Max-Wertheimer Minerva Center

for

Cognitive Processes and Human Performance

Report of Activities

1/10/2002 - 30/9/2011

Haifa, September 2012

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a. Introduction

a.1 History of the Center

The Max-Wertheimer Minerva Center for Cognitive Processes and Human Performance was established in 1996. It is a joint Center that combines the activity of eight senior researchers from two institutions - the University of Haifa and the Technion, both located in Haifa, Israel. The research activity is conducted in laboratories that the two institutions allocated for the Center at its onset. Part of the joint German-Israeli research is also conducted in Germany. The administrative activity is centered at the University of Haifa, which houses the Center's research coordinator.

The first seven-year evaluation of the Center was in 2003. The members of the evaluation committee were Prof. Peter Alexander Frensch (chairman), Prof. Nelson Cowan, Prof. Randall W. Engle, Prof. Larry L. Jacoby, and Prof. Carlo Umiltá.

The committee's report noted: "Given that some of the world's most important scientists in the areas of meta-cognition, attention, perception, and skill acquisition are members of the Max-Wertheimer Center, it is perhaps not surprising that the scientific impact of the Center has been outstanding. There is no doubt that the Center has been and continues to be a major international player and has been operating at an internationally visible level. The research performed in the last seven years has remained within the scope of the original application".

"The Max-Wertheimer Minerva Center for Cognitive Processes and Human Performance has performed excellently in the past seven years. The Center has adapted very well to changes in the scientific field and to personal changes. It is noteworthy that the Center has attracted a number of highly innovative young scientists. The continuation of funding for the next period is strongly recommended. Possibilities for additional funding have been indicated".

Over the following nine years (2002-2011) the researchers of the Center conducted numerous studies within the framework of four research areas: Meta-cognition of learning and memory, visual perception and attention, decision making, and skill acquisition and training. These studies yielded about 250 publications, and led to about 200 conference presentations (for more detailed information see below section d.). The Center also hosted 40 Joint University of Haifa – Technion Minerva Seminars, and 17 Minerva workshops, where researchers and students from both Institutions met to discuss issues of mutual concern (for more detailed information see below sections a.4.2, and a.4.3).

During this period, the Advisory Board of the Center met four times (March 2004, February 2006, February 2008, and March 2010). All of those meetings were held in Israel. Each meeting lasted for three days, during which the Board attended research presentations and learned about the progress of the research activities of the Center. These meetings took place both at the University and at the Technion, so the Board's members had the opportunity to visit both campuses.

The Center was headed since its establishment by Prof. Koriat (U. of Haifa) and Prof. Gopher (Technion); in 2010 they have handed over the directory of the Center to Prof. Kimchi (U. of Haifa) and Prof. Erev (Technion). Nevertheless, all the major decisions at the Center are made democratically by all members of the Center. The two Heads of the Center are responsible for the day-to-day matters and for the implementation of the decisions of the Center's members. Until 2005, there were six members at the center, four from the University of Haifa (Prof. Asher Koriat, Prof. Ruth Kimchi, Prof. Joel Norman, and Prof. Morris Goldsmith) and two from the Technion (Prof. Daniel Gopher, and Prof. Ido Erev). These were the same members who prepared the proposal for the Center. In 2005, the members of the Center decided unanimously to invite two additional young scientists to join the Center: Dr. Yaffa Yeshurun from the University of Haifa**,** and Dr. (now Prof.) Eldad Yechiam from the Technion. Dr. Yeshurun and Prof. Yechiam have collaborated previously with Minerva members, and since 2005 they are full members of the Center.

a.2 Scientific Aims at the Outset and to Date

The Center's main purpose at its onset was to foster collaborative research projects between the two groups of Israeli scientists, and between Israeli scientists and their German colleagues, working in the area of human cognition and human performance.

The goals of the Center to date are to foster both basic-theoretical and applied research on several aspects of human cognition and performance. Using the concepts of experimental psychology, we address such questions as how people organize and process incoming sensory information to build a mental representation of the environment? How perceptual, attentional, and memory processes interact when people perform complex tasks? What means and strategies people use to control their performance? What processing and representational changes underlie the development of skilled performance? and so on. This basic research, important in its own right, also has many practical implications: (a) design of training programs, (b) cognitive rehabilitation techniques, (c) human-machine interfaces, (d) memory query procedures, and so forth.

a.3 Members of the Center and their Research Areas

University of Haifa

- Prof. Ruth Kimchi
  Peprceptual Organization; Visual Cognition; Object and Face Perception; Visual Attention.
- Prof. Asher Koriat
  Metacognition: Judgments of Learning, Feeling-of-Knowing and Partial Knowledge; Memory Processes and Organization; Spatial Representation and Transformation.
- Prof. Joel Norman
  Vision and Visual Perception; Space Perception; Oculomotor Mechanisms and Visual Performance; Ergonomics of Visual Displays.
- Prof. Morris Goldsmith
  Human Memory and Metamemory; Attention; Visual Cognition; Artificial Intelligence.
- Dr. Yaffa Yeshurun
  Visual Perception; Spatial Attention; Crowding.

Technion

- Prof. Ido Erev
  Decisions from experiences; Learning among Cognitive Strategies.
- Prof. Daniel Gopher
  Human Attention; Work Load; Training of Complex Skills; Components of Motor Behavior.
- Prof. Eldad Yechiam
  Decision Making; Individual Differences.

a.4 Summary of Activities and Participating Scientists

a.4.1 Research Projects

The research projects pursued by members of the Center cover aspects of human cognition and human performance in four research areas:

1. **Meta-Cognition of Learning and Memory**:
   Prof. Koriat and Prof. Goldsmith

2. **Visual Perception and Attention**:
   Prof. Kimchi, Dr. Yeshurun, Prof. Goldsmith, and Prof. Norman.

3. **Decision Making**:
   Prof. Erev, Prof. Yechiam, and Prof. Norman.

4. **Skill Acquisition and Training**:
   Prof. Gopher, Prof. Erev, Prof. Yechiam, and Prof. Norman

The studies in each area span from the evaluation of basic cognitive processes to the analysis of practical human factors questions.

The main contributions of our research are described in detail in chapter c.

a.4.2 Joint University of Haifa and Technion Minerva Seminars

The Center conducted a long series of joint seminars for Minerva researchers and students at both institutions. The purpose of these seminars was to increase interaction between Minerva members at the two sites, and to lead to more collaborative projects. Each seminar consists of a lecture (of one of the Center's researchers, or a guest lecturer), followed by a free discussion. Below is the list of all the seminars that took place over the last nine years (German lecturers are marked by an asterisk):

- Prof. Albert "Skip" Rizzo, University of Southern California.
  Virtual Reality Application to Psychology
- Dr. Dominique Lamy, University of Tel Aviv, Israel.
  The Role of Bottom-Up in Attentional Capture
- Dr. Nira Liberman, University of Tel Aviv, Israel.
  Construal Level Theory: Implications for Construal, Prediction and Evaluation
- *Dr. Andrea Kiesel, University of Würzburg, Germany.
  Parallel Activity of Task Sets - Evidence from Subliminal Priming in Task Switching

- * Dr. Jochim Hansen, University of Basel, Switzerland.
  The Role of Expectation in the Ease of Retrieval Effect
- * Prof. Dr. Klaus Fiedler, University of Heidelberg, Germany.
  Pseudo-Contingencies – an Overlooked Cognitive Illusion
- Prof. Nachshon Meiran, Ben-Gurion University, Israel.
  Using the Task-Switching Paradigm to Unveil Principles of Cognitive Control: Mixing Cost and the Task Rule Congruency Effect
- Prof. Michael Kubovy, University of Virginia.
  Prolegomena to a Theory of Pleasure
- Dr. Galit Yovel, MIT.
  What Makes Upright Faces Special? The Role of Parts and Spacing Information in Face and Object Recognition
- * Prof. Dr. Hans J. Markowitsch, University of Bielefeld, Germany.
  Brain Imaging Correlates of Patients with Emotion-Related Memory Disorders
- Dr. Nurit Gronau, Harvard Medical School.
  Visual Associative Processing is Mediated by a Unified Representation for Semantic and Spatial knowledge
- Dr. Eldad Yechiam, Technion.
  Using Cognitive Models to Map Relations between Neuropsychological Disorders and Human Decision Making Deficits
- Prof. Marius Usher, University of London.
  Modeling Choice, Metacognitive Judgments and Intuition
- Prof. Norbert Schwarz, University of Michigan.
  Constructing Heuristics on the Spot: Malleable Inferences from Experimental Information
- Dr. Daphna Heller, University of Rochester.
  The Use of Perspective Information in Language Comprehension: What Eye-Movements Tell Us about Real Time Processing
- Prof. Ronald Fisher, Florida International University.
  The Relation between Consistency and Accuracy of Eyewitness Memory
- Dr. David. I. Shore, McMaster University, Canada.
  Attention and Perceptual Grouping: Exploring the One-Object COST in Temporal Resolution.
- * Prof. Ralph Hertwig, Max Planck Institute for Human development in Berlin, and University of Basel, Switzerland.
  Mental Powers: How Less Can Be More
- * Dr. Andreas Glöckner, Max Planck Institute for Research on Collective Goods, Bonn, Germany.
  Investigating Intuition Automatic and Deliberate Processes in Quick Decisions

