscles, and with them performance, while they decrease the proportion of fat. High levels of oestrogen lead to female body, the accumulation of fat on buttock, breasts and lips and a stop of facial bone growth (Thornhill 1999). High levels of oestrogen have been shown to correlate with attractiveness of women, as they indicate high fertility and health (Smith 2006). Attractiveness of men however depends on the menstrual cycle of the women. During fertile days women seem to prefer more masculine men with strong jaws and small angle between eyes and lips than during unfertile days (Danel 2006). Clearly hormones influence the human brain, the gene expression and the synaptic plasticity. Though the reason for differences in *brain anatomy and activity* (Baron-Cohen 2003; Arnold and Burgoyne 2004) is still unclear, researchers assume that they might even compensate for physiological differences (De Vries 2004).

10.3.2 A female sensitivity to negative emotion

If we had to assign a gender to negative emotions, it would be female. Yet one has to consider that gender differences are always the result of means. There are men who are more female than most women and the other way round, though women react more strongly to negative stimuli, be it Heavy Metal music, negative pictures, or pain (Rhudy and Williams 2005). Both nature and nurture are considered as reasons for this female disposition. Men are protected by a stronger build but also by their traditional male hero role-identity. We suggest that this strong female sensitivity to negative emotions results in female *risk aversion* in crime, sports, health or even finance. Effects are a longer life span, lower criminality, and a more attentive handling of credits in developing countries. In 97% of the cases these are assigned to women and paid back with 99%. However women more often suffer from anxiety disorders, stress and pain. (Wittwer 2009). Regarding *psychological differences* of men and women, we are facing three dangers:

- *Misinterpretation*: there is no causal connection between biological sex and psychological attributes like cognitive abilities. Empirical studies always show correlations. Is there a significant effect of biological sex, it indicates that on average, male and female values are significantly different. In most cases overlapping distribution curves indicate that the variation in one sex is bigger than the variation between men and women. There is no way in predicting psychological abilities based on biological sex.
- *Stereotyping*. Stereotypes are negative judgements based on prejudices and can influence the affected individuals like self fulfilling prophecies (Aronson 1999). Stereotypes are most threatening if biological differences are used to justify social injustice.
- *Equality*. The wrong argument of equation is politically correct and says that all humans are on average the same. According to law we live in a time of equal rights and chances though social inequality is still a threat by undifferentiated interpretation of scientific results and a negative appraisal of traditionally female attributes like low aggression and strong empathy (Lawrence 2006). We suggest that these attributes could be useful in an extended context of management, armed forces and economy - in the form of unaggressive individuals holding leading positions.

10.3.3 Sex differences in pain perception and risk behaviour

10.3.3.1 Why women suffer more

Women had a lower pain tolerance and gave higher subjective pain ratings than men in all studies in this thesis.

There is a myth concerning the pain perception of women, holding that "Women have to endure labour pains hence they can endure more pain than men". This picture of a modern Amazon does not only object Stone Age stereotypes and every day life experience, but also research results. Empirical and clinical studies on acute and chronic pain have shown that women are more sensitive to pain, report pain more often and give pain higher subjective pain ratings (Rollman, Abdel-Shaheed et al. 2004). The exact reasons why women suffer more from pain are not known, as multiple *physiological* and *emotional* factors influence pain. A goal to go for is to adapt pain medication on the special needs of women concerning active ingredient, dosage, and side effects; and to identify new traditionally male emotional techniques like our role play strategies, able to reduce also womens' pain.

The *nervous system* processing and modulating pain differs between men and women (Gorski 2000; Rhudy and Williams 2005) – though it is not known whether these differences are innate or emerge in time. Female brains show different activity during states of pain (Berman, Naliboff et al. 2006), opioids[11] are less effective (Zubieta, Smith et al. 2002), and the sex hormone oestrogen reinforces pain (Craft, Mogil et al. 2004).

Moreover differences in *psychosocial factors* increase female pain. Basically men and women differ in their motivation to endure pain due to gender roles and corresponding expectations. Traditional male "macho" roles call for men to endure pain stoically, in order not to appear ridiculous. Female gender role is more variable, however most people expect from women to be more sensitive than men (Myers, Riley et al. 2003). And actually women in pain show more often anxiety, vulnerability, less control and self-efficacy and inadequate coping strategies than men.

[11] Opioids are substances that bind to specific receptors, suppressing pain signal conduction by prohibiting a transmitter relieve or hyper polarisation of the cellular membrane of the neuron. They are produced during sports, sexual activity or placebo or can be taken as a pain relieving drug.

10.3.3.2 Women and financial risk

Women and volunteers with female gender roles take less financial risks in this thesis.

Surprisingly little work has been done on the effect of sex and gender on financial decisions. Empirical studies render inconclusive results. However and like others (Croson Rachel 1999; Schubert 1999; Fehr-Duda 2006), our results show that biological sex has an effect on risk taking: women are more risk averse than men in financial decisions considering all winning probabilities. Moreover, we observed for the first time that women require being paid for risk taking: imagine a women has to decide several times in a lottery mechanism between A) a guaranteed payoff that she receives for sure and B) a risk option with given expected utility. In each decision the guaranteed payoff decreases. We observed the effect that women stuck more to the safe guaranteed payoff than men. For a woman to choose the risky option, the expected utility of the risky option had to be on average 40 CHF higher than the guaranteed payoff. For a man, it had to be only 20 CHF. So, women had to be paid double for taking risks. This renders the behaviour of women less predictable than males', their switch of preferences from option A to option B occurs within a broader interval. Moreover, the gender role, measured with the Bem Sex Role Inventory (BSRI) affected risk behaviour. BSRI measures self-perceived male ("instrumental, dominant, aggressive") and female ("expressive, nutritive, empathic") attributes on independent dimensions. We observed that besides biological sex maleness in gender role went along with higher financial risk taking, independently of biological sex, whereas female gender role indicated risk aversion.

10.4 Role identities in human behaviour

Die Demokratie setzt moralische Grundwerte voraus, die sie selbst nicht bereitzustellen vermag.

Moritz Leuenberger

10.4.1 Cultivating the heroic image, a hypothesis in three parts

Our everyday culture is strongly influenced by the mass media. What many people experience is Big Brother, Superstar and Supermodel, reality-TV-shows, quizzes and top-level sport events with a philosophy called „the winner takes it all". Many modern heroes are avengers; clever liars and murderers that create a reality of consumption, fun and violence and might probably blunt the viewer. When we consider that man has a trainable *inhibition threshold* we can consider that this might lead us back to a reign of the strongest instead of the law, to everyday violence, racism and inconsiderateness. Thinking in black and white, the moral sense of community is prone to rob the "enemys" dignity, to kill him with a good laugh. Only an attentive spectator will recognize the "banality of evil" (Arendt 1986) and the "intelligence of evil" (VonSass 2009)

Who do we want to be? Man and society are oriented towards hero identities, whether we like it or not. Society, the state, political parties, confessions have an educational task well beyond formal education and science. No human becomes good by ethics. Although they can reveal the source of moral consciousness, and thus be helpful in setting a "doctrine for moral education and cultivation" (Liangkang 2007).

Values are not just springing up like emotions, they are essentially cultural attainments. A basic implication of this is that 1) role identities are dynamic, variable and trainable. They depend on a historical and social context, as it is the case with gender roles. However, it is recognized that 2) on average there exist differences between men and women, as traditional male roles can be characterized by risk proneness in decision making in different domains of life. In cultural science the human kind is represented by the man, l`homme, l`uomo, der Mann. The woman is made from his rib. In the great monotheistic religions, in economy, military and also research women are acting in an auxiliary role. In decision making typical male approaches are dominant and selected. This approach does not seem to us to be, as a rule, satisfactory, so 3) traditionally female approaches in both male and female decision-making is to be encouraged, paying special attention to emotional attentiveness that still does not deter from courageous decisions.

10.4.2 The I Ging, modern heroes, and the moral sense

Kultur dämmt die archaische Gewalt ein.

after Gerhard Roth

The idea of emotional attentiveness is not new. The I Ging, the book of changes that probably originates from Confucian original texts in the sixth or seventh century B.C. is based on this principle. Before the decision maker consults the I Ging, he meditates on the question he is going to ask, its context and his own position. Then he formulates questions. The answers are sayings and instructions. Insight grows from a new, emotionally tested appraisal of the situation and allows for new answers.

Philipp Zimbardo conducted and cancelled the "Stanford Prison Experiment" at an early stage, delivering a modern approach to caution in decision behaviour. He introduced the term "*natural heroes*" for people who refuse blind obedience to authority. Natural heroes accept even threat and refuse commands that would endanger others. His opinion is that only about four percent of the people act like natural heroes. And he requires that people learn and be trained to pause and to question even under pressure of authority of senior people, whether the imposed decision is right. Zimbardo calls for sociological structures that prohibit blind obedience to authorities, to "cultivate the heroic imagination".

When anthropologists survey moral patterns across the globe, they find that a few themes dominate. People everywhere, at least in some circumstances, think it is bad to harm others and good to help them. They have a sense of fairness: that one should reciprocate favours, reward benefactors and punish cheaters. They value loyalty to a group, to share and to act in solidarity with the group members and to conform to the groups norms. They believe that it is legitimate to confer power to authorities and to pay respects to people of high status. They also exalt purity and sanctity while loathing contamination and sexual desires. The idea that the *moral sense* is an innate part of human nature is not far-fetched. Though no one has identified genes for morality, there is evidence, that they exist. The psychologist Jonathan Haidt counts five primary types of our moral senses – harm, fairness, community (or group loyalty), authority and purity. They keep reappearing in cross-cultural surveys, and influence the moral intuitions of people in our own culture.

- *Harm*: The impulse to avoid harm can also be found in animals.
- *Fairness*: Scientists argue that it is implemented in the brain as a „suite“ of moral emotions, more than just reciprocal altruism or “the selfish gene.”
- *Authority:* Respect for authority is clearly related to the pecking orders of dominance that are widespread in the animal kingdom.
- *Community:* an emotion that prompts people to sacrifice without an expectation of payback.
- *Purity*: the emotion of disgust is triggered by potential disease vectors like bodily fluids, decaying flesh and unconventional meat, and by risky sexual practices like incest. Violations of purity prevented the moral vegetarians and non-smokers from tolerating the slightest trace of contaminant. At the other end of the scale, displays of extreme purity lead people to worship religious leaders who dress in white and radiate an aura of chastity and asceticism.

Steven Pinker (Pinker 2009), describes in an article in the New York Times in May 2009 the moral sense to be as vulnerable subject to illusions as the other senses. It can also turn to immoral. It may confuse morality per se with purity, status and conformity. It tends to tackle practical problems by moral crusades, seeking solutions in aggression. Taboos are imposed, rendering the discussion of unwelcome ideas out of the question. In addition there may be the questionable tendency to see oneself on the side of the angels. Our habit of moralizing problems, merging them with conceptions of purity and contamination, feeling happy when we sense the right feelings, can be a hindrance to act properly.

Is our “moral instinct” fitting to a liberal and multicultural society? It can be assumed that *fundamentalism, status, authority, group loyalty and purity* might sometimes bear dangers, whereas *fairness,* and the *avoidance of harm* should always be trained and institutionally strengthened. Research on morality and its biological and cultural reasons can be seen as a way to strengthen moral foundations, by defining what morality is and how it should steer our actions.

10.4.3 Effects of traditional, male, hero identities in this thesis

Induced and natural traditional male hero identities lead to risk prone behaviour in states of pain and in financial decisions.

Empirical evidence in this thesis indicates that role identities affect decision behaviour in pain as well as in financial risk. A basic hypothesis for this thesis was that traditional male hero identities are insensitive to negative emotions; as a consequence, they have advantages in the field of pain, as they reduce pain sensation, but disadvantages in the field of risk taking, as they prime risky behaviour. In short, our data support this hypothesis:

We suggest that traditional male hero identities can be described by masculine gender role, narcissism, high self-efficacy, low focus on the security of a decision but on danger and by a mainly positive emotional state. The *induction of hero identities* resulted in a mainly positive emotional state with a decrease in pain perception, and increased risk taking in pain behaviour. Participants with a *natural hero role-identity* that could be characterized by low appreciation of security and control and high positive arousal were risk prone in financial decisions. Moreover, male participants with traditionally male gender roles were significantly risk prone and showed lower pain perception. Interestingly, we observed a correlation of pain perception and risk behaviour in our participants. Participants with high pain tolerances were risk prone in financial decisions.