- Prof. Evelyn. G. Schaefer, University of Winnipeg, Canada.
  The Role of Day-planning Devices in Prospective Memory
- Dr. Tal Makovski, University of Minnesota.
  Maintaining Spatiotemporal Continuity in Vision
- * Dr. Andreas Nicklisch, Max Planck Institute for Research on Collective Goods, Bonn, Germany.
  Wage Differentials, Fairness, and Social Comparison: An Experimental Study of Interrelated Ultimatum Bargaining
- * Prof. Boris Velichkovsky, Dresden University of Technology, Germany.
  From Studying Cognitive Systems to Developing Cognitive Technologies
- Dr. Pia Rotshtein, University of Birmingham, UK.
  Different Ways by which Perception Can be Modulated
- Dr. Carmel Mevorach, University of Birmingham, UK.
  The Intraparietal Sulcus and Its Battle against Saliency
- * Dr. Masami Ishihara, Max Planck Institute for Human Cognitive and Brain Sciences Leipzig, Germany.
  Horizontal Spatial Representations of Number and Time
- Prof. Marcel Just, Carnegie Mellon University, Pittsburgh.
  Identifying the Content of Simple Thoughts from the Underlying Pattern of FMRI-Measured Brain Activity
- PhD. student Ido Roll, Carnegie Mellon University, Pittsburgh.
  Knowing 'Further' – The Effect of Symbolic Invention Tasks on the Flexibility of Students' Knowledge
- * Prof. Jochen Braun, Otto-von-Guericke University, Magdeburg, Germany.
  Why is Visual Perception Multi-Stable?
- *Prof. Wolfgang Prinz
  Action Simulation: Exploring Representational Underpinnings of Unseen Action
- Prof. Donald T. Stuss
  The Anterior Attentional System Consists 0f Several Components: Consistency of Findings
- Prof. Ruben Gur
  Exploring the Neurobiology of Emotion Processing from Brain Activation to Genomics
- PhD. Student Yaron Shlomi
  Subjective Integration of Probabilistic Information from Description and from Experience
- Dr. Noam Sagiv
  Synaesthesia – a Window into Perception, Consciousness and Cognition

- Dr. Inbal Arnon
  Starting Big - The Role of Multi-Word Phrases in Language Learning and Processing
- Prof. Sarah Berger
  Cognition in Motion: Decision-Making in Infants' Adaptive Locomotion
- Prof. Marlene Behrmann
  Complementary Neural Representations for Faces and Words
- Prof. Michael Kubovy
  Audio-Visual Objects
- Dr. Assaf Botzer
  Strategic Behavior, Single Decisions And User Effort when using Binary Cues
- Prof. Albert F. Smith
  Insufficiency of a Letter Route for Word Identification
- Dr. Shira Elqayam
  Inferring Normative Values from Descriptive Premises

a.4.3 Minerva Workshops

In addition to Minerva Seminars, following the recommendations of the previous Minerva Review Committee (November, 2003), we decided to initiate Minerva Workshops. Each workshop focused on one main theme, and included several lectures, followed by free discussions. Members of the Minerva Center, graduate students, and external researchers involved in the projects of the Center, participated in the workshops, gaining the opportunity to produce a synergy of ideas, that can inspire significant future collaborative research.

Below is the list of all the workshops that took place over the last nine years (German lecturers are marked by an asterisk):

- **The 1st Minerva Workshop: Decisions from Experience**

* Prof. Ralph Hertwig
Bernoulli Goes Cognitive
Ph.D. Student Nira Munichor
Risk Attitude in Small Timesaving Decisions
Dr. Morris Goldsmith
On the (Potential for Stronger) Mutual Relations between Decision-Making and basic Cognitive Research- an Open Discussion

- **The 2nd Minerva Workshop: The Many Faces of Attention**

Prof. Daniel Gopher
Control Processes in the Formation of Task Units
Dr. Yaffa Yeshurun
Transient Spatial Attention and Visual Temporal Processes
Prof. Ruth Kimchi
Perceptual Organization and Visual Attention
Dr. Morris Goldsmith and Ph.D. Student Meni Yeari
Visual Attention to Objects and Space: A Dynamic, Interactive Framework

- **The 3rd Minerva Workshop: 2nd Workshop on Decisions from Experience**

Prof. Greg Barron, Jennifer Stack and Stephen Leider
Forewarned is Forearmed: The Effect of Experience on a Warnings' Impact.
Joachim Meyer, Liat Frenkel and Yisrael Parmet
Target Detection with Different Levels of Automation
Dr. Eldad Yechiam
Using Cognitive Models to Map Relations between Neuropsychological Disorders and Decision-Making Deficits
Prof. Ido Erev, Dr. Eyal Ert, Tal Shavit, Uri Ben Zion, and Prof. Ernan Haruvy
Chasing, Confusion, and Index Funds

- **The 4th Minerva Workshop - a Special Minerva Workshop on Decision Making**

Dr. Eldad Yechiam
Prof. Ido Erev
Prof. Eric J. Johnson
Prof. Elke U. Weber
A Round Table Discussion of the Value of Qualitative and Quantitative Models of Behavior
Prof. Eric J. Johnson
Aspects of Endowment: A Query Theory Account of Loss Aversion
Prof. Elke U. Weber
Preference Construction and the Role of Memory: Explaining Asymmetries in Intertemporal Choice

- **The 5th Minerva Workshop: on Decision Making**

Nira Munichor
Risk Attitude in Small Timesaving Decisions
Yakov Ben-Haim
Robust-Satisficing and the Probability of Survival
Dr. Eldad Yechiam
Acute Drug Effects on Motivational and Cognitive Processes Involved in Repeated Choice Behavior
Gilly Koritzky
Inequity Aversion: A Social Utility or a Reasonable Strategy?
Dr. Shahar Ayal
Diversity-Seeking in Gains and Diversity-Aversion in Losses
Dr. Eyal Ert
The Effect of Losses in Decisions from Description and from Experience
Guy Hochman
The Partial Reinforcement Extinction Effect: Boundaries and Implications
Prof. Ido Erev
On the Psychological Impact of Rare Events
Guy Hochman and Dr. Shahar Ayal
The Weakness of the Noncompensatory Assumptions as a Processes' Descriptive model: Challenging the "Priority" and the "Take the Best" Heuristics
Dr. Eyal Ert and Prof. Ido Erev
On the Origin of the Loss Aversion Hypothesis

- **The 6th Minerva Workshop: on Small Decisions**

* Dr. Guido Biele
Human Learning in Partially Observable Markov Problems
Amos Schurr
Two Systems, Careful Analysis, and Base Rate Neglect
Dr. Ro'i Zultan
Peak or Rare
Dr. Shahar Ayal and Guy Hochman
The Priority Heuristic, Confidence and Reaction Time

- **The 7th Minerva Workshop: on Small Decisions**

Timothy Rakow
One Step Closer to "True Uncertainty": Repeated Choices with Non-Stationary Payoffs as a New Test Bed for Decision Model
Shai Danziger,
The Effect of Store Discount Frequency and Depth on Choice and Judgment Under Price Uncertainty

Ariel Telpaz
Pre-Task Arousal as Predictor of Risk Taking Behavior
Dr. Eldad Yechiam
Losses Signal Risk and Increase Consistency in Human Behavior
Kinneret Weiss
On the Decision to Explore
Uri Gneezy
White Lies
Prof. Ido Erev and Amos Schurr,
Peaks, Feqs, and the Effect on Extreme Experiences
Gur Huberman
Discussion

- **The 8th Minerva Workshop: on Small Decisions, Culture and Emotions**

Simon Gächter
Culture and Cooperation
Mia Erez
Culture and innovation
Anat Refaeli
The Effects of Anger at Work
Rosemarie Nagel
Assessing Risk and Uncertainty with FMRI
Giorgio Coricelli
Counterfactual Thinking and Emotions: Regret and Envy Learning
Eldad Yechiam
The Emotional Agents within us: Brain and behavioral Responses to Losses
Ido Erev
Emotions, Culture and Contingent Sampling