Our results are only valid for our group of participants under the circumstances of our empirical studies. Nevertheless we think that our results are valid as hints and food for thought. Therefore we assume that traditionally male hero identities can mainly be of advantage in extreme situations, e.g. during acute states of pain as it was the case in our role-play study, or facing a lion. However when we are driving a car, they may be dangerous. We suggest that hero identities in financial decisions prefer short time gains but are less sustainable as they prime wrong decisions. Wilhelm Steckel says that the immature wants to die nobly for a cause, whereas the mature wants to live humbly for a cause. Oskar Schindler or the natural heroes of Philipp Zimbardo *could be considered Modern heroes*, but not fighter pilots like Manfred von Richthofen.

10.4.4 The social appraisal of risk

Who does not change the rules, provokes the repetition of the crises, because the rules determine which risks the manager takes. But what happens? Almost nothing. In most supervisory boards reigns zero insight. Banks like Citigroup just raise the fixed salary of their peak forces drastically, to compensate declining bonus payments.

after Götz Hamann (Hamann 2009)

While cleaning ladies and harvesters were speculating about the future, investment bankers were inventing new financial products that disguised the immense risks of these mortages. What under normal circumstances would have been called fraud, was named collateral debt obligations or credit default swaps. Those are securities without an economical justification.

after Wolfgang Münchau (Münchau 2007)

Official programs of political parties and the corporate identity of enterprises today call for security, wealth, economic growth, customer benefits, sustainability, environmental protection, responsibility, transparency, etc. They stand in contrast to a risk culture, where the guiding principle seems to be: the winner is the hero, and he takes all. Studies on risk in this thesis were planned and data was recorded well before the actual financial crisis. Still risk taking is a positive, heroic attribute standing for fast riches, prosperous management and innovation. In general, risky decisions still seam to savour highest social appraisal. Above all if others and bystanders have to pay for it. We suggest that the recruitment processes that call decision-makers into their leading positions support this status quo. Moreover the culture of supervisory board and legal system biotopes that favour or cannot cope with risk-prone decision-makers have the same effect.

It is not in the scope of this investigation to describe the sub-context of delight for risk. Maybe the biggest risks have been taken under the pretext of avoiding risks, e.g. the prominent example or the “balance of terror” during the world war, and the still present and eminent danger of atomic weapons.

10.5 The reproducibility of behaviour under the influence of risk

The basic idea of *reproducibility in science* can be seen in Aristotle's dictum that „there is no scientific knowledge of the individual“, where the word used for individual in Greek had the connotation of the idiosyncratic, or wholly isolated occurrence. Thus all scientific knowledge involves the formation of general concepts, formulated as laws for the behaviour of equivalence classes or ensembles of individuals or occurrences, and the invocation of their corresponding symbols in language. Reproducibility is one of the main principles of the scientific method, and refers to the ability of a test or experiment to be accurately reproduced[12] within some measurement error. A compact general account of its basic features is due to Tetens (1995) in the German "Enzyklopädie Philosophie und Wissenschaftstheorie":

„*Reproducibility means that the process of establishing a fact, or the conditions under which the same fact can be observed, is repeatable... The requirement of reproducibility is one of the basic methodological standards for all sciences claiming law like knowledge about their domain of reference. In particular, reproducibility is an inevitable requirement for experiments in the natural sciences: each experiment must be repeatable at any time and at any place by any informed experimentalist in such a way that the experiment takes the same course under the same initial and boundary conditions. The reproducibility of an experiment in the natural sciences includes the reproducibility of experimental setups and measuring instruments…”*(translated into English by Atmanspacher and Jahn 2003).

The *reproduction of organisms* describes the biological process by which each new individual organism is produced. It is a fundamental feature of life that each individual organism exists as the result of sexual or asexual reproduction. In asexual reproduction, an individual can reproduce itself on its own; e.g. the division of bacterial cells into daughter cells or the division of cells in the human body. Most plants have the ability to reproduce asexually. Sexual reproduction requires the involvement of two individuals, typically one of each sex (see Chapter 10.3.1).

[12] What is the connection between reproducibility, reproduction and replication? Reproducibility is a *property* that indicates the ability to reproduce, and the closeness of accordance. Reproduction denotes an *event* of a duplication of an entity, i.e. of generating a copy. Replication is a synonym of reproduction.

Reproducibility in arts and literature describes the possibility to copy the work of art and opens the discussion about original, copy, fake, unique specimen and serial product. We suggest to extend this concept to the transferability and therefore to the reproducibility of specific emotional states. This thesis shows that literary role plays lead to reproducible emotional states in several individuals (see Chapter 10.1.3).

10.5.1 The limits of reproducibility

Reproducibility has its *limits*. We suggest that endless reproducibility of a process *lacks the possibility of improvement*, of evolution. Difference acts as a catalyst. As a consequence, the overestimation of reproducibility deserves our attention!

- *Complex and unstable structures*
- For *human decision behaviour under risk* our studies (S4-6) show that single decisions are not always reproducible, as different preferences might occur. However RALT depicts ensembles of events as a reproducible probability distribution (10.5.3).
- *Sexual reproduction* allows an exchange of genetic material between individuals and the formation of highly variable, potentially beneficial combinations of genes. So the best product survives stress and parasites and is selected to be dominant in the biotope.
- *Cellular death*, the end of reproduction on the cellular level: for an *organism* to work, most of its cells need to accept they are the end of the line and stop to replicate. Therefore, there exist several sorts of genetic locks like the Hayflick limit to stop the reproduction of cells, once they have reached their physiological destination. Damage to these fixed physiological suicide programs results in unconstrained growth – in other words, cancer. The Hayflick mechanism counts the number of times a cell divides and stops further division at a particular value, which differs from species to species. Only stem cells have the special permission to multiply indefinitely. Thus cellular death is a curse but also a blessing – some cells don't stop to reproduce and to die like they should, and some cells die too eagerly. Knowledge on cellular death could lead to cures e.g. of cancer. (Wittwer 2008)

- A scientific paper can never be a foolproof recipe for the replication of its results because a sort of information called “tacit knowledge” by the chemist and philosopher Michael Polanyi can never be entirely captured. It is thus impossible in principle to tell whether a failure to replicate is due to a lack of tacit knowledge or due to flawed results. Forty years ago, the Nobel-prize winning immunologist Peter Medawar declared that all scientific papers were frauds, inasmuch as they describe research as a smooth transition from hypothesis through experiments to conclusions whilst the truth is always messier than that (Giles 2006). In accordance we called our second study (S2) by the acronym ACALAP standing for as complicated and lunatic as possible. However reading our publication in the journal Pain, ACLAP does not fit as good as before. One would rather use the acronym KISS standing for keep it simple and sexy. Moreover, *“the possibility of reproducible experiments in behavioural science, psychology, and cultural science is questionable. The reason is that in experiments about the behaviour and action of human beings the test persons know that an experiment is repeated. This reflexive knowledge changes the initial and boundary conditions of the original experiment in a way, which is essential for its outcome. As a consequence, the original experiment cannot be repeated under the same initial and boundary conditions*. (Tetens 1995 translated into English by Atmanspacher and Jahn 2003).
- The economical system in “real existing socialism” was based upon the assumption of perfect planning and reproducibility of the economic processes.
- As an economical concept, the *continuity of a company* does not imply slavish reproduction of the same old techniques and products but requires permanent improvement, often found serendipitously by accident.
- In *science fiction*, clones, replicants and robots fight against their status as artefacts, claim to be originals, and arouse almost racist emotions in men. Reproducibility in this context indicates a (zombie-like) lack of “soul” and serves as a symbol of control and limitation.

However, unconditional striving for permanent innovation is not always advisable, as we cannot predict what will become dominant in a market or biological niche. Analyzing the limits of reproducibility can help to improve the situation. In this thesis especially the limits of reproducibility of decision behaviour are of interest – as decision behaviour might be influenced and improved by training.

10.5.2 A short definition of acategoriality

Jean Gebser introduced the term "acategoriality" in the 1950s to describe a mode of consciousness, not much discussed so far, as an epistemic act oriented towards a primary experience of being that is highly integrative and exceeds categorial knowledge (Gebser 1986). In German idealism, culminating with Hölderlin's descriptions of how an individual (Hyperion) can realize this experience, Gebser's conceptions had been anticipated 150 years earlier. Figure 37 illustrates the idea of an acategorial state as proposed by Harald Atmanspacher and Wolfgang Fach (Atmanspacher and Fach 2005, Atmanspacher 2002). They suggested to characterize a cognitive system with the formal theory of dynamical systems by three properties.

1. The cognitive system, which is physically realized by a neural network, is treated as a dynamic system S.
2. Mental representations within the cognitive system are assumed to be co-existing attractors (categorial states, minima of Figure 37) of S with particular stability properties.
3. The instability V_1 represents any change of mental state from one category to the other. It can be triggered by external stimuli or thoughts (acategorial state V_1, see Figure 37).

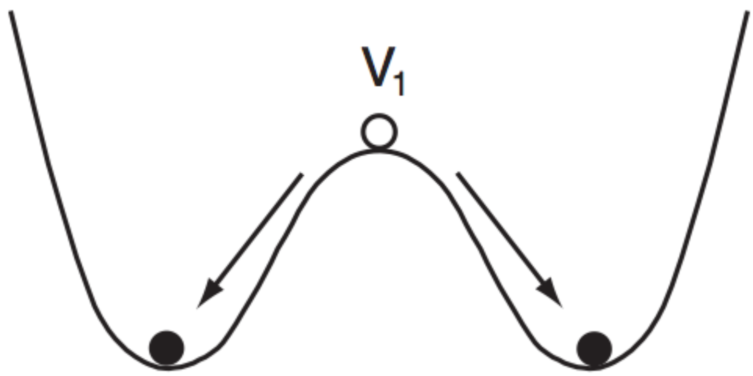


Figure 37 Unstable states in the neighbourhood of an acategorial state V1 of a locally convex potential are unstable and relax into adjacent potential minima, the categorical states (Atmanspacher and Fach 2005).

In terms of this dynamical systems approach that describes a cognitive system, acategorial states are unstable points in an attractor landscape. They might be distinguished *by unstable behaviour* and can be *triggered by external stimuli or thoughts*. The degree of their instability is determined by the degree of stability of neighbouring attractors.

The *Necker cube* (Figure 39) is an ambiguous stimulus inducing perceptual instability. During its observation a spontaneous and unavoidable switch occurs from one perspectival configuration into another. This phenomenon was first described by the geologist Necker (Necker 1832) and has been studied extensively for a long time in psychophysics, psychophysiology and, more recently, in cognitive neuroscience. Atmanspacher et al. suggest that ambiguous figures offer ideal experimental paradigms to investigate the various parameters involved in the transition between stable categorial states as well as properties of the unstable acategorial state in between. Since these properties provide robust physiological measures, they might complement existing results of psychological studies of insight problem solving and of decision-making in an important manner (see Chapter 10.8).

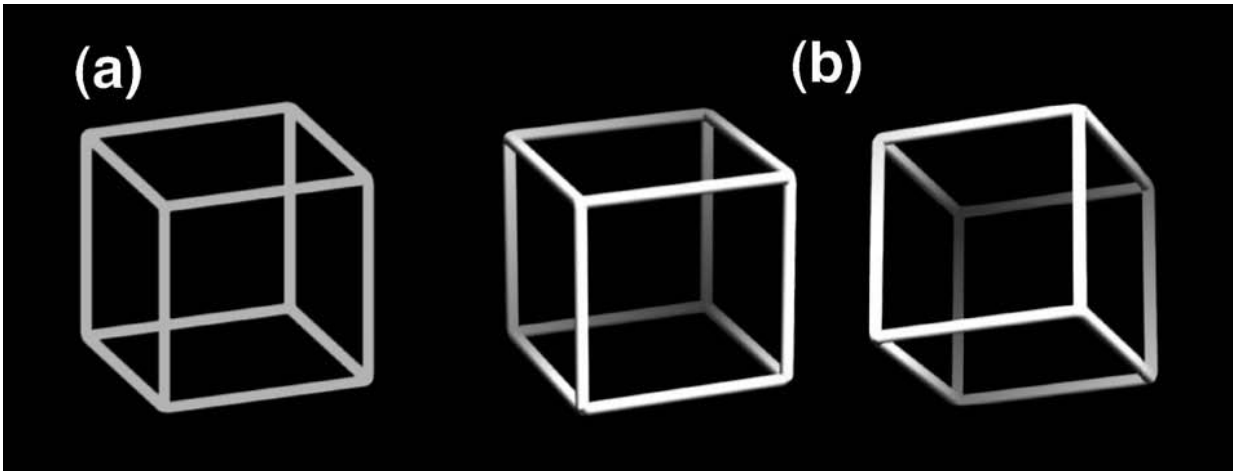


Figure 38 (a) The Necker cube, a two-dimensional projection of a three-dimensional cube structure, as an ambiguous visual stimulus. (b) Modified cube with depth cues removing the ambiguity of the Necker cube, so that two different, non-ambiguous stimuli are perceived.

10.5.3 Reproducibility and acategoriality in this thesis

This chapter focuses on an important frontier of contemporary knowledge: problems of reproducibility in decision behaviour. We assume that the repetition of identical patterns of decision behaviour over time does not lead to the same reproducible results, and that an evolutionary principle might cause the observed reproducible and acategorial (R/A) ranges in behaviour. It is plausible to assume that the observed instability offers and expedites the exertion of influence. A more comprehensive understanding of these mechanisms might lead to deeper insight about a detailed analysis of the processes involved in decision-making.

10.5.3.1 Working definition

Since *reproducibility* and *acategoriality* refer to stable versus unstable behaviour, they are *opposite attributes of decision behaviour*. If behaviour in a single decision is stable and can be predicted with certainty, such behaviour is reproducible. If, on the other hand, different behavioural preferences occur under similar conditions, they are not reproducible. The corresponding mental state of the behaving subject then carries more or less pronounced features of acategoriality.

Our results indicate that R/A in decision behaviour can be:

a) Measured R/A= f (RALT),

b) Predicted R/A = f (personality characteristics), and

c) Controlled R/A = f (framing).

10.5.3.2 R/A in decision behaviour under risk can be measured

Is behaviour during financial risk predictable and reproducible? By calculation of means common economical tools depict decision behaviour as perfectly determined (probability p=1), i.e. as reproducible, within measurement error (Figure 39, left). However our results show that human decision behaviour differs from this simple model. As a consequence, we suggest that economical tools so far give an inaccurate picture of undue precision for risk behaviour. Is this of any importance for the capital market? It might be e.g. possible that models that calculate changes in prices of shares by calculation of means might cause wrong predictions. In future work we will investigate further limitations.

Imagine a lottery mechanism where participants decide 50 times between two options, a lottery and a guaranteed payoff (see Chapter 7). Here, our risk tool RALT for the first time depicts reproducible behaviour and acategorial states by means of a probability distribution (Figure 2, right). The risk measure of participants' behaviour is the *preference function* that spreads from categorial to acategorial and again to categorial ranges of behaviour depending on the payoff in option B. The preference function is given by the probability of the two options. In contrast to traditional methods that merely depict participants' indifference points at 50% probability for risky choice.

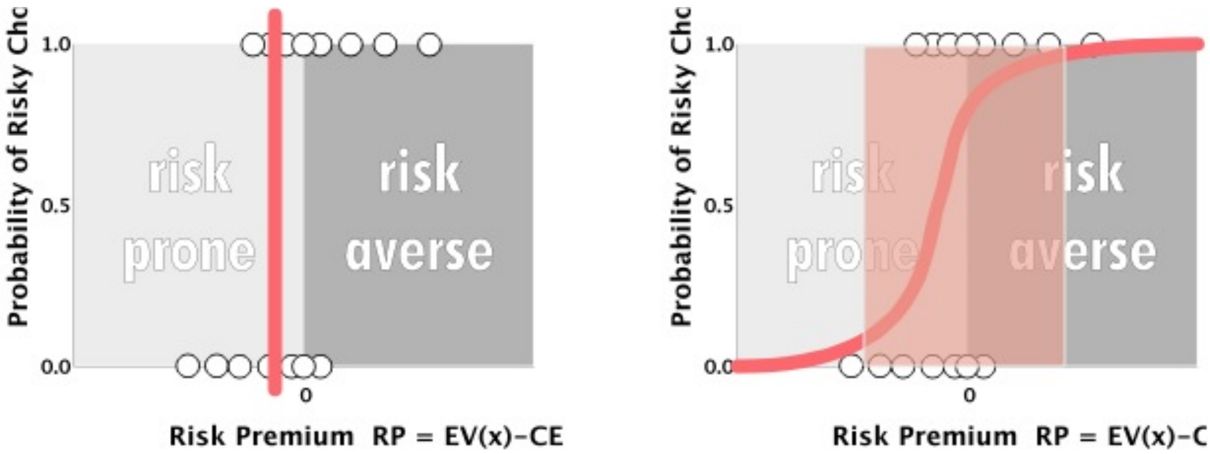


Figure 39 Measurement of the reproducibility of decision behaviour. Small circles represent the outcomes of a set of pairwise choices and the preference for risky choice (p = 1) or the certain option (p = 0). Previous studies (left) characterized the risk measure for a distribution of risk premiums with a *single parameter,* the indifference point. Our approach uses a *probability distribution function* and allows us, for the first time, to depict both reproducible and acategorial ranges (red area on the left) of behaviour.

Reproducible (categorial) range: When the offered payoff is very high, subjects choose this option rather than the lottery, and the probability of risky choice will be zero. When the payoff is very low, subjects choose the lottery and the probability of risky choice will be one. In these ranges, their decision behaviour is reproducible.

Acategorial range between (p = 0.05 and p = 0.95): If subjects are offered two similar options, our results show that they do not always choose the same option: Individual acts of behaviour become irreproducible, they cannot be predicted with certainty but only probabilistically. So, if *two options are similarly attractive*, (1) *single decisions are not reproducible* and different preferences occur. However, (2) *the measured probability distribution of an entire ensemble of events is reproducible* also in the acategorial range. Thus, decisions between similar options cannot be *individually* predicted with certainty but they can by *statistically* predicted by a probability distribution. The mental state during such a decision can be described as unstable and acategorial, waiting for one of the alternative options to be adopted with their associated categorial states. It is important to note that preference functions do not represent an individual acategorial state itself but the probability distribution of admissible categorial states, resulting from the acategorial state after the decision has been made.

10.5.3.3 R/A in decision behaviour under risk can be predicted

Decision behaviour concerning financial risk depends on personality characteristics. Our results show that biological sex, self-perceived role-identity and pain tolerance have an influence on the size and position of R/A ranges.

Biological sex has an effect on the location and the distribution of reproducible and acategorial ranges of behaviour: the position of the acategorial range for males typically indicates higher risk proneness than for females. Moreover, the decision behaviour of males has a narrower acategorial and a larger reproducible range than that of females. This result indicates that female behaviour is less predictable, and females have to be paid more for taking risk. In a chemical picture, their preference function resembles the titration curve of a system less buffered than for males. Further implications of these observations need further deliberation.

Self-perceived role-identity, here defined as a mode of variable self-perception that can be trained, has a distinct effect on the position of the acategorial range. Looking for attributes that could explain differences in risk behaviour of different individuals, we identified correlates and reduced their complexity with principal component analysis. On the one hand, traditional female role identities characterized by security, control and calmness had an acategorial range tending toward higher risk aversion; whereas traditionally male role identities characterized by danger and sensation seeking had ranges tending toward higher risk proneness.

Pain tolerance, here defined as the maximal heat pain participants are willing to receive also had an influence on the position of the acategorial range. 1°C increase of pain tolerance correlates with a shift of the acategorial range toward risk proneness by 10 CHF. This is the first evidence that risk behaviour is consistent for the domains of coping with pain as well as financial risk.

10.5.3.4 R/A in decision behaviour under risk can be controlled

Can we influence behaviour by an emotional framing of the situation? Our results indicate that antithetic emotions influence the position of R/A ranges of decision behaviour. Positive affective pictures prime the decision maker toward gains and increased risk proneness, whereas negative affective pictures prime the decision maker toward losses and increased risk aversion.

10.8. Further investigations

The work presented in this thesis can be continued in different fields. The discussion of each subproject S1-S6 suggests future steps. An external observer might propose an implementation of the *role-play strategies* in patients as it is planned by Dr. Kathi Thieme, or to analyze their physiological processes to enlighten the black box of their functional mechanism. Besides a deepening of the study of *biomarkers* like salivary Alpha-amlyase is of interest, as it would allow an objectivation of otherwise subjective states bypassing language. However we focus this chapter on *behaviour under the influence of risk*, and the *limits of its reproducibility*. We think that this research shows the biggest potential for new findings. This chapter presents further studies that show potential for publication – for most of the single projects data has been already collected.

10.5.4 Behaviour under uncertainty

Background: The Balloon Analogue Risk Task BART was originally designed by Lejuez et al. (Lejuez, Read et al. 2002). BART measures decisions under uncertainty that are closer to real life than decisions under risk. BART has been shown to be highly reproducible for young adults and correlates with self report on sensation seeking and impulsivity, as well as increased risk taking as smoking, drug abuse and risky sexual behaviour (Lejuez, Aklin et al. 2003; Lejuez, Aklin et al. 2007). Participants pump up a balloon. Each pump delivers an amount of 0.1 CHF on a visible account. However when the balloon bursts, the participant receives no money. Participants are informed that that some balloons burst immediately, while others will fill out the whole screen. Actually the balloon bursts at n pumps with a probability of $1/n$.

Hypothesis: We suggest that BART shows potential for improvement, as some of the basic principles of experimental design (see Chapter 7) have been neglected. Moreover a model based statistical inference and interpretation might improve the risk metric.

State of research: We have improved the design of this risk tool concerning randomization and user interface (Figure 40). Data of 27 participants has been recorded (27 x 50); the risk metric remains to be improved.

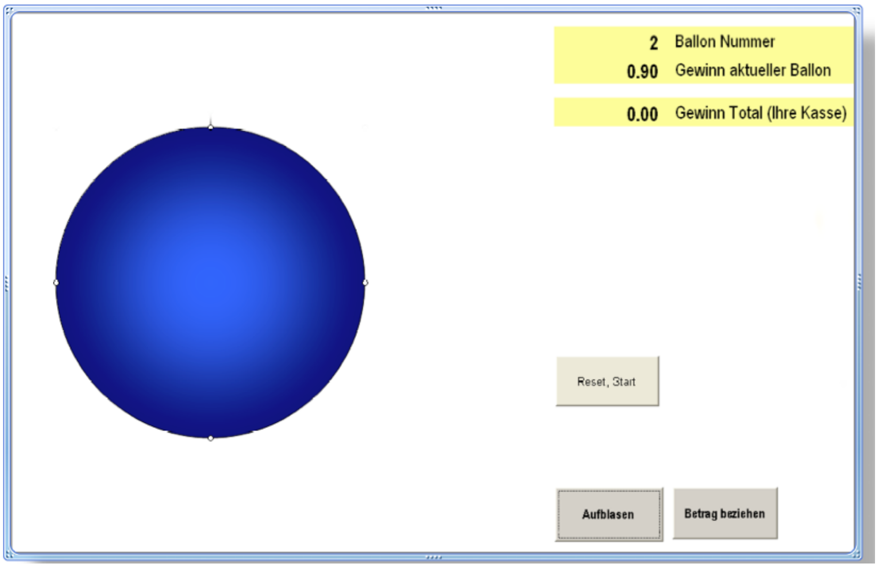


Figure 40 **The user interface of the improved BART**. Participants pump up a balloon. Each pump delivers an amount of 0.1 SHF on a visible account. However when the balloon bursts, the participant receives no money. Participants decide weather to pump on or to draw the benefits. Participants are informed that some balloons burst immediately, while others will fill out the whole screen. Actually the balloon bursts at n pumps with a probability of $1/n$.