- **The 9th Ninth Minerva Workshop**

Luigi Mittone
Experimental Studies of Tax Evasion
Eitan Man
The Economics of Learned Helplessless
Gregory Gurevich and Doron Kliger
Rational Thinking and Social Factors in Economics

- **The 10th Minerva Workshop**

* Martin Hohnisch, * Sabine Pittnauer, * Reinhard Selten and * L. Kramer
Taste Characteristics and the Deployment of Selection Procedures
Yael Steinhart
Whether You Win or whether You Lose: The Differential Risk of Priming the Deliberative and Affective Systems in On-Line Auctions
Eitan Gerstner
Brands as Investments

- **The 11th Minerva Workshop: on the Effect of Rare Events**

Laurence T. Maloney
Distortions of Probability Information in Human Judgment: Ubiquitous Log Odds
Ido Erev
Rare Events and the Experience-Description Gap
Amos Schurr
Peak or Freq?
Eldad Yechiam
Super-Underweighting of Rare Events with Forgone Payoffs

- **The 12th Minerva Workshop**

Irwin Levin
Accentuating the Positive: Measuring Decision Making Competence
Jolie Martin
Experience Theory: Reversals in Risk Preferences between Experiences and Gambles
John Payne
Live to or Die by: Framing Effects on Life Expectations
Eldad Yechiam
More about Losses: How a Small Loss can be a Blessing

- **The 13th Minerva Workshop: on the Neuroscience and Psychophysiology of Experience-Based Decisions**

Eldad Yechiam and Itzhak Haharon
Welcome
Larry Maloney
Experience and Uncertainty in Perception and Action
Yael Niv
Is Experiential Reinforcement Learning Sensitive To Risk?
Nathaniel Daw
Reinforcement Learning: Beyond Reinforcement

Eldad Yechiam
Losses, Experience, and the Brain
Ido Erev
On Surprise, Change, and the Effect of Recent Outcomes
Rachel Tomer
Experience Based Decision Making: The Significance of Dopamine Asymmetry
Marius Usher
Psychometrical Investigations of Fast Value Integration in Multi-Alternative Decisions
Yonatan Loewenstein
Primacy in Operant Learning
Michal Lavidor
Transcranial Direct Current Stimulation (tdcs) Facilitates Decision in a Probability Guessing Task
Davide Marchiori
Learning and Generalizing Regret-Driven Neural Networks
Itzhak Aharon
fMRI and Experience-Based Decisions

- **The 14th Minerva Workshop**

Oren Musicant "Or Yarok" Association
In-Vehicle Data Recorders for Monitoring and Feedback on Drivers' Behavior
Hadas Marciano
The Effect of Advertising Billboards on Driving Performance as A Function of Size and Type
Yoram Shiftan
The Impact of in Vehicle Data Recorder Information on Driving Behavior
Eldad Yechiam
The Decision Making Style of Reckless Drivers

- **The 15th Minerva Workshop: on Cognition and Organizational Behavior: In Honor of Daniel Gopher and Miriam Erez**

Day 1: Cognition and Performance in Honor of Daniel (Danny) Gopher
Cognitive Process and Neuroscience
Peretz Lavie
TBH
Yaakov Stern
Intervening in Cognitive Aging
Attention and Executive Control
Arthur F. Kramer
A Tale of two Training Strategies: Boosting Cognition and Brain Function

Christopher D. Wickens
Strategic Control of Attention to Events and to Tasks.
Applications
Yaakov Greenshpan
Emphasis Change, Basketball and Ice Hockey
Yoel Donchin
A Short History of Medical Errors
Learning and Decisions
Eldad Yechiam
Attention Investment and Decision Making
Ido Erev
On the Decision to Explore
Panel of former students and co-workers (short presentations): Yael Einav, Gil Hupert-Graff, Nahum Fosfeld, Michael Brikner, Vered Erev-Yehene, Chair: Yair Lifshitz
Daniel Gopher

Day 2: Organizational Behavior in Honor of Miriam (Mia) Erez
Climate and Innovation (Chair: Cynthia Lee)
Ben Schneider
An Historical Overview of the Service Climate Research Paradigm
Dov Zohar
What is the Difference between Organizational Climate and Culture (and Why do People Mix the Two)?
*Michael Frese
Toward a Psychology of Entrepreneurship - An Action Regulation Theory Perspective
Motivation (Chair: Avi Kluger)
Ed Locke
The Effect on Performance of Having Simultaneous Learning and Performance Goals
Gary Latham
The Importance of Subconscious Goals for Influencing Organizational Behavior
Dov Eden
Means Efficacy: A Motivational Construct Whose Time Has Come
Cross-Culture and Emotions (Chair: Julia Bear)
Anat Rafaeli
Emotions at Work
Simcha Ronen
Ecocultural Predictors of Country-Culture clusters

Chris Earley
Cultural Intelligence and the Evolution of Cross-Cultural OB
Innovation Center - Iris Arbel
Panel of former students (short presentations): Eitan Naveh, Ester Unger-Aviram, Dana Vashdi, Ella Miron-Spektor, Alon Lisak (Chair: Cynthia Lee)
Mia Erez

- **The 16th Minerva Workshop**

Robin Hogarth
What are the Chances of Winning? Exploring the Ecology and Psychology of Competitions
Orit Tykocinski
Embracing Chance to Deflect Responsibility: A Different Perspective on Risk-Seeking Choices
Shahar Ayal
Reducing Ethical Dissonance
Ramzi Suleiman
A Theory of Harmony
Eldad Yechiam
A Dissociation between Subjective Evaluations and Behavioral Decisions Concerning Losses
Ido Erev
On Loss Aversion, Level-1 Reasoning, and Betting

- **The 17th Minerva Workshop**: **on Decisions and Emotional Expressions**

Ido Erev
My view of Gary Bornstein's Views of Decisions and Emotions
Ori Heffetz
Beyond Happiness and Satisfaction: Towards National Well-Being Indices Based on Stated Preference
Eyal Winter
Mental Equilibrium Emotions and Mind Reading
Arnon Lotem
Why Organisms Need Emotions: An Evolutionary Perspective
Talya Miron-Shatz
"Is it Good, Bad, or Indifferent?" Misunderstanding Medical Information
Amos Schurr
The Peak and the Freq Effects
Kinneret Teodorescu
On Learned Helplessness, Absence of Control and the Cost of Exploration

a.4.4 Minerva Lectures

Since 2004 we initiated a series of Minerva Lectures that are open to the academic community in both the University of Haifa and the Technion, hosting the following lectures:

* Prof. Frank Rösler
Episodic memory: In what Sense is it Unique?
Prof. Elizabeth F. Loftus
What's the Matter with Memory?
Prof. Michael Posner
How Genes and Experience Shape Attentional Networks?

a.4.5 Co-investigators and Collaborators

(German co-investigators and collaborators are marked by an asterisk):

- Prof. Carlo Alberto Avizzano, Scuola Superiore Sant'Anna di Studi Universitari e di Perfezionamento, Perceptual Robotics Laboratory, (PERCRO), Pisa, Italy.
- * Prof. Carlos Alos-Ferrer, Department of Economics, University of Konstanz, Germany.
- Dr. Galia Avidan, Department of Psychology, Ben Gurion University, Israel.
- Dr. Tamar Avraham, Computer Science Department, Technion, Israel.
- Prof. Benoit Bardy, University of Montpellier, France.
- Prof. Gregory Barron, Harvard University, U.S.A.
- Prof. Antoine Bechara, University of Iowa, Iowa City, U.S.A.
- Prof. Marlene Behrmann, Department of Psychology, Carengie Mellon University, Pittsburgh, Pennsylvania, U.S.A.
- Prof. Massimo Bergemasco, Scuola Superiore Sant'Anna di Studi Universitari e di Perfezionamento, Perceptual Robotics Laboratory, (PERCRO), Pisa, Italy.
- * Dr. Guido Biele, Max-Planck-Institute, Berlin, Germany.
- Prof. Robert Bjork, Department of Psychology, UCLA, California, U.S.A.
- * Prof. Dr. Herbert Bless, University of Mannheim, Germany.
- Dr. Helena Bluman, Sergievsky Center and the Taub Institute, Columbia University College of Physicians & Surgeons, NY, U.S.A
- * Dr. Ulrich Bochhult, Fraunhofer Institut für Graphische Datenverarbeitung (IGD), Virtual and Augmented Reality laboratory, Munich, Germany.
- Dr. Sylvain Bouchigny, Commissariat l'energie atomique et aux énergies alternatives (CEA), France.
- Prof. David Budescu, University of Illinois, U.S.A.

- Prof. Jerome Busemeyer, Indiana University, Bloomington, Indiana, U.S.A.
- Prof. Marisa Carrasco, Department of Psychology, New York University. U.S.A.
- Prof. Cesare Cornoldi, Department of Psychology, University of Padova, Italy.
- Prof. Rossana De Beni, Department of Psychology, University of Padova, Italy.
- Prof. Richard de Mulder, Erasmus University, Rotterdam, Holland.
- *Dr. Niels Dingemanse, Department of Behavioural Ecology and Evolutionary Genetics, Max Planck Institute for Ornitholog at Seewiesen, München, Germany.
- Prof. Yadin Dudai, Department of Neurobiology, Weizmann Institute of Science, Israel.
- Dr. Hagit El-Or, Dept. of Computer Science, University of Haifa, Israel.
- Prof. Tor Endestad, Department of Psychology, University of Oslo, Norway.
- * Prof. Dr. Edgar Erdfelder, University of Mannheim, Germany.
- Dr. Vered Erev-Yehene, Technion, Israel.
- * Prof. Dr. Klaus Fiedler, University of Heidelberg, Germany.
- Prof. Peter Finn, Indiana University, Indiana, U.S.A.
- Prof. Ronald Fisher, Department of Psychology, Florida International University, Florida, U.S.A.
- Prof. Antonio Frisoli, Scuola Superiore Sant'Anna di Studi Universitari e di Perfezionamento, Perceptual Robotics Laboratory, (PERCRO), Pisa, Italy.
- * Dr. Andreas Glöckner, Max Planck Institute for Research on Collective Goods, Bonn, Germany.
- Prof. Florian Gosselin, CEA, Commissariat à l'Energie d'Intégration des Systèmes et Technologies France.
- *Dr. Ben Grainer (Max Planck Institute of Economics, Strategic Interaction Group, Jena, Germany), now in University of New South Wales, Australia.
- Prof. Seth N. Greenberg, Psychology Department, Union College, New York, U.S.A.
- Prof. Arthur Grunwald, Technion, Israel.
- Dr. BatSheva Hadad, Department of Behavioral Science, Emek Yezreel College, and Department of Special Education, University of Haifa, Israel.
- Prof. Dorte Hammersh, Acoustics Section (AAU), Aalborg University, Denmark
- * Dr. Jochim Hansen, Institute for Psychology, University of Basel, Switzerland.
- Prof. Ernan Haruvy, University of Dallas, Texas, U.S.A.
- Dr. Elizabeth Hayden, University of Western Ontario, Canada.
- *Prof. Hauke, R. Heekeren Freie, Universiät Berlin, and Max Planck Institute for Human Development, Germany.
- * Dr. Elisabeth Hein, Universität Tübingen, Tübingen, Germany.
- Prof. Tore Helstrup, Department of Psychology, University of Oslo, Norway.
- * Prof. Ralph Hertwig, Max Planck Institute in Berlin, Germany.

- Prof. Bill Hetrick, Indiana University, Indiana, U.S.A.
- Dr. Pablo F. Hoffmann, Acoustics Section (AAU), Aalborg University, Denmark
- *Anja Hoffmann-Biencourt, University of Wuerzburg, Germany.
- Dr. Martin Hohnisch, Department of Economics, Bonn University, Germany.
- Dr. Cristina Iani, University of Modena, Italy, and University of Illinois, U.S.A.
- * Dr. Masami Ishihara, Department of Psychology, Max Planck Institute for Human Cognitive and Brain Sciences Leipzig, Germany.
- Prof. Larry, L. Jacoby, Washington University, St. Louis, MO, U.S.A.
- *Prof. Martin Kocher, Department of Economics, Ludwig-Maximilians-Universität München, München, Germany.
- * Dr. Ralf Koeppe, KUKA Roboter GmbH, Augsburg, Germany.
- Dr. Hamutal Kreiner, Open University, Israel.
- Prof. Isabelle Laffont, Departement de Medecine Physique et de Readaptation CH&U Montpellier, France.
- Dr. Julien Lagarde, University of Montpellier, France.
- Prof. Peretz Lavie, Faculty of Medicine, Technion, Haifa, Israel.
- Prof. Michael Lindenbaum, Computer Science Department, Technion, Israel.
- * Dr. Kathrin Lockl, Otto-Friedrich-University of Bamberg, Bamberg, Germany.
- Prof. Arnon Lotem, University of Tel Aviv, Israel.
- Prof. William R. Lovallo, University of Oklahoma Health Sciences Center, U.S.A.
- Dr. Anna MacKay - Brandt, Sergievsky Center and the Taub Institute, Columbia University College of Physicians & Surgeons, NY, U.S.A.
- Prof. Svein Magnussen, Department of Psychology, University of Oslo, Norway.
- Prof. Laurence, T. Maloney, New York University, U.S.A.
- * Prof. Dr. Hans J. Markowitsch, University of Bielefeld, Germany.
- * Prof. Dr. Cristina Meinecke, Friedrich-Alexander-University, Erlangen, Germany.
- Prof. Amina Memon, Aberdeen University, UK.
- Prof. Nanacy Minshew, University of Pittsburgh School of Medicine, U.S.A.
- Prof. Denis Mottet, University of Montpellier, France.
- * Prof. Dr. Jochen Müsseler, Max-Planck Institute for Psychological Research, Munich, Germany. Now in Work and Cognitive Psychology Department, RWTH Aachen University, Germany.
- *Dr. Andreas Nicklisch, Max Planck Institute for Collective Goods, Bonn, Germany.
- * Prof. Dr. Monika Nisslein, Psychology Department, University of Munich Max Planck Institute for Human Cognitive and Brain Sciences, Leipzig, Germany.

- Prof. Steve Palmer, Department of Psychology, University of California, Berkeley, U.S.A.
- Prof. Mary A. Peterson, Department of Psychology, University of Arizona, U.S.A.
- * Dr. Ulrike Phleps, KUKA Roboter GmbH, Augsburg, Germany.
- *Dr. Sabine Pittnauer, Department of Economics, Bonn University, Germany.
- * Dr. Carsten Preusche, Deutsche Zentrum Raumfahrt e.V. (DLR), Darmstadt, Germany.
- Prof. Emauele Raffaldi, Scuola Superiore Sant'Anna di Studi Universitari e di Perfezionamento, Perceptual Robotics Laboratory, (PERCRO), Pisa, Italy.
- Dr. Tim Rakow, University of Essex, UK.
- Dr. Irene Razpurker-Apfeld, Technion, Israel.
- Prof. Alvin Roth, Department of Economics at Stanford University, U.S.A.
- Dr. Emilio Sanchez, Departamento de Mecanica Aplicada Centro de Estudios e Investigaciones, Tecnicas de Gipuzkoa (CEIT), University of Navara, San Sebastian, Spain.
- Dr. Suzy Scherf, Department of Psychology, Carnegie Mellon University, Pittsburgh, Pennsylvania, U.S. A.
- * Prof. Dr. Wolfgang Schneider, Psychology Department, University of Würzburg, Germany.
- *Prof. Reinhard Selten, Department of Economics, Bonn University, Bonn, Germany.
- Dr. Pe'erly Setter, Ergonomics and Human Factors Unit, University of Haifa, Israel.
- Dr. Serge Sevy, Zucker Hillside Hospital, Glen Oaks, NY, U.S.A.
- Dr. Simone Shamay-Tsoory, Haifa University, Israel.
- Dr. Sarah Shomstein, Department of Psychology, George Washington University, Washington, DC., U.S.A.
- Dr. Branka Spehar, University of New South Wales, Australia.
- * Prof. Dr. Dagmar Stahlberg, University of Mannheim, Germany.
- Prof. Yaakov Stern, Sergievsky Center and the Taub Institute, Columbia University College of Physicians & Surgeons, NY, U.S.A.
- * Dr. Med. Aglaja Stirn, Clinic for Psychosomatic Medicine of the Johann Wolfgang Goethe-University, and a Research Fellow at the Max-Planck-Institute for Brain Research, Frankfurt, Germany.
- * Prof. Dr. Fritz Strack, Psychology Department, University of Würzburg, Germany.
- Prof. Julie Stout, Indiana University, Bloomington, Indiana, U.S.A.
- *Dr. Didier Stricker, Fraunhofer Institut für Graphische Datenverarbeitung (IGD), Virtual and Augmented Reality laboratory, Munich, Germany.
- Prof. Franco Tecchia, Scuola Superiore Sant'Anna di Studi Universitari e di Perfezionamento, Perceptual Robotics Laboratory, (PERCRO), Pisa, Italy.