10.5.5 Precision and decision time of RALT

Background: a) The intra-individual reproducibility of RALT has not been analyzed yet. In order to measure the reproducibility of RALT the results of four RALT per participant can be compared. b) A premise for the SNF proposal “Beyond categories” is, that in decision-making we overcome an acategorial mental state. When both options/attractors are similar, we will be longer in this acategorial mental state.

Hypotheses: a) in similar conditions RALT shows high intra-individual reproducibility. b) The decision time is an indicator for an acategorial mental state. We suggest that decision time increases when decisions are coming close to the indifference point. This would be an indication for an individual acategorial mental state in decision behaviour, as defined by Atmanspacher et al. (Atmanspacher 2002).

State of research: Data recorded in 4x50 decisions of 27 Participants. 2x50 decisions are recorded in a “neutral” condition.

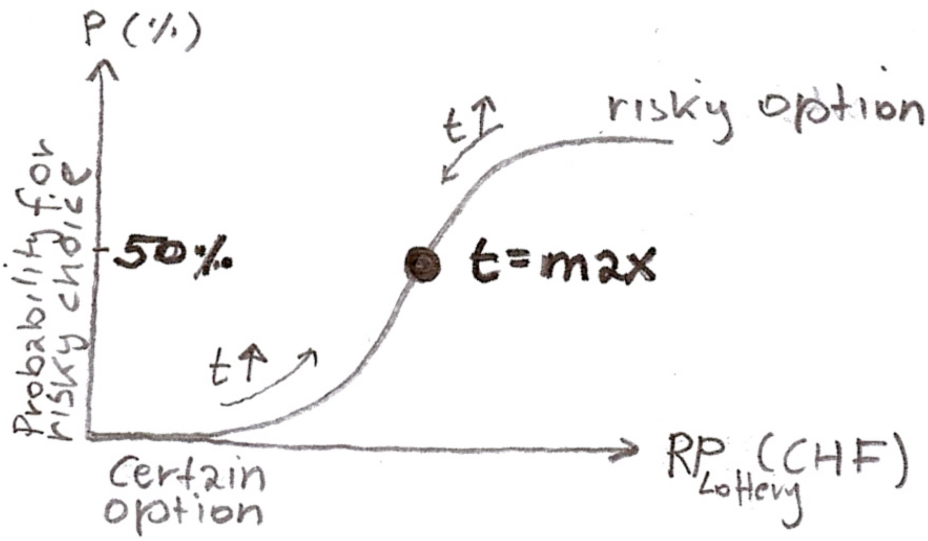


Figure 41 Sketch of the connection between the RALT preference function and subjective mental states. We suggest that at the participants' indifference point (p = 50%) decision time will have its maximum.

10.5.6 The prediction of risk behaviour

Background: In a next step, we will compare the results of the risk task RALT with the model based prediction of risk behaviour based on psychological and physiological personality characteristics (see results Chapter 8). This comparison will show if risk behaviour in financial decisions can be predicted by personality characteristics.

Hypothesis: The aggregated factors calmness and appreciation of security and control will allow a prediction of risk behaviour that is similar to the results of RALT.

State of research: Data are recorded and mostly analyzed (see results Chapter 8).

10.5.7 Is there a hysteresis effect in lottery sheets?

Background: The phenomenon of hysteresis is known from the electric, magnetic or also elastic behaviour of phenomena. A hysteresis curve contains infinitely many states, but a simple application is to let the threshold regions (usually to the left and to the right) represent respectively the on and off states. In this way, the system can be regarded as bistable.

Hypothesis: Common lottery sheets have a hysteresis effect. We suggest that a switch of order of certain payoffs could inhibit this effect and therefore data can be improved.

State of research: Data recorded for 7 lotteries in 27 Participants.

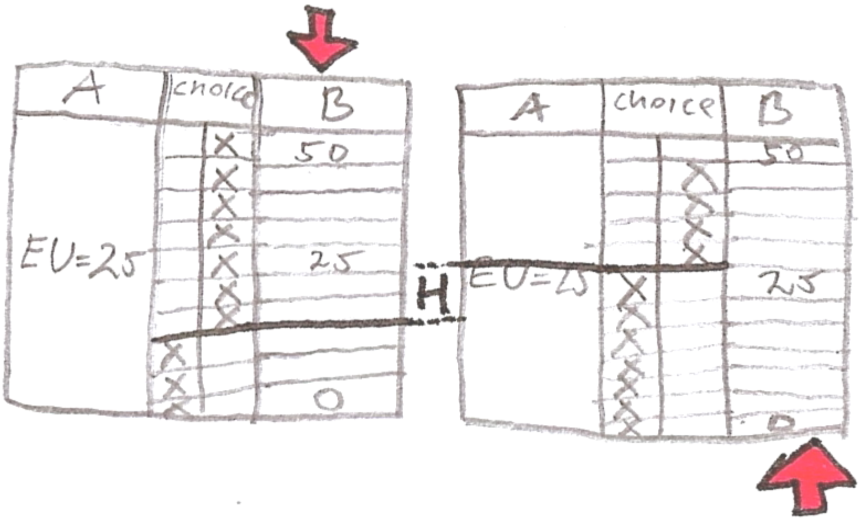


Figure 42 Hysteresis effect in option sheets of winning lotteries (see Chapter 3.5.). Participants have to decide between option A (a lottery) or B (a guaranteed payoff, that is decreasing from 50 to 0 CHF). When participants start (arrow) from the top, their choices will remain longer option B. When they start from the bottom, their choices will remain longer option A. EU: Expected utility of the lottery; H: Hysteresis Effect

10.5.8 Prosperous decision behaviour

Background: Identify the personality characteristics in the distributional tails of sustainable behaviour. Deliverables are the effect of role-identity on decision behaviour and training concepts.

Hypothesis: Traditional male role identities are not effective for sustainable brokers and managers.

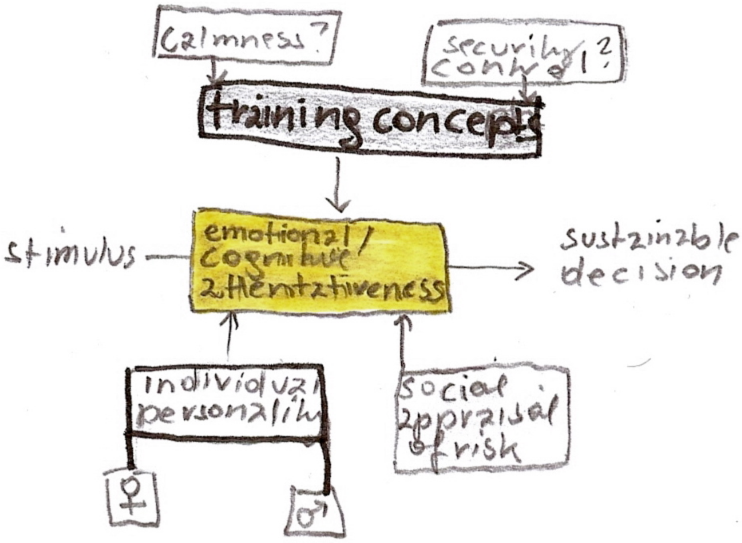


Figure 43 Sketch of factors that might improve sustainability of decision-making.

10.5.9 Beyond categories, a short overview on an SNF proposal

The work described in this chapter will be done in collaboration with the following people: Hans Rudolf Heinimann, Harald Atmanspacher, Reinhard Nesper, Jürgen Kornmeier, Jannis Wernery, Mark Wittmann, Gerd Folkers, et al.

Background: The Synergia Proposal "Beyond Categories" will be applied in 2010 to the Swiss National Science Foundation. Its overall goal is to explain human risk behaviour employing the *limits of its reproducibility*. Complex systems behaviour plays a significant role in cognitive systems. The duration of acategorial mental states, feelings such as pain tolerance, physiological parameters, and personality characteristics are taken into account. Figure 45 depicts the conceptual model of the four subprojects A-D that involve expertise of different areas of knowledge including model-based experimentation and inference, behavioural experiments, the theory of dynamical systems, and psycho-physiological measurements. We suggest that this project will contribute to an improved understanding of human behaviour under risk and uncertainty and help to bridge "disciplinary ditches" between systems theory, neuroscience, and behavioural studies. It might add to the ongoing debate "experts versus laymen", which has been an unsolved problem in the area of risk management since the 1960s. It will be a building block for the ETH Risk Initiative, which was initiated in 2008, aiming to integrate research in the areas of technical, natural, and socials risks with development activities of the insurance industry.

Hypotheses: Our basic set of hypotheses is that low frequency of reversal rate in the Necker cube have an effect on the *reproducible ranges of behaviour* (definition see Chapter 10.5.3): the position of the acategorial range for low reversal rates indicates risk aversion. Visual or auditory stimulation will extend the stay in the acategorial state (H1, Figure 45), and emotion induction will affect transition time (H2, Figure 45). Table 13 summarizes the results of this thesis that underlie this conceptual approach.

State of research: A proposal to correlate reversal rate, risk taking and pain perception has been provided to the ETH ethical committee by Jannis Wernery. The Synergia proposal "Beyond Categories" will be resubmitted in 2010.

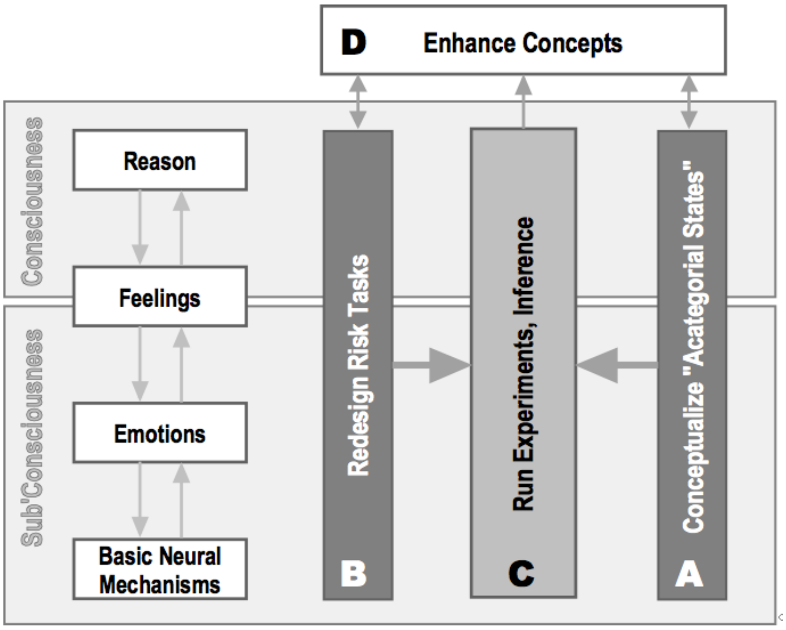


Figure 44 Conceptual model, aiming to use interactions between concept enhancement and experimental verification**. A to D refer to subprojects**[iii]**.**