- Dr. Cibu Thomas, Department of Psychology, Carnegie Mellon University, Pittsburgh, Pennsylvania, U.S.A.
- Dr. Tomer Toledo, Faculty of civil and environmental engineering, Technion, Israel.
- * Dr. Patrick van der Smagt, Deutsche Zentrum Raumfahrt e.V. (DLR), Darmstadt, Germany.
- * Prof. Dr. Michaela Wänke, University of Erfurt, now: University of Basel, Switzerland.
- *Dr. Sabine Webel, Fraunhofer Institut für Graphische Datenverarbeitung (IGD), Virtual and Augmented Reality laboratory, Darmstadt, Germany.
- Prof. Elke Weber, Columbia University, New York, U.S.A.
- Prof. Bruce Whittlesea, Department of Psychology, Simon Fraser University, Canada.
- *Max Wolf, Department of Biology and Ecology of Fishes, Leibniz-Inst. of Freshwater Eco.& Inland Fisheries, Berlin, Germany.
- * Dr. Hubert Zimmer, Psychology Department, Saarland University, Saarbruecken, Germany.
- * Dr. Owe Zimmerman, KUKA Roboter GmbH, Augsburg, Germany.

a.4.6 Grants from other Foundations

The members of the Minerva Center have won a number of grants from several research agencies. Partial support for the studies conducted in the Center came from these grants.

- **The mutual effects of monitoring and control processes in metacognition**
  Israel Science Foundation (2000-2003). $60,000
  Prof. Asher Koriat.
- **Visual interaction and human effectiveness in the cockpit**
  European Community 5th Framework (2000-2003). $ 263,000
  Prof. Daniel Gopher and Prof. A. Grunwald. International collaboration with partners from UK, Netherlands, Sweden, Denmark and Poland.
- **Visual perceptual organization: Psychological and neural mechanisms**
  US-Israel Binational Science Foundation (BSF) - (2000-2003). $150,000
  Prof. Ruth Kimchi and Prof. Marlene Behrmann.
- **The time course of forgetting: Focus on memory accuracy and mediating mechanisms**
  Israel Foundation Trustees (2002-2004**)**. $20,000
  Prof. Asher Koriat and Prof. Morris Goldsmith.
- **Are transient and sustained attention adaptable: Can they both increase and decrease spatial resolution?**
  United States Israel Binational Science Foundation (BSF) (2002-2005). $89,343
  Dr. Yaffa Yeshurun and Prof. Marisa Carrasco, New York University.
- **Metacognition: A window to the conscious and unconscious determinants of behavior**
  A collaborative Israel-German project (2002-2006). € 1,066,000
  Bundesministerium für Bildung und Forschung (BMBF) – DIP Israel: € 816,000 Germany: € 250,000
  Israel
  Prof. Asher Koriat, Prof. Morris Goldsmith, Dr. Ravit Nussinson, and Dr. Ainat Pansky – Minerva Center, University of Haifa.

  Germany

  Prof. Dr. Herbert Bless - University of Mannheim.
  Prof. Dr. Dagmar Stahlberg - University of Mannheim.
  Prof. Dr. Klaus Fiedler - University of Heidelberg.
  Prof. Dr. Fritz Strack - University of Würzburg.
  Prof. Dr. Michaela Wänke - University of Erfurt (now University of Basel).

- **Small decisions**
  US-Israel Binational Science Foundation (BSF) (2003-2006). $40,000.
  Prof. Ido Erev, Prof. Al Roth and Prof. Ernan Haruvy.

- **Cognitive biases in humans and birds**
  Israel Science Foundation (ISF) (2003-2007). $160,000.
  Prof. Ido Erev and Prof. Arnon Lotem.

- **A Study of human stereoscopic eye-movements to provide data for computer vision models**
  The Caesarea Edmond de Rothschild Foundation Institute for Interdisciplinary Applications of Computer Science, University of Haifa (2004-2006). $10,000.
  Dr. Pe'erly Setter and Prof. Joel Norman.

- **Improving baggage inspection with the aid of a stereoscopic x-ray display**
  Center for Security Science and Technology – Technion, Israel Institute of Technology (2004-2006). $10,000.
  Prof. Joel Norman and Dr. Pe'erly Setter .

- **Seeking evidence for the independent functioning of the two perceptual systems: dorsal system pickup of optic flow with concurrent ventral perception of object identity**
  Israel Science Foundation (2005-2008). NIS 348,978.
  Prof. Joel Norman.

- **Transient attention and the temporal impulse response**
  The Israel Science Foundation (ISF) (2005- 2008). NIS 351,496.
  Dr. Yaffa Yeshurun.

- **Cognitive modeling of impulsive decision-making: An integrative approach**
  Israel Science Foundation (2006-2009). $44,762.
  Prof. Eldad Yechiam.

- **Perceptual organization and visual attention: Stimulus-driven attentional capture by a perceptual object**
  The Israel Science Foundation (ISF) (2006–2009). NIS 327,374.
  Prof. Ruth Kimchi, and Dr. Yaffa Yeshurun.

- **Hierarchical navigation of visual attention: Object-based and/or space-based focusing and orienting**
  Israel Science Foundation (Israel Academy of Sciences and Humanities) (2006-2010). NIS 633,420.
  Prof. Morris Goldsmith.

- **Quality control in memory retrieval and reporting**

  United-States Binational Science Foundation (BSF) (2006-2010). $ 155,686.
  Prof. Morris Goldsmith and Prof. Larry Jacoby

- **Multimodal interfaces for capturing and transfer of skill- SKILLS**

  An Integrated Project of the European Community 6th Framework Program (2006-2011). € 963,000 (Total grant support € 10,000,000)
  Prof. Daniel Gopher and Prof. Eldad Yechiam:
  - (coordinator) Scuola Superiore di Studi Universitarie di Perfezionamento Sant'Anna. Pisa, Italy.
  - Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung e.V. Germany.
  - Commissariat à l'Energie Atomique Laboratoire d'Intégration des Systèmes et Technologies. France.
  - University of Montpellier-1. France
  - Deutsches Zentrum für Luft-und Raumfahrt. Germany.
  - Fundaciòn LABEIN. Spain.
  - Centro de Estudios e Investigaciones Técnicas de Gipuzkoa. Spain.
  - Technion: Israel Institute of Technology. Israel
  - University of Tampere. Finland.
  - Queen's University Belfast. Ireland.
  - Aalborg University. Denmark
  - Haption S.A. France.
  - KUKA Roboter. Germany
  - OMG .Oxford UK.
  - Sim onazzi S.p.A. Italy.

- **Adequate level of mental arousal in a cognitive task: A new approach**

  US Air Force (2007-2008). $29,286.
  Prof. Eldad Yechiam.

- **Visual fatigue from extended computer usage: Individual differences, causes, and mitigation.**

  USAF-AFRL (2007-2008). $119,760.
  Prof. Joel Norman and Dr. Pe'erly Setter.

- **The assessment of eyewitness memory: A multi-componential, correspondence-oriented approach**

  European Union 6th Framework Program (FP6), New and Emerging Science and Technology (NEST) (2007-2010). € 1,700,000
  Prof. Asher Koriat, Prof. Morris Goldsmith, Dr. Ainat Pansky, Prof. Amina Memon, Prof. Hans Markowitsch, and Prof. Richard De Mulder.

- **The intricate relationships between metacognitive monitoring and metacognitive control during learning: A developmental perspectives**

  German-Israeli Foundation for Scientific Research and Development (GIF) (2007-2010). € 178,250

  Prof. Asher Koriat, Prof. W. Schneider and Dr. K. Lockl.

- **Developing a visual transparency tool for improving INTERNET navigation – a human factors approach**

  Israel Internet Association (2008-2011). NIS 225,000

  Prof. Joel Norman, Dr. Hagit Hel-Or, Dr. Pe'erly Setter, and Hadas Marciano.

- **A systematic evaluation of in-car warning systems under varying conditions of perceptual load**

  The Ran Naor Foundation (2009-2010). NIS 79,640

  Dr. Yaffa Yeshurun.

- **The effect of billboards on driving as a function of type of billboard, their size, and density**

  The Israel National Road Safety authority (2009-2010). NIS 244,835

  Prof. Joel Norman, Dr. Yaffa Yeshurun, Dr. Tomer Toledo, Dr. Pe'erly Setter, and Dr. Hadas Marciano.

- **The effects of perceptual load on driving quality and the usability of in-car warning systems**

  The Research Fund on Insurance Matters (2009-2011). NIS 158,500

  Dr. Yaffa Yeshurun.

- **The boundaries of loss aversion**

  Israel Science Foundation (ISF) (2009-2012). $102,000.

  Prof. Ido Erev.

- **Prediction competitions**

  US-Israel Binational Science Foundation (BSF) (2009-2013). $68,000

  Prof. Ido Erev, Prof. Al Roth and Dr. Eyal Ert.

- **Automatic enforcement methods: overt versus covert speed cameras and the best conditions for their implementation**

  The Research Fund on Insurance Matters (2010-2012). 355,795 NIS

  Prof. Joel Norman, Dr. Peerly Setter, and Dr. Hadas Marciano.

- **Long-Term Treatment with Dehydroepiandrosterone (DHEA) and its effect on quality of life, psychosocial factors and cognitive functioning in multidrug-dependent addicts.**

  Israel Anti-Drug Authority (2010-2012). NIS 161,548.

  Prof. Eldad Yechiam, Prof. Gal Yadid, and Dr. Paula Rosca

- **Role of attention in object recognition: an interactive iterative framework**

  Israel Science Foundation (ISF) (2010-2014). $164,103.
  Prof. Ruth Kimchi, and Prof. Morris Goldsmith.

- **Attention as an attraction field (AAF): The development and evaluation of a novel model of spatial attention**

  The National Institute for Psychobiology in Israel - NIPI (2011-2013)
  $100,000.
  Dr. Yaffa Yeshurun

a.4.7 Support and Integration of Younger Scientists

Although the information in this section overlaps, in part, some of the information mentioned in the following sections, we thought that it would be important to bring to the fore the specific contribution of young scientists to the operation of the Minerva Center.

During the last nine years a number of M.A and PhD. students conducted researches at the Center under the supervision of one of the members of the Center. Here is a list of all the students that have been supported by the Center:

M.A Students (University of Haifa and Technion)

Adi Luria, Adiela Meshulam, Aliza Cohen, Alon Galili, Alon Shimoni, Amabell Asoulin, Amos Schurr, Avichay Baram, Avshalom Ehrlich, Barak Sofer, Chen Sperling Ben-Zvi, Einat Rashel, Eyal Ert, Eyal Hershkovitz, Gilad Sabo, Gilly Koritzky, Guy Hochman, Guy Sha'ashua, Idan Zelikovich, Ido Lev Ran, Ido Nagid, Ilanit Hochmitz, Inon Hyman, Ira Lybman, Iris Nevo, Itay Ben Naftaly, Josh Kotler, Liat Levi, Maya Arad, Meir Druyan, Meni Yeari, Michal Amir, Moran Barkan, Nira Shaked, Noam Mor, Olga Arshavski, Olga Chuntonov, Ori Plonski, Orly Cohen, Rachel Shitzer, Rachel Zeituni, Rani Bar-On, Reut Livne, Ron Arazi, Rotem Lammfromm, Ruth Peled, Sari Eran-Herskovitz, Shabtai Spigel, Shai Aviram, Shani Guy, Sheffer Oded, Shiri Adiv, Taly Ish Shalom, Tomer Carmel, Yamit Provisor, Yifat Shor, Yonatan Tal (Tarlovsky), Yossef Pirkner.

The University of Haifa

Ph.D. and M.A. Students

- Dr. Ainat Notea-Koren: Performance accuracy and quantity in psychometric testing: An examination and assessment of cognitive and metacognitive components, 2006.
- Dr. BatSheva Hadad: Development of perceptual organization, 2006.
- Einat Rashal: Competition in the process of perceptual organization, In progress.
- Dr. Hadas Marciano Perceptual load in different regions of the visual field and its relevance for driving, 2012.
- Dr. Hamutal Kreiner: Prosody in reading: The contribution of prosody to text processing, 2004.
- Dr. Hilit Ma'ayan: Process underlying the allocation of study time in self-paced learning, 2005.
- Dr. Irene Razpurker-Appfeld: Perceptual grouping: A unitary preattentive process, of several operations which differ in their time course and attentional demands?, 2002.
- Dr. Limor Sheffer: The reliability and structure of metacognitive skills and their relationship to cognitive performance, 2004.
- Dr. Meni Yeari: Dynamic aspects of hierarchical attentional navigation, 2009.
- Dr. Orit Baruch Control over grain size in question answering under differing states of knowledge, 2012
- Dr. Rakefet Ackerman: Control over grain size in question answering under differing states of knowledge, 2008.
- Dr. Rama Amishav: Analytic and holistic processes in face perception, 2008.
- Shiri Adiv: Time is not all you need: the effects of study time on judgments of learning and recall. In progress.
- Dr. Shiri Avnion: Social cognition and the use of language in Williams syndrome children and in other developmental social pathologies, 2002.
- Dr. Vered Halamish (Galon): Quality control in memory retrieval and reporting: Cognitive and metacognitive components, 2009
- Dr. Yaron Alima: Perceptual preference for congruency: Modal and inter-modal investigation, 2012

Highlighted Past/Current Graduate Students Starting an Academic Career

Dr. Rakefet Ackerman - received her Ph.D. at the Center under the supervision of Prof. Morris Goldsmith, 2008**.** During 2009, she held a Post Doc position at Ben-Gurion University, Israel, with Prof. David Leiser). In addition to her dissertation research, she has been collaborating with Prof. Koriat on developmental aspects of metacognitive judgments. Dr. Ackerman now holds an academic position at the Technion, in the Faculty of Industrial Engineering and Management, and recently was granted tenure.

Dr. Rama Amishav - received her Ph.D. at Haifa under the supervision of Prof. Ruth Kimchi, 2008. She has been collaborating with Prof. Kimchi on gender differences in global-local processing, and on the processes underlying face perception, and she is currently collaborating with Prof. Ruth Kimchi and with Dr. Alon Reshef and Dr. Boaz Bloch from the Psychiatric Services at Ha'Emek Hospital on face and object perception processes in schizophrenic patients. Dr. Amishav is a Research Associate at the Center, a clinical psychology intern at Ha'Emek Hospital, and a lecturer at the Open University, and at Emek Yezreel College.

Dr. Orit Baruch - received her Ph.D. at the Center under the supervision of Prof. Ruth Kimchi and Prof. Morris Goldsmith, 2012. Dr. Baruch is currently collaborating with Professors Kimchi and Goldsmith in a project on object recognition that is supported by the Israeli Science Foundation, and with Dr. Yaffa Yeshurun in two projects, one on attentional mechanisms that is supported by the National Institute for Psychobiology, and the other on temporal judgments. Currently, Dr. Baruch is a Research Associate of the IIPDM.

Dr. BatSheva Hadad - received her Ph.D. (Summa cum laude) at the Center under the supervision of Prof. Kimchi in 2006. During 2007-2009 Dr. Hadad was a McDonnel Foundation Post-Doctoral fellow at the Department of Psychology, Neuroscience & Behavior, McMaster University, Canada, working with Prof. Daphne Maurer at her Visual Development Lab. Afterwards she was an ISEF Post-doctoral fellow with Dr. Galia Avidan and Dr. Tzvi Ganel at Ben-Gurion University. Dr. Hadad is a senior lecturer position in Special Education in Haifa University and received the prestigious Alon fellowship. She continues to collaborate with Prof. Ruth Kimchi on the development of perceptual organization.

Dr. Vered Halamish **(Galon)** - received her Ph.D. at the Center under the supervision of Prof. Morris Goldsmith in 2009. She collaborated with Prof. Goldsmith and with Prof. Jacoby from Washington University in St. Louis, on a research project that concerned quality control in memory retrieval and reporting, which was supported by the United States-Israel Binational Science Foundation. Dr. Halamish was a post-doctoral scholar at the University of California, Los Angeles, supported by a Rothschild fellowship (Yad Hanadiv), working with Prof. Robert A. Bjork at the Bjork Memory and Forgetting lab.

Currently, Dr. Halamish is a post-doctoral scholar at the Open University of Israel, working with Dr. Ravit Nussinson. She is lecturing teaching fellow at the Department of Psychology, University of Haifa. Her research concerns memory and metacognition. She is particularly interested in applying metacognitive findings to improve educational practice.

Dr. Hamutal Kreiner - received her Ph.D. at the Center under the supervision of Prof. Koriat, 2004, and she is a Research Associate of the IIPDM. Dr. Kreiner has spent five years at the universities of Glasgow and Edinburgh, using eye-tracking methods to study different aspects of reading comprehension. At present, Dr. Kreiner is a lecturer at the Open University of Israel, and at the Ruppin Academic Center.

Dr. Hadas Marciano - received her Ph.D. at the Center under the supervision of Dr. Yaffa Yeshurun, 2012. She is a Teaching Fellow in the Psychology Department at the University of Haifa. The Driving Simulator Lab was established to support her Ph.D. thesis and many more projects on road safety followed. She is a collaborator in several projects conducted at the Center and at the Human Factors and Ergonomic Unit.