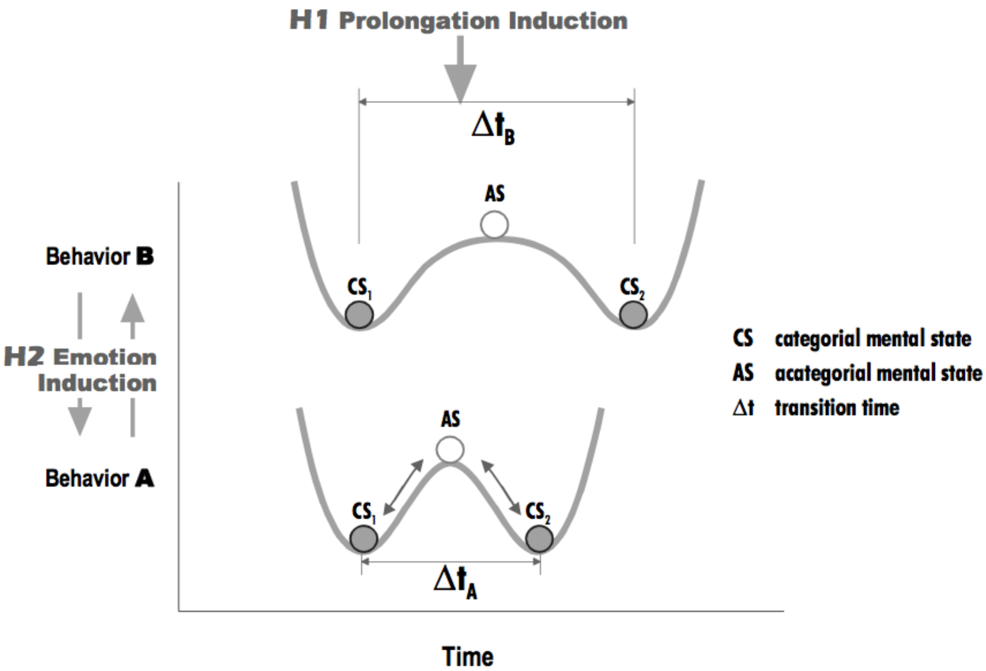


Figure 45 Conceptual approach. We assume that the duration of an acategorial state between switching from a discrete state CS_1 to a discrete state CS_2 is a decisive parameter to characterize decision behaviour under risk and uncertainty. We assume that (H1) visual or auditory stimulation or (H2) emotion induction would allow us to change the transition time between CS1 and CS2, and thus to change the duration of the unstable acategorial state between CS1 and CS2. However these hypotheses remain to be tested.[iv]

Table 13 Table of correlations of risk behaviour with cognitive, emotional, physiological and personality characteristics that have been observed in this thesis. Our findings indicate that the state of the two reasoning systems (cognition, emotion), personality characteristics, and psychophysiology affect risk-behaviour. Grey fields remain to be analyzed.

	Expected Factor of Influence	Risk Behaviour		Sources of indication
		Risk-averse	Risk-prone	
Cognition	Low frequency of reversal rate	✚	-	
Cognition	Length of Patchwork duration	✚	-	
Cognition	Insight	?	?	
Emotion	Positive emotional state	-	✚	Positive picture viewing leads to risk prone behaviour in men (Chapter 9). High positive arousal correlates with risk proneness in RALT (Chapter 8). Role Induction (1) hero demonstrated to have positive effect pain tolerance (Chapter 5).
Psychophysiology	Arousal and sensation seeking	✚	-	Low calmness correlates with high risk-taking (Chapter 8).
Psychophysiology	Magnitude of pain tolerance	-	✚	There is a positive correlation between pain tolerance and risk proneness in financial decisions (Chapter 8).
Personality	Believing in fate Social externality	-	✚	Chapter 8 shows that a high belief in fate and narcissism positively correlates with risk proneness.
Personality	Degree of rationality	✚	-	Own preliminary experiments demonstrate that a high degree of rationality negatively correlates with risk proneness.
Personality	Degree of security and control: femininity, self efficacy, safety seeking	✚	-	Chapter 8 shows that high degree of feminity, self-efficacy and safety seeking negatively correlates with risk proneness.

The role-play strategies

Prinz

Du lässt die Früchte in die Schale zurückfallen. Honigmelonen und Feigen munden dir vorzüglich, aber das Essen langweilt dich. Du hast gerade ein mehrgängiges Menu genossen: ein Rebhuhn, das du gestern geschossen hast, eingelegt mit Preiselbeeren und Kastanien, Schweinebraten und zum Nachtisch kandierte Äpfel. Um ehrlich zu sein, bezweifelst du, dass der Pfeil, der das Huhn erlegt hat, tatsächlich aus deiner Armbrust stammte. Du würdest nicht mal ein Schwein direkt vor deiner Nase treffen. Aber wen interessiert das schon? Du grinst und streichst dir über den Bauch. Geschmeckt hat es jedenfalls wunderbar. Du klatschst in die Hände. Ein paar Sekunden verstreichen, dann hörst du Glöckchen. Die Hoftänzerinnen, in bunte Stoffe gehüllt, treten auf und schlagen das Tamburin. Ein wenig Zerstreuung vor dem Mittagsschläfchen. Deine Eltern sind ausser Haus, auf Besuch beim benachbarten Königshaus, und du hast den Hofmeister gebeten, die Tänzerinnen Festtagsgewänder tragen zu lassen. Mit halboffenen Augen verfolgst du ihre trägen Bewegungen. Die Blonde mit dem rosa Tuch gefällt dir heute am besten. Du musst nur mit den Fingern schnippen, und du bekommst alle Frauen des Reiches. Und zwar nicht, weil du schön, stark und klug bist, sondern weil du der Erbe des Königsreiches bist. Das ist eine gute Sache. Stolz bist du. Du musstest dich nie anstrengen, dir wurde alles in die Wiege gelegt. Und wozu solltest du dich auch anstrengen, wenn du doch ohne Mühe als der Beste galtest? Du bist der Erbe deines Vaters. Auf dass er lange lebe und du noch lange deine Ruhe habest. Du wirfst der Tänzerin eine Feige zu. Sie fängt sie auf, lacht und wird rot. Sie kichert. Du bist dir sicher: was im Leben zählt, ist Bestimmung. Und dir ist es bestimmt, ein angenehmes Leben zu führen. Es ist nicht deine Sache, wenn andere leiden. Die werden es wohl verdient haben. Was gibt es bequemeres, als auf diesem Diwan zu liegen, zu träumen oder Zerstreuungen zu geniessen? Du folgst den Bewegungen eines Seidenschals um eine Hüfte – als Schreie ertönen.

Der Rhythmus stockt, die Tänzerinnen kommen aus dem Takt. Wer wagt es, deine Mittagsruhe zu stören? Die Tänzerinnen springen zum Fenster und beginnen zu kreischen. Diese Närrinnen, hat ihnen niemand beigebracht, sich angemessen in deiner Nähe zu verhalten? Als die Frauen aus dem Zimmer stürzen, stemmst du dich schliesslich hoch und gehst auch zum Fenster. Du siehst Rauch am Tor, das Tor ist aufgebrochen! Dein Herz beginnt zu rasen. Über den Innenhof rennen, mit Gebrüll, bewaffnete Eindringlinge; die Wachen liegen am Boden. Ein Aufstand? Jemand schreit: "Die Raubritter sind da!" Die Raubritter. Diese blutrünstige Meute ist ins Schloss eingedrungen. Die Leibgarde ist weg, mit den Eltern. Du hast einen Schwiessausbruch. Du taumelst. Du siehst wie das Gesinde sich in alle Richtungen verstreut. Sie rennen aus der Burg, bringen sich in Sicherheit, anstatt dich zu beschützen. Die Raubritter durchsuchen jeden Winkel, plündern, morden jeden, den sie finden. Du musst dich retten. Barfuss und im seidenen Hausgewand rennst du aus dem Saal über die Treppe. Hinter dir hörst du wüstes Gelächter, von weitem siehst du die blonde Tänzerin, sie versucht sich von jemandem loszureissen, der sie an den Haaren gepackt hält. Du eilst an ihr vorbei in den Keller. Dein Blick schweift fahrig hin und her: verstaubte Weinkrüge, Rohschinken an Haken. Du hörst Verfolger die Treppe herunter poltern. Ach, hättest du doch den Umgang mit Waffen erlernt; aber du kannst nicht kämpfen, du bist verloren! Da! Ein Geistesblitz! Du erinnerst dich an die Falltür neben den süssen Kartoffeln. Hier beginnt der verbotene Gang, der angeblich in das Flammenlabyrinth führen soll, in die Katakomben unter der Stadt. Ammenmärchen erzählen, dass keiner, der sie betreten hat, je wieder zurückgekehrt ist. Aber wer glaubt in deinem Alter schon an Märchen? Es ist deine letzte Chance! In diesem verbotenen Gang willst du dich verstecken und warten, bis die Luft wieder rein ist.

Deine Nägel brechen als du keuchend das Siegel zum Labyrinth öffnest. In letzter Sekunde kriechst du in den Gang und schiebst den Riegel vor. Die Verfolger sind da! Einer schreit mit rauher Stimme: "Da kommst du nie mehr aus!"Erschöpft sinkst du auf den kalten Steinboden bei der Falltür. Die Flucht hat dich so angestrengt, dass dein Herz hämmernd bis zum Hals hinauf klopft. Dein seidenes Hausgewand klebt an deinem in Schweiss gebadeten Körper.Wie konnte es nur soweit kommen? Ein Schluchzen entfährt dir. Du solltest nicht hier sein. Du solltest draussen im lauen Wind liegen und ein Nickerchen machen. Die königliche Leibgarde soll kommen und diese Raubritter erledigen.Schnell ist dein Körper abgekühlt. Es zieht und dein feuchtes Gewand gibt dir keinen Schutz.Da beginnt der Steinboden zu vibrieren; ein tiefes, dumpfes Donnern, wie von einem nahenden Gewitter füllt den Raum; du spürst, dass der Boden sich hebt, der Gang wird enger, die Wände geraten in Schieflage, wollen dich erdrücken. Ein Schrei entfährt dir.

Was machst du? *Lässt du dich von den Steinen erdrücken oder suchst du einen Ausweg?* Am Ende des sich verengenden Ganges angekommen ertastest du

eine Wand aus trockenem Holz, eine Klinke aus Eisen. Es ist eine Tür, sie ist offen und du kannst dich retten – vorerst... Du betrittst einen von bläulichem Licht durchfluteten Hohlraum. Am Boden huscht etwas vorüber. Mäuse? Du ekelst dich; aber der Weg hinter dir ist versperrt. Rechts und links siehst du schwere Eisentüren; eine steht offen, die andere ist ganz mit Spinnweben überzogen. In der Mitte des Raumes steht ein Tisch, auf dem etwas glänzt. Auf dem Tisch liegen mehrere Gegenstände ausgebreitet. Sie sind von einer dicken Staubschicht bedeck. Du erkennst ein Rattengerippe, ein schweres Handbeil, einen kleinen silbernen Dolch, und einen wunderbar funkelnden Diamanten von der Grösse eines Hühnereis. So etwas Schönes hast du noch nie gesehen. Welchen der Gegenstände nimmst du mit? Du stehst am Eingang einer riesigen, schummrig beleuchteten Höhle. Du spürst einen starken Luftzug. Dein Hemd bläht sich auf und kalte Luft streicht über deinen schweissnassen Körper. Dich fröstelt. Dein Körper schmerzt von der Anstrengung. Deine Finger mit den gebrochenen Nägeln bluten. Du bist müde. Du willst dich in deinem seidenen Bett ausruhen.Stattdessen lässt du dich an der steinernen Wand entlang auf den Boden sinken, deine Augen sind feucht. Doch du schiesst abrupt wieder in die Höhe. Fast hättest du dich in deiner Unterhose auf etwas Lebendiges, Felliges gesetzt. Entsetzt schaust du genauer hin. Der ganze Boden ist voller riesiger Ratten! Reflexartig ziehst du ein Bein hoch. Die Ratten streichen an dir vorbei. Du riechst ihre nassen Pelze. Ihre Augen glänzen rot im Schummerlicht.Du schaust dich nach einer Fluchtmöglichkeit um.Da erkennst du, dass du direkt vor einem schwarzen Abgrund stehst. Der Boden des Saales ist eingebrochen.Nur noch ein schmaler Grat führt auf die andere Seite, kaum ein halber Meter breit, ohne Geländer, ohne Sicherung. Ach, wäre deine Körperbeherrschung doch besser!

Bleibst du bei den Ratten oder riskierst du den gefährlichen Weg über den Abgrund, balancierend, kriechend? Was machst du? Mit klopfendem Herzen bist du auf der anderen Seite angekommen. Welches Grauen erwartet dich hier? Ach, hättest du doch einen Bruder, der das alles an deiner Stelle erleiden müsste.

*Bitte sprich jetzt laut und deutlich für einige Sekunden den Vokal A.*Der Gang vor dir ist rotglühend heiß. Schnell ist deine feuchte Haut getrocknet. Hinter einer schmalen Steinmauer schiebt sich Magma an dir vorbei. Es scheint, die Mauer könnte jeden Augenblick bersten. Der Gestank nach Schwefel nimmt dir den Atem. Deine Schläfen brennen und deine Augen sind ausgetrocknet. Müde schleppst du dich, so schnell du kannst, den brennenden Wänden entlang. Sie wollen kein Ende nehmen. Nur Feuer. Mit Brandblasen an den Füssen. Endlich. Eine dunkle Treppe führt ins Nichts hinab. Fauliger Dampf schlägt dir entgegen. Du steigst hinunter. Setzt einen Fuss vor den anderen, deine Schritte hallen wieder, hundertmal, deine Beine sind schwer, tausendmal. Bis du Boden unter den Füssen hast.Fast wäre es dir lieber, die Treppe hätte kein Ende gnommen. Du hast genug gelitten. Das Labyrinth macht keinen Sinn. Du hast hier nichts verloren, und du hast gehofft, du könntest nun ins Freie treten, in einen Wald, auf eine Wiese. Stattdessen öffnet sich vor dir eine Halle. Wände und Boden gleichen einer riesigen Schlangenhaut. Glänzende, alles reflektierende Schuppen. Du kannst die Echsenhaut fast spüren. Du betrittst den Saal; da hallt eine Stimme donnernd von den Wänden wider:

„WER BIST DU, DASS DU DEN WÄCHTER DES TORES NACH SO LANGEM SCHLUMMER ERWECKST? WARUM BEGEHRST DU DURCHGANG?“

Wer bist du und warum begehrst du Durchgang? Was antwortest du dem Wächter?

WAS DU WILLST, INTERESSIERT MICH NICHT. DU HAST MEINE RUHE GESTÖHRT UND WIRST ALS STRAFE DIE FEURIGEN SCHMERZEN DIESER HALLE SPÜREN, HIER UND JETZT! Du erschrickst. Verzweifelt rufst du „Tu mir nichts!“ und in letzter Verzweiflung: „Ich gebe dir alles, was du willst“ Doch der Wächter antwortet nicht mehr. Warum sollte der Wächter dich strafen? Niemand darf dir etwas antun, du bist doch der Sohn des Königs! Entsetzt weichst du zurück zur Tür. Du bist verloren. Da packt dich eine glühende Hand am Unterarm. Und du spürst den Schmerz. Die glühende Hand lässt dich los. Sind die Qualen endlich vorbei?Da hallt das böse Lachen des Wächters von den Wänden wider: "DU HAST NOCH NICHT GENUG GELITTEN!" brüllt er. Du erstarrst vor Schreck, als der glühende Arm dich wieder packt. Du spürst den Schmerz.

Held

Dein Brustpanzer scheppert und dein Atem geht keuchend, als du zum geheimen Eingang des Flammenlabyrinths rennst, um die Prinzessin zu retten. Du bist Kämpfer, und kein Läufer. Dein Körper ist stämmig. Deine Beine sind gemacht, um fest auf dem Boden zu stehen, dein Rumpf ist stark wie ein Baumstamm und deine Arme können mühelos Schläge abwehren. Dein Brustpanzer spannt sich um deinen enormen Brustkasten, dein Haar ist lose gebunden von der letzten Nacht. Dein Schwert schlägt dir gegen die Schenkel, es ist aus gefaltetem Stahl und doppelt geschmiedet. Du hast deinen Helm in der Absteige zurückgelassen, und bist sofort losgerannt, als dich die schreckliche Kunde erreicht hat: Der Raubritter Korath hat die nahe Stadt überfallen und ist ins Schloss eingedrungen. Er hat es nicht gewagt, Elina, die Tochter des Königs, die Hoffnung der Stadt, zu töten. Aber er hat sie in die sichere Verdammnis, in das Flammenlabyrinth, in die tödlichen Katakomben unter der Stadt geworfen. Aber Korath hat nicht mit Männern wie dir gerechnet, denn Männer wie du herrschen oder sie werden aus diesem Königreich verbannt. Du wirst die Prinzessin retten. Im Sprinten erinnerst du dich an vergangene Zeiten, an ihre weichen Züge, an ihre dunklen Augen, an ihre breiten Hüften unter dem durchsichtigen Schleier. Oh Prinzessin Elina! Du hast mehr von ihr gesehen, als dein Herz ertragen konnte, als du noch bei der Leibgarde des Königs warst und sie hat dich mehr beachtet als dem Heerführer recht war. Intrige. Durch eine Intrige des Heerführers, der Elina für sich beanspruchte und keinen Konkurrenten neben sich duldete, wurdest du vom Königshaus verbannt. Deine Kraft, dein Können, dein eiserner Wille wurden für gefährlich erklärt. Du bist in der Gosse gelandet, im Sumpf: ein gefährlicher, geprügelter Köter, verschlagen und wild, wurde aus dir, ein Söldner mit Messer und Narben und Fäusten, der jeden Tag sterben kann oder stärker wird. Ein Mann, der für die Schwachen kämpft. Währenddessen der Heerführer sich heimlich in Elinas Herz schlich und in Absprache mit dem König die Hochzeit plante. Nun, da die letzte Stunde schlägt, alle Hoffnung dahin ist und um Elina die schwarzen Flammen der Verzweiflung lodern, ist deine Zeit gekommen: Du erkämpfst dir die Gunst deines Herrn und deiner Prinzessin zurück. Du wirst ihnen zeigen, dass sie sich in dir getäuscht haben. Endlich ist dein Lauf zu Ende, du stehst vor der Falltür, dem versiegelten Eingang zum Labyrinth und zückst dein Beil. Die blassen Schädel der Vorfahren grinsen dir zu. Wirst du endlich dein Können und deine Zuneigung beweisen und Prinzessin und Königreich retten können? Dein Beil donnert gegen das Holz der Falltür, das Holz splittert. Du spürst die Wucht des Schlages in jeder Sehne deines Körpers. Du magst dieses Gefühl. Du zwängst dich mit den Beinen voran in das Loch. Du schürfst dir am rauhen Holz einen Arm auf; aber du spürst es kaum. Deine Füße ertasten eine Strickleiter. Sie schwankt und führt hinab in die Dunkelheit.Du kletterst eilig in die Tiefe. Deine Hände packen die rauhen Seile mit festem Griff. Pechschwarze Leere ist um dich. Du atmest feuchte, modrige Luft. Du hoffst, dass die Leiter nicht reisst. Du hängst im leeren Raum am letzten Querseil. Kein Grund ist zu sehen. Aber du bist bereit, jedes Opfer zu bringen. Du holst tief Luft und springst.Der Aufprall presst dir die Luft aus den Lungen. Dann stehst du still: Der Raum ist erfüllt von Geräuschen. Mit dem ersten Schritt spürst du, dass da etwas ist. Du spürst ein Kratzen zwischen den Riemen der Sandalen hindurch an deiner nackten Haut. Schnell entzündest du deine Fackel und hältst sie über den Höhlenboden. Es graust dich: Der Boden ist mit einer dicken Schicht Ungeziefer übersät. Große gepanzerte Käfer kriechen über Massen von weissen Würmern. Die unterirdische Halle ist erfüllt vom Scheuern der Panzer aneinander. Schwarze Kakerlaken strecken ihre Fühler nach dir aus. Sie folgen dem Schein deiner Fackel: eines deiner muskulösen Beine ist beschienen. Eine handtellergroße, graue Assel klettert an der Innenseite deines Unterschenkels hoch. Du spürst jedes ihrer einzelnen Glieder auf deiner Haut. Ungerührt wischt du sie mit der Hand weg. Arme Kriecherin. Du hältst die Fackel in die Höhe, rennst los, knack, knack, über Tausende von Tieren hinweg, welche den ganzen Boden beleben. Du fühlst dich stark und deine Muskulatur sehnt sich nach Beanspruchung. Du hast ein Ziel und bist bereit, alle nötigen Opfer zu bringen. Feuerschein erhellt deinen Weg. Die Wände flackern. Du biegst vorsichtig um die Ecke.Vor dir liegt ein brennender Teich. Er füllt die ganze Höhlenbreite aus, das schwarze Wasser kräuselt sich wild, Feuerzungen lecken die Wände hoch, beißender Rauch füllt deine Lungen. Ist dies das Ende deines Weges? Muss deine Mission so enden?Die giftigen Dämpfe sind gefährlich, aber es bleiben dir zwei Möglichkeiten:

Nimmst du einen tiefen Atemzug und tauchst unter den Flammen durch? Oder kletterst du über die Wand am brennenden Teich vorbei? Du erreichst mit Mühe die andere Seite. Deine Beine zittern vor Anstrengung. Du hoffst, dass die Prinzessin nicht solchen Gefahren ausgesetzt ist. Vor dir ist eine Falltür in den Boden eingelassen. Deine Sorge treibt dich weiter. Du kniest dich auf den vom Feuer heissen Boden und stemmst die Falltür auf. Da gibt es ein lautes Gequietsche: große, fellige Tiere springen dir entgegen. Es sind Ratten. Sie klatschen gegen deinen Körper und klettern an deinem Kettenhemd hoch.

Schützend hältst du die Hände vor die Augen, die sie angreifen. Ihre feuchten Schnauzen zittern und du siehst ihre nackten Schwänze im Feuerschein zuckend verschwinden. Die Ratten sind geflüchtet und du zwängst dich mit dem Kopf voran in den Schacht. Es hat gerade Platz genug für deine Schultern. Du riechst Rattendreck und feuchte Haare. Du kriechst vorwärts. Der Boden ist feucht und klebrig. Da berührt deine Hand eine Bewohnerin. Die Ratte quietscht und verbeißt sich in deine Hand. Ihre wütenden Knopfaugen, ihre Zähne blitzen. Du zückst dein Schwert und stichst zu. Die Ratte lässt von deiner Hand ab.Endlich ist das Dreckloch zu Ende, du kannst wieder gerade stehen. In einem Finger sind Biss-Spuren. Du spuckst auf die Wunde. Sie wird schon wieder heilen.Vor dir verzweigt sich der Weg:Ein Schacht führt senkrecht nach oben, ein anderer nach unten. Rostige Eisenstangen bilden eine Leiter.

Welchen Weg wählst du? Den nach oben oder den nach unten? Bitte sprich jetzt laut und deutlich für einige Sekunden den Vokal A. Du steigst an den Eisenstangen hoch. Am Ende des Schachtes, vor dir auf dem Boden, liegt ein Untier; der giftige Stachel zum Greifen nah. Ein Feuerschlund. Um eine Handbreit streift der Tod an deinen Augen vorbei. In tiefer Frequenz vibriert der Boden. Schwefeldampf steigt in Säulen auf, wo du den liegenden Kopf vermutest. Riesige Dornen ragen auf dem Rücken aus der schleimigen, grauen, großporigen Haut. Eine bewehrte Frühgeburt der Dunkelheit, bewegungslos, farblos und doch giftig, tödlich.