Dr. Ravit Nussinson (Levy-Sadot) - A former doctoral student of Prof. Asher Koriat, and a former post-doctoral student of Prof. Dr. Fritz Strack at the University of Würzburg, Germany. She is one of the participating researchers contributing to sub-projects within the BMBF – DIP. At present, Dr. Nussinson is a lecturer at the Open University of Israel, and an associate researcher at the Center. She continues to cooperate with German researchers, current and former members of the Würzburg group.

Dr. Irene Razpurker-Apfeld – received her Ph.D. at the Center under the supervision of Prof. Ruth Kimchi, 2002. Her M.A. thesis was done under the supervision of Prof. Asher Koriat. During 2003-2004, Dr. Razpurker-Apfeld was a Lady Davis Postdoctoral Fellow at the Evoked Potentials Laboratory, Unit of Behavioral Biology, Faculty of Medicine, Technion, with Prof. Hillel Pratt.
Currently, Dr. Razpurker-Apfeld holds a lecturer position at the Zefat Academic College.

Dr. Limor Sheffer - received her Ph.D. at the Center under the supervision of Prof. Asher Koriat and has been associated with the Center since her graduate studies. She has been a Research Associate at the Center and is one of the participating researchers contributing to a sub-project within the BMBF - DIP Project. Currently, Dr. Sheffer is a Clinical Psychologist at Sha'ar Menashe Mental Health Center.

Dr. Meni Yeari - received his Ph.D. at the Center under the supervision of Prof. Morris Goldsmith, 2009. At present, Dr. Yeari is a Marie Curie Post-doctoral fellow at the Leiden Institute for Brain and Cognition in the Leiden University, with Prof. Paul van den Broek.

The Technion

Ph.D. and M.A. Students

- Dr. Hupert-Graff Gil: Comparative study of learning procedures in human and in neural networks. 2005.
- Dr. Kahana Allon: Workload measurement of team interaction style during complex task execution. 2005.
- Dr. Gavish Nirit: Developing trust in simulation based decision aids. 2007.
- Dr. Yariv Yael: Timeout: The effects of short briefing on team performance in the operation room. (With Prof. Yoel Donchin). 2008.
- Dr. Ert Eyal: Loss aversion, diminishing sensitivity, and the effect of experience on repeated decisions. 2008.
- Dr. Pavlodsky Julia. On the connection between decision making based on descriptions and decision making based on experience. (In progress), 2008.
- Dr. Shpilinger Avishag: The influence of web based medical information systems on work patterns of family physicians. 2009.
- Dr. Koritzky, Gilly: The impact of social desirability on description and experience based choice tasks, 2010.
- Dr. Hochman Guy: The role of losses in decision making processes: The interplay between physiological and behavioral measures, 2010.
- Dr. Agai Nirit: Computational models for decision making processes in ADHD, 2011.
- Morag Ido: Developing a new approach for studying and resolving human factors and safety problem in daily hospital work, 2009.
- Kedmi Efrat: Development of patient status map in neonatal intensive care, 2011.
- Aurbach –Shpak Yael: Task models and patient medical status maps of doctors and nurses in neonatal wards, 2011.
- Telpaz Ariel: The mind's eye: Predicting future decisions from pupil size and movement (Ph.D. Dissertation) (In progress).
- Kinneret Teoderscu: On the decision to explore. (In progress).
- Tal Nevo: The effect of feedback frequency in e-learning. (In progress).

Post Doctoral and Research Fellows

- Dr. Johnatan Levy: 2001-2003
- Dr. Cristina Iani: 2002 -2004 (see below; currently an Associate Professor at Modena University)
- Dr. Dror Lev: 2007-2009
- Dr. Nirit Gavish: 2007 – 2011 Currently a faculty member at the Ort Braude College
- Dr. Stas Krupenia: 2007-2009 (currently a Research Scientist at the Human Factors & Cognition Research Lab, Delft University, the Netherlands).
- Dr. Shahar Ayal: 2007
- Dr. Arava Kallai: 2008 (currently a post-doctoral fellow at the University of Pittsburgh).
- Dr. Maria Korman: 2009 – 2011 Currently a faculty member at Haifa University
- Dr. Geva Vashitz: 2009 – Present
- Dr. Davide Marchiori 2010-2011
- Dr Anna Barlashov 2010-2012

Highlighted Past/Current Graduate Students Starting an Academic Career

Prof. Eldad Yechiam – completed his Ph.D. at the center under the supervision of Prof. Ido Erev and Prof. Daniel Gopher. Afterwards did his post-doctoral fellowship in Indiana University with Prof. Jerry Busemeyer. Currently Prof. Yechiam is an Associate Professor at the faculty of Industrial Engineering and Management at the Technion, and a Minerva principle investigator.

Prof. Cristina Iani – arrived from U. Bologna, Italy and completed her Ph.D. at the Technion with Prof. Daniel Gopher and Prof. Peretz Lavie. She stayed as a post doc at the Center, and then spent one year as post doc. with Prof. Art Kramer at the Beckman Center for Advanced research, at the University of Illinois. At present Dr. Iani is an Associate Professor faculty member at the Dept. of Psychology, University of Modena.

Dr. Nirit Gavish – completed her Ph.D with Prof. Daniel Gopher and stayed as a Post Doc in the Skills project. She is now a faculty member of the Ort Braude College

Dr. Adi Luria – completed her M.Sc. (2005) and PhD (2010) at the Center under the supervision of Prof. Ido Erev. She is currently a faculty member at the Ropin College.

Dr. Amos Schurr – completed his M.Sc at the center under the supervision of Ido Erev in 2006, and he is about to finish his Ph.D. at the Hebrew university. Next year, Amos will be a post doc fellow at Ben Gurion University.

Dr. Eyal Ert – completed his Ph.D. under the joint supervision of Prof. Ido Erev and Dr. Eldad Yechiam in 2008. Dr. Ert was a post doc. fellow at Harvard University under the supervision of Prof. Al Roth, and his is currently a faculty member at the Hebrew University.

Dr. Shahar Ayal – completed a postdoc. training with Prof. Ido Erev in 2007, and continues a post doc training with Prof. Dan Ariely at Duke University. Dr. Ayal is currently a faculty member at the Psychology Department at the IDC center in Hertzlya, Israel.

Dr. Guy Hochman – completed his M.Sc at the center under the supervision of Prof. Ido Erev in 2007, and his Ph.D. with Prof. Eldad Yechiam in 2010. Won the Fulbright fellowship. He is currently a post-doctoral fellow at Duke University under the supervision of Prof. Dan Ariely. Dr. Hochaman plans to accept an offer to join (starting 2014, as a faculty member) the Psychology Department at the IDC center in Hertzlya, Israel.

Dr. Gilly Koritzky – completed her M.Sc at the center under the supervision of Prof. Ido Erev, and her Ph.D. with Prof. Eldad Yechiam in 2010. Currently a post doctoral fellow at USC under the supervision of Prof. Antoine Bechara.

Dr. Gil Hupert and Dr. Yaakov Greenshpan (a former graduate of the center) have founded together UI Human Factors consultancy, which is now the largest and most respected in Israel. It employs more than 50 HF professional, many of them previous graduates of the Center.

Kinneret Teoderescu – completed her M.Sc at the center under the supervision of Prof. Ido Erev in 2010, and plans to complete her PhD at 2013. Kinnert was (informally) offered, and plans to accept, a post doc position with Alvin E. Roth at Stanford University.

b. Administration of the Center

b.1 Support Staff

Administration of the Center

The administration of the Center is carried out at the University of Haifa. The administration includes handling the daily matters of the Center, preparing reports, budget, and budget follow-ups, organizing the Board meetings, and so on. The Minerva budget distribution between the two branches is therefore - 40% for the Technion and 60% for the University of Haifa, as the extra 20% is allocated for the Minerva administration.

Until 2008 the Minerva Research Coordinator was Ms. Hadas Marciano, who has recently received her Ph.D. degree, doing her work at the Center. Since 2008 the Minerva Research Coordinator has been Rinat Gil. Other people, mostly at the University of Haifa, helped in various administrative chores. These include Ms. Etti Levran, Ms. Ornit Tsoury, and Ms. Maya Lipkin-Goldberg.

Technical Support

The technical support includes preparation of research equipment, computer programming, purchasing and maintenance of equipment, and so on. Personnel: Mr. Baruch Kaplan, Ms. Anna Vednichev, Ms. Yafa Lev, Mr. Erez Ofek, and Mr. Dan Manor.

Upon the establishment of the Minerva Center, both the University of Haifa and the Technion allocated space for setting up laboratories and administrative offices.