Was machst du?Schleichst du dich leise der Wand entlang, in weichen Sandalen, und hoffst, dass das Monster nicht nur so gut schläft, weil es deine Prinzessin gefressen hat?Oder stürzt du dich mit Gebrüll auf das Tier und schlägst ihm kurzerhand den Kopf ab? Triumph! Du hast es geschafft! Du scheust keine Qualen. Das Tier liegt weit zurück und du lebst. Du bist die Hoffnung des Landes und rettest die Prinzessin. Dein Name wird in die Annalen der Geschichte eingehen. Du durchschreitest die nächste Tür, da öffnet sich vor dir die Halle des Schmerzes. Echsenschuppen spiegeln das Licht und blenden dich. Eine Quelle entspringt in der Mitte des Raumes. Vor dir, auf dem Boden, liegt die Prinzessin. All deine Sorgen, die Schmerzen, sind vergessen. Blass, weiss, im Nachthemd, das lose Haar verklebt und trotzdem wunderschön. Sie atmet kaum... Aber sie lebt! DU kannst sie retten! Du willst sie hochheben, da hallt eine schreckliche Stimme durch die Halle:

WER BIST DU, DASS DU DEN WÄCHTER DES TORES NACH SO LANGEM SCHLUMMER ERWECKST?WARUM BEGEHRST DU DURCHGANG?

Wer bist du, und warum begehrst du Durchgang? Was sind deine Antworten?

ICH LASSE DICH DURCH, WENN DU DIE BLUTENDE, BRENNENDE QUELLE ÜBER DEINEN ARM RINNEN LÄSST. DU MUSST FEURIGE SCHMERZEN SPÜREN, HIER UND JETZT! Dieses Opfer wirst du gerne bringen. Diesen Schmerz wirst du auf dich nehmen, er wird von kurzer Dauer sein und brennend, dann wirst du mit der geliebten Prinzessin Elina fliehen und deine Ehre retten. Du gehst langsam zu der blutenden Quelle hin. Die Luft ist heiß, du atmest tief und regelmässig. Du nimmst deine ganze Kraft zusammen und denkst an dein Ziel;dann hältst du einen Arm unter den blutroten Strahl. Jetzt spürst du den Schmerz. Du ziehst deinen Arm zurück. Lässt dich der Wärter jetzt durch?Da hallt sein böses Lachen donnernd von den Wänden wider:

"ZU KURZ!" brüllt er. "DU FEIGLING, DAS WAR ZU KURZ!"Du weißt nun, was dich erwartet und stellst dich gerne diesem Schmerz.Du nimmst deinen ganzen Mut zusammen, denkst an die Prinzessin und hältst deinen Arm wieder unter den blutroten Strahl. Jetzt spürst du den Schmerz.

Heldin

Du bist auf dem Weg. Und es ist möglich, dass es dein letzter sein wird. In Sandalen treten Deine Füsse weich am Boden auf. Deine Beine geben dir kraftvoll halt.Du trägst den Elmon, das leichte Kettenhemd. Es liegt kühl auf deiner Haut. Es wird seinen Dienst tun, heute.Im Schreiten flichtst du dein Haar, du knotest es. Es soll dir nicht die Sicht behindern. Deine Hand fährt zu deinem Gurt, spürt den kalten Stahl.Dein Atem geht regelmässig. Es gibt keinen Grund mehr für Zweifel. Du hast heute deinen Auftrag. Du rennst mit vollem Lauf. Durch die dunklen Hallen des Tempels. Dein Ziel sind die Katakomben, dort befindet sich der geheime Durchgang zum Flammenlabyrinth. Du bist schnell und dein Atem geht gleichmässig. Die Wahl ist auf dich gefallen. Du wirst über die Zukunft des Landes entscheiden. Wer bist du?Du wurdest auf dem Land geboren, als Tochter eines Bauern. Du erinnerst dich an die gegerbte Haut deines Vaters. Seine warmen Augen. Seine schwieligen Hände, wie sie Ochsen vor den Pflug spannen und Ziegel schlagen.Das braune Fell des Fohlens im Licht der Sonne. Die Mutproben der Kinder.Das Leben auf dem kargen Weideland.Dann hat dich die Hohepriesterin zu sich genommen. Du wurdest in den Orden der heiligen Flamme aufgenommen: die Hüterinnen des Tempels und gleichzeitig die Leibgarde des Königs. Deine Ausbildung zur Priesterin begann hart: Die anderen lehnten dich ab, sie lachten dich aus. Du seist eine Bäuerin. Ein einfaches Mädchen, dumm und willig. Doch ihr Lachen hielt nicht lange an. Es zeigte sich, dass du die Beste warst: im Umgang mit den Feuerruten; sie erinnerten dich an die Peitschen für die jungen Stiere, die zu Hause zur Tränke getrieben werden mussten. In der Kasteiung; dein zäher Körper war an einiges gewöhnt: an Eiseskälte im Winter unter einem Strohsack, brütende Hitze im Sommer auf den Feldern, der förmlich gebackenen Ackerkrume. An den bohrenden Schmerz in deiner rechten Schulter vom Horn des Bullen, der dich angegriffen hatte. An die Stiche der Bienen beim Ernten von Honig. All das hatte dich abgehärtet. Nach sieben Jahren wurde die Heilige Flamme in die Haut eingebrannt, über deinem Herzen. Deine Ausbildung zur Priesterin war abgeschlossen.Jetzt ist dein Ziel das Flammenlabyrinth. Deine Gefährten kämpfen draussen, im Freien, gegen die Raubritter des Korath. Deine Gefährten sind zu wenige, vier, fünf gegen eine ganze Legion. Sie brauchen dich, deine kraftvollen Arme; aber dich hat eine Kunde erreicht. Die Tochter des Königs, die letzte des hohen Hauses, befindet sich, in äusserster Verzweiflung, im Flammenlabyrinth. Der üble Korath hatte kein Erbarmen mit ihr. Sie ist die einzige Hoffnung für Ehreb, und es scheint, du bist ihre einzige Chance. Du wirst sie retten. Du stehst tief unter dem Tempel vor der Falltüre, dem versiegelten Eingang zum Labyrinth. Du zückst dein Beil. Dein Beil donnert gegen das Holz der Falltür, das Holz splittert. Du spürst die Wucht des Schlages in jeder Sehne deines Körpers. Du magst dieses Gefühl. Du bist stark. Du hast ein Ziel. Du wirst jedes Opfer bringen. Du zwängst dich mit den Beinen voran in das Loch. Am rauhen Holz schürfst du einen Arm auf, du spürst es kaum. Deine Füße ertasten eine Strickleiter. Sie schwankt und führt hinab in die Dunkelheit. Du kletterst eilig in die Tiefe. Deine Hände packen die rauhen Seile mit festem Griff. Pechschwarze Leere umgibt dich. Du atmest feuchte, modrige Luft. Du hoffst, dass die Leiter nicht reisst. Du hängst im leeren Raum am letzten Querseil. Kein Grund ist zu sehen. Aber du bist bereit, jedes Opfer zu bringen. Du holst tief Luft und springst.Der Aufprall presst dir die Luft aus den Lungen. Dann stehst du still: Der Raum ist erfüllt von Geräuschen. Mit dem ersten Schritt spürst du, dass da etwas ist. Du spürst ein Kratzen zwischen den Riemen der Sandalen hindurch an deiner nackten Haut. Schnell entzündest du deine Fackel, und hältst sie über den Höhlenboden. Es graust dich. Der Boden ist mit Ungeziefer übersäht. Große Käfer mit Schildpanzer kriechen über Massen von weissen Würmern. Die unterirdische Halle ist erfüllt vom Scheuern der Panzer aneinander. Schwarze Kakerlaken strecken ihre Fühler nach dir aus. Sie folgen dem Schein deiner Fackel; eines deiner braunen Beine ist beschienen. Eine handtellergroße, graue Assel klettert an der Innenseite deines Unterschenkels hoch. Du spürst jedes ihrer einzelnen Glieder auf deiner Haut. Ungerührt wischt du sie mit der Hand weg. Arme Kriecherin. Im Kornspeicher deiner Eltern gab es auch große Insekten. Du hältst die Fackel in die Höhe, rennst los, knack, knack, über Tausende von Tieren hinweg, welche den ganzen Boden beleben. Du fühlst dich stark und deine Muskulatur sehnt sich nach Beanspruchung. Du schießt vorwärts wie ein Blitz. Flackernder Feuerschein erhellt deinen Weg. Du biegst vorsichtig um eine Ecke.Vor dir liegt ein brennender Teich. Er füllt die ganze Höhlenbreite aus, das schwarze Wasser kräuselt sich wild, Feuerzungen lecken die Wände hoch, beißender Rauch füllt deine Lungen. Ist das das Ende deines Weges? Muss deine Mission so enden? Die giftigen Dämpfe sind gefährlich, aber es bleiben dir zwei Möglichkeiten:

Nimmst du einen tiefen Atemzug und tauchst unter den Flammen durch oder kletterst du über die Wand am brennenden Teich vorbei? Du erreichst mit Mühe die andere Seite. Deine Beine zittern vor Anstrengung. Du hoffst, dass die Prinzessin nicht solchen Gefahren ausgesetzt ist. Du bist abgehärtet, trainiert und zäh. Aber wie könnte sie solche Situationen meistern? Wie könnte sie überleben? Vor dir ist eine Falltüre in den Boden eingelassen. Nur deine Sorge treibt dich weiter. Du kniest dich auf den vom Feuer heissen Boden und stemmst die Falltür auf. Da gibt es ein lautes Gequietsche: große, fellige Tiere springen dir entgegen. Es sind Ratten. Sie klatschen gegen deinen Körper und klettern an deinem Kettenhemd hoch. Schützend hältst du die Hände vor die Augen, die sie angreifen. Ihre feuchten Schnauzen zittern und du siehst dann ihre nackten Schwänze im Feuerschein zuckend verschwinden. Die Ratten sind geflüchtet und du zwängst dich mit dem Kopf voran in den Schacht. Es hat gerade Platz genug für deine Schulten. Du riechst Rattendreck und feuchte Haare. Du kriechst vorwärts. Der Boden ist feucht und klebrig. Da berührt deine Hand eine Bewohnerin. Die Ratte quietscht und verbeisst sich in deine Hand. Ihre wütenden Knopfaugen, ihre Zähne blitzen. Du zückst dein Messer und stichst zu. Die Ratte lässt von deiner Hand ab. Endlich ist das Dreckloch zu Ende, du kannst wieder gerade stehen und biegst dein Kreuz durch. In einem Finger sind Bißspuren. Du spuckst auf die Wunde. Sie wird schon wieder heilen.Vor dir verzweigt sich der Weg:Ein Schacht führt senkrecht nach oben, ein anderer nach unten. Rostige Eisenstangen bilden eine Leiter.

Welchen Weg wählst du? Den nach oben oder den nach unten? Du kletterst an den Eisenstangen über das faulige Gemäuer. *Bitte sprich jetzt laut und deutlich für einige Sekunden den Vokal A.*Am Ende des Schachtes, vor dir auf dem Boden, liegt ein Untier; der giftige Stachel zum Greifen nah. Ein Feuerschlund. Um eine Handbreite streift der Tod an deinen Augen vorbei. In tiefer Frequenz vibriert der Boden. Schwefeldampf steigt in Säulen auf, wo du den liegenden Kopf vermutest. Riesige Dornen ragen auf dem Rücken aus der schleimigen, grauen, großporigen Haut. Eine bewehrte Frühgeburt der Dunkelheit, bewegungslos, farblos und doch giftig, tödlich.

Was machst du? Schleichst du dich leise der Wand entlang, in weichen Sandalen, und hoffst, dass das Monster nicht nur so gut schläft, weil es deine Prinzessin gefressen hat, oder stürzt du dich mit Gebrüll auf das Tier und schlägst ihm kurzerhand den Kopf ab? Triumph! Du hast es geschafft! Du scheust keine Qualen. Das Tier liegt weit zurück und du lebst. Du bist die Hoffnung des Landes und rettest die Prinzessin. Dein Name wird in die Annalen der Geschichte eingehen. Du durchschreitest die nächste Tür, da öffnet sich vor dir die Halle des Schmerzes. Echsenschuppen spiegeln das Licht und blenden dich. Vor dir, auf dem Boden, liegt die Prinzessin. All deine Sorgen, die Schmerzen sind vergessen. Blass, weiss, im Nachthemd, das lose Haar verklebt, sie atmet kaum. Aber sie lebt! DU kannst sie retten! Du willst sie hochheben, da hallt eine schreckliche Stimme durch die Halle:

WER BIST DU, DASS DU DEN WÄCHTER DES TORES NACH SO LANGEM SCHLUMMER ERWECKST? WARUM BEGEHRST DU DURCHGANG? *Wer bist du, und warum begehrst du Durchgang? Was sind deine Antworten?*

ICH LASSE DICH DURCH, WENN DU DIE BLUTENDE, BRENNENDE QUELLE ÜBER DEINEN ARM RINNEN LÄSST. DU MUSST FEURIGE SCHMERZEN SPÜREN, HIER UND JETZT!

Dieses Opfer wirst du gerne bringen. Diesen Schmerz wirst du auf dich nehmen, er wird von kurzer Dauer sein und brennend. Dann wirst du mit der Prinzessin fliehen und das Land retten. Du gehst langsam zu der brennenden Quelle hin. Die Luft wird heiß, du atmest tief und regelmäßig. Du nimmst deine ganze Kraft zusammen, denkst an dein Ziel und hältst deinen Arm unter den blutroten Strahl. Jetzt spürst du den Schmerz.

Prinzessin

Das Leben ist nicht immer leicht für dich. Als einziges Kind des gerechten Königs Aralas weilt das wohlwollende Auge des Volkes immer auf dir. Es gibt große Erwartungen an dich.Aber als Mädchen von edlem Blut ist dir der höfische Umgangston angeboren. Du bewegst dich anmutig, mit kleinen Schritten, du spitzt deinen Mund und sprichst gewählt. Am liebsten demonstrierst du deinen guten Umgangston, deine zarten Handgelenke, deinen gesetzten Schritt, wenn ein paar Bauern-trampel bei Hofe sind.Leider sind die königlichen Köche unfähig. Du kannst dir nicht erklären, warum deine Mutter sie nicht schon längst entlassen hat. Sie sind einfach nicht fähig, das Essen in mundgerechte Bissen zu schneiden. Sie verkochen regelmässig das Obstkompott und lassen Gräten im Fisch stecken. Es ist eine Katastrophe. Du kannst dir dein Essen schliesslich nicht selbst kochen. Dein Vater hat die besten Lehrer an den Hof geholt, um dich in Tanz, Musik und gesellschaftlichem Umgang zu unterrichten:alles kuriose Künstler, seltsame Gestalten, und du lachst über sie hinter vorgehaltener Hand. Deine Ausbildung ist bald abgeschlossen, du probst eine Vorführung für deine Mutter und deinen Vater, den König. Die beiden benehmen sich in letzter Zeit sehr geheimnisvoll, sprechen über die Zukunft, über das Schicksal des Reiches. Du bist zuversichtlich und es bereitet dir immer mehr Vergnügen, dich schön zu machen; denn du vermutest, die Geheimnistuerei könnte etwas mit Männern zu tun haben, und es gibt einige, die dir gefallen. Täglich wird deine Haut mit wohlriechenden Balsamölen eingerieben, damit sie weich wie Samt ist. Dein helles Haar wird in Kamillenblüten gebadet, dass es im Sonnenlicht glänzt. Und du wirst gekämmt. Das ist das einzig Unangenehme. Es treten dir regelmässig Tränen in die Augen, auch wenn die sanfte Hand deiner liebsten Zofe den Kamm führt.Deine Eltern sind mit einem Teil der königlichen Garde zum Hof der Alterer gefahren, und du bist beleidigt, dass du nicht mit durftest. Du habest schliesslich zu üben, hiess es. Du sitzt im weißen, seidenen Hemd auf dem Bett und deine Zofe kämmt dich – als das Schreien beginnt. Mit noch tränenden Augen springst du auf, stürmst zum Fenster, siehst Rauch am Tor, mein Gott, das Tor ist aufgebrochen! Und über den Innenhof kommen mit Gebrüll die Eindringlinge; die Wachen liegen am Boden. Ein Aufstand? Du stehst da, erstarrt. Die Zofe nimmt deinen Arm, "Mylady, wir müssen Sie verstecken!" Sie drückt dich in deinen Kleiderschrank. Im Kleiderschrank ist es warm. Du riechst das Parfum, während von draussen die Schreie an dein Ohr dringen. Dann packt dich eine raue Hand. Du blickst in das verzerrte Gesicht eines Mannes. Er stinkt, dir bleibt der Atem weg. Er wirft dich in hohem Bogen aufs Bett. Du siehst aus den Augenwinkel deine liebste Zofe am Boden liegen, sie stöhnt. "Wen haben wir denn da?" Er legt den Schurz ab. Jemand schreit: "Das ist die Tochter des Königs, bring sie zu Korath!" Du wirst über eine Schulter geworfen und fort getragen.Man stellt dich grob auf die Beine. Du stehst barfuss, im Nachthemd, im Thronsaal. Du weinst. Auf dem Thron sitzt er: Korath, der Raubritter. Du siehst ihn nur verschwommen, durch deinen Tränenschleier."Guten Tag meine Dame! Die edle Prinzessin ist wohl allein zu Haus? Ich bin der neue Herrscher in dieser Stadt! Leider," er mustert langsam deinen Körper, "habe ich keinen Bedarf an königlichem Blut in meiner Nähe. Ich will deine königlichen Schreie aus den tiefsten Katakomben hören, und mich daran ergötzen. Werft sie ins Flammenlabyrinth!" donnert er. Das Flammenlabyrinth, die verfluchten Katakomben unter der Stadt: du kennst sie aus Ammenmärchen. Luftschächte führen herauf bis in den Thronsaal. Frühere, grausame Herrscher ergötzten sich an den Schreien der Unglücklichen. Keiner war je zurückgekehrt, alle nahmen dort unten ein qualvolles Ende. Aber du, du bist die Tochter des Königs, niemand darf dir etwas antun!Da packen dich schmutzige Hände, du meinst, deine Arme brechen, als sie dich wegschleifen. Wo ist dein Vater, deine Leibgarde, dein Schutz? Jahrzehnte war kein Schrei mehr durch die dunkeln Schächte unter der Stadt gehallt. Jetzt werden die Siegel entfernt, und die Männer stossen dich in den Schacht. Einer schreit: "Hier kommst du nie mehr heraus!" Die Türe wird verschlossen. Das Lachen der Männer verhallt. Du bist allein. Das Lachen der Männer ist verhallt, du bist allein, es ist stockdunkel. Du sinkst vor der Tür auf den kalten Steinboden und vergehst fast vor Kummer: Wie konnten deine Eltern dich so alleine, so schutzlos zurücklassen? Für die Leibgarde wäre es ein leichtes gewesen, Korath zu schlagen.Ein kalter Luftzug weht. Du ziehst dein dünnes Seidenhemd um deinen schlanken Körper, aber es gibt dir keinen Schutz. Da beginnt der Steinboden zu vibrieren, ein tiefes, dumpfes Donnern, wie von einem nahenden Gewitter füllt den Raum; du spürst, wie der Boden sich hebt;der Gang wird enger, die Wände kommen ins Rutschen und wollen dich erdrücken; ein Schrei entfährt dir.

Was machst du? *Lässt du dich von den Steinen erdrücken oder suchst du einen Ausweg?* Am Ende des sich verengenden Ganges angekommen, ertastest du eine Wand aus trockenem Holz, eine Klinke aus Eisen: es ist eine Tür, sie ist offen und du kannst dich retten – vorerst... Du betrittst einen von bläulichem Licht durchfluteten Hohlraum. Am Boden huscht etwas vorüber. Mäuse? Du ekelst dich; aber der Weg hinter dir ist versperrt.Rechts und links siehst du schwere Eisentüren; eine steht offen, die andere ist ganz mit Spinnweben überzogen. In der Mitte des Raumes steht ein Tisch, auf dem etwas glänzt. Auf dem Tisch liegen mehrere Gegenstände ausgebreitet. Sie sind von einer dicken Staubschicht bedeck. Du erkennst ein Rattengerippe, ein schweres Handbeil, einen kleinen silbernen Dolch, und ein goldenes Halsband, bestückt mit erlesenen Diamanten und Rubinen. So etwas Schönes hast du noch nie gesehen.

*Welchen der Gegenstände nimmst du mit?*Dein Weg führt dich weiter: Du stehst im Eingang einer riesigen, schummrigen Höhle. Du spürst einen starken Luftzug. Du musst dein Hemd runter ziehen, damit es sich nicht aufbläht. Deine Haare werden in die Luft geweht. Dein ganzer Körper schmerzt. Du bist müde. Du möchtest dich in deinem seidenen Bett ausruhen, wie es für dich angemessen wäre. Stattdessen lässt du dich an der Wand entlang auf den Boden sinken, Tränen treten dir in die Augen. Doch du schiesst abrupt wieder in die Höhe. Fast hättest du dich in deiner Unterhose auf etwas Lebendiges, Felliges gesetzt. Entsetzt schaust du genauer hin. Der ganze Boden ist voller riesiger Ratten! Reflexartig ziehst du ein Bein hoch. Die Ratten streichen an dir vorbei. Du riechst ihre nassen Pelze. Ihre Augen glänzen rot im Schummerlicht. Du schaust dich nach einer Fluchtmöglichkeit um.Da erkennst du, dass du direkt vor einem schwarzen Abgrund stehst. Der Boden des Saales ist eingebrochen.Nur noch ein schmaler Grat führt auf die andere Seite, kaum ein halber Meter breit, ohne Geländer, ohne Sicherung.

Bleibst du bei den Ratten oder riskierst du den gefährlichen Weg über den Abgrund, balancierend, kriechend? Was machst du? Mit klopfendem Herzen bist du auf der anderen Seite angekommen.

Bitte sprich jetzt laut für einige Sekunden den Vokal A. Der Gang vor dir ist rotglühend heiß. Schnell sind deine feuchten Wangen getrocknet. Hinter einer schmalen Steinmauer schiebt sich Magma an dir vorbei. Es scheint, die Mauer könnte jeden Augenblick bersten. Der Gestank nach Schwefel nimmt dir den Atem. Deine Schläfen brennen und deine Augen sind ausgetrocknet. Müde schleppst du dich, so schnell du kannst, den brennenden Wänden entlang. Sie wollen kein Ende nehmen. Nur Feuer. Mit Brandblasen an den Füssen.Endlich. Eine dunkle Treppe führt ins Nichts hinab. Fauliger Dampf schlägt dir entgegen. Du steigst hinunter. Setzt einen Fuss vor den anderen, deine Schritte hallen wider, hundertmal, die Haare kleben dir im Gesicht, tausendmal. Bis du Boden unter den Füssen hast. Fast wäre es dir lieber, die Treppe hätte kein Ende genommen. Du hast genug gelitten. Das Labyrinth macht keinen Sinn. Du hast hier nichts verloren, und du hast gehofft, du könntest nun ins Freie treten, in einen Wald, auf eine Wiese.Stattdessen öffnet sich vor dir eine Halle. Wände und Boden gleichen einer riesigen Schlangenhaut. Glänzende, alles reflektierende Schuppen. Du kannst die Echsenhaut fast spüren. Du betrittst den Saal; da hallt eine Stimme donnernd von den Wänden wider:

„WER BIST DU, DASS DU DEN WÄCHTER DES TORES NACH SO LANGEM SCHLUMMER ERWECKST? WARUM BEGEHRST DU

DURCHGANG?“ *Wer bist du und warum begehrst du Durchgang? Was antwortest du dem Wächter?*

WAS DU WILLST, INTERESSIERT MICH NICHT. DU HAST MEINE RUHE GESTÖRT UND WIRST ZUR STRAFE DIE FEURIGEN SCHMERZEN DIESER HALLE SPÜREN, HIER UND JETZT!Du erschrickst. Verzweifelt rufst du „Tu mir nichts!“ und in letzter Verzweiflung: „Ich gebe dir alles, was du willst!“ Doch der Wächter antwortet nicht mehr. Warum lässt er dich nicht einfach durch? Du kannst doch nichts dafür, dass du ihn gestört hast!Weinend weichst du zurück zur Tür. Du bist verloren. Eine glühende Hand packt dich am Unterarm. Und du spürst den Schmerz.

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