At the University, the offices of the center and several laboratories were set up in a separate wing adjacent to the Institute of Information Processing and Decision Making (IIPDM). Cooperation and time-sharing of resources between the Minerva Center and the IIPDM have been a key element to success in establishing a sophisticated and multi-faceted research facility.

At the Technion also, two experimental laboratories have been established, one of which allows 12 workstations, that allow to conduct multi-participant studies.

In 2003 we established a *Virtual Reality Lab* at the Minerva Center at the University of Haifa. Our Lab facility delivers high quality performance and realism, in a wide range of display configurations. The Lab facilities are a seamless integration of hardware and software technologies used for immersive, collaborative visualization, also known as Virtual Reality (VR). These facilities enable the creation and use of interactive, multisensory, three-dimensional worlds, or environments and models. Immersive visualization configurations are historically recent. The Virtual Reality Lab enables Minerva members' new and highly advanced opportunities for their researches.

At both sites, a further element has been the success of the Minerva researchers in obtaining additional funding for research equipment, above and beyond the initial endowment by the Minerva foundation (as was detailed above in section a.4.6).

Despite (and to some extent because of) the success in utilizing and extending the initial Minerva endowment for research equipment received in 1996, some of that equipment has become outdated and needs replacement. Furthermore, special equipment that is designed for extension of our research was also needed. We therefore applied to the "2009 Call for Applications: Minerva Centers Funding for Equipment", and received a budget of 32,000 Euro. The 2009's funding helped us to establish a multiuser integrative laboratory for research and graduate training in cognition and human performance (for application's documents and details see Appendix section g.1). In light of the need for further research equipment, enabling the ongoing research, especially the study of dynamic cognitive processing, we applied to the "2010 Call for Applications: Minerva Centers Funding for Equipment", and received a budget of 105,000 Euro. New and advanced workstations were completed and eyetrackers devices were purchased to enable the studies (for application's documents see Appendix section h).

Due to the growth of research activity in the Center, we asked the University of Haifa for allocation of additional research space. We have, accordingly received additional space for research purposes and for accommodating postgraduate students.

b.2 Interaction between the Center and the Academic Departments

All the Minerva researchers from the University of Haifa are also members of the Psychology Department. They teach courses in the department, particularly in the Cognitive Psychology graduate program, where they also supervise M.A. and doctoral students.

The researchers from the Technion are also faculty members at the Faculty of Industrial Engineering and Management. They are associated with the Industrial Psychology and Human Factors program. They teach students at the undergraduate and graduate levels.

A detailed description of the Center's PhD. Graduates, under the supervision of the Minerva members appears in section a.4.7

b.3 Use of the Center's Facilities by Non-Members

The University of Haifa

The Center's research and facilities are located mainly in the laboratories of the IIPDM (Institute of Information Processing and Decision Making). Although priority is given to the Minerva projects, all members of the IIPDM (9 researchers) and their students/assistants (about 30) may use the equipment, when the equipment is available. Thus, the Minerva facilities have supported a great deal of research activity that goes beyond the specific projects that have been reported here.

The Technion

The Technion established an independent experimental laboratory for the Minerva research activities. The equipment for this facility has been purchased by the initial Minerva budget, Technion internal resources, and other grant support. The laboratory serves the 3 PIs and their graduate students, faculty collaborators, postdoctoral students and short-term visitors (a total of about 25 people).

b.4 The Current Advisory Council

- Prof. Dr. Reinhold Kliegl, Cognitive Psychology/Interdisciplinary Center for Cognitive Studies, University of Potsdam, Germany.
- Prof. Dr. Dietrich Manzey, Institut für Psychologie und Arbeitswissenschaft, Technische Universität Berlin, Germany, Chairman.
- Prof. Dr. Pienie Zwitserlood, Psycholinguistik und Kognitive Neurowissenschaft, Universität Münster, Germany.
- Prof. Yaakov Kareev, School of Education, The Hebrew University, Jerusalem, Israel.
- Prof. Arie Melnik, Department of Economics, University of Haifa, Israel.
- Prof. Hillel Pratt, Evoked Potentials Lab, Technion, Haifa, Israel.

c. Research Reports

c.1 Metacognition of Learning and Memory: Prof. Koriat and Prof. Goldsmith.

A great deal of research has been conducted in the context of the Minerva Center on metacognitive monitoring and regulation during learning and remembering. There has been a surge of interest in metacognitive processes in recent years, with the topic of metacognition pulling under one roof researchers from traditionally disparate areas of investigation. Undoubtedly, the Minerva team is one of the leading groups in this development. This report presents a selective review of some of the work in this area, organized around three general headings.

c.1.1 Metacognitive Processes in Learning

Several projects have been conducted in recent years on the question of how learners monitor their degree of competence during study, and how they allocate learning resources to different items. These projects are predicated on the assumption that the effective self-management of learning requires the on-line monitoring of one‘s own degree of mastery of the studied material and the adaptive regulation of various cognitive operations.

Much of the work has been guided by Koriat's cue utilization framework (1997, see Figure 1) distinguishing between different cues and heuristics underlying judgments of learning (JOLs). This framework predicts several dissociations between predicted and actual memory performance.

One marked dissociation concerns the effects of retention interval: JOLs made during learning are entirely indifferent to the expected retention interval, although actual recall exhibits the typical forgetting function (Koriat, Bjork, Sheffer, & Bar, 2004). Thus, learners were found to give similar recall predictions whether they expected to be tested immediately after study, after a week, or even after a year. The results support the idea that metacognitive judgments are based primarily on "here and now" – on mnemonic cues (such as ease of processing) deriving on-line from performance rather than on declarative knowledge and theories (See Koriat, Nussinson, Bless, & Shaked, 2008). One condition that yielded sensitivity to retention interval is "forgetting framing" -- when learners predicted forgetting ("how many words will you forget") rather than remembering ("how many words will you recall"), suggesting

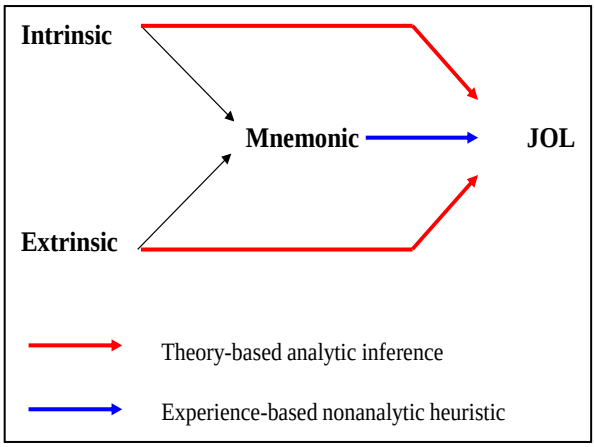

Figure 1

that participants apply their theory about forgetting only when the notion of forgetting is activated. When it comes to reliance on mnemonic cues, however, learners were found to exhibit adaptive and differential sensitivity to different mnemonic cues (such as encoding fluency vs. retrieval fluency) according to their relative validity in predicting memory performance (Koriat & Ma'ayan, 2005). This project has spurred a number of interesting studies by other researchers, demonstrating the complexity of the processes underlying metacognitive monitoring during learning.

Another dissociation, labeled "foresight bias", relates to the illusion of competence sometimes observed during learning. The idea is that the monitoring of one‘s own knowledge during study suffers from the inherent discrepancy between study and test situations: JOLs are made in the presence of information that is absent during testing. The failure to discount the effects of that information when making JOLs can instill a sense of competence during learning that proves unwarranted during testing. A series of studies yielded support for a foresight bias under specific conditions. Subsequent studies explored procedures that can alleviate the foresight bias. The results have educational implications. They suggest that overconfidence and misallocation of study time arise from a mismatch that is inherent to education—that the answer is present at study and absent at test—and that alleviating the problem requires creating conditions at study that sensitize learners to retrieval conditions at test.

Possibly related to the foresight bias is the underconfidence-with-practice effect (UWP): When participants are presented with the same list of paired-associates for several study-test cycles, their JOLs exhibit relatively good calibration on the first cycle, with a tendency towards overconfidence. However, a shift towards marked underconfidence occurs from the second cycle on. The UWP effect was found to be very robust across several experimental manipulations. The effect engendered interest among several researchers. In a subsequent series of experiments we provided evidence that the UWP effect is related to the foresight bias -- JOLs are inflated when the to-be-recalled target highlights aspects of the cue that are not transparent when the cue appears alone. Repeated presentation of the same items tends to mend this bias by increasing sensitivity to mnemonic cues. Indeed, the UWP effect was strongest for items that induce a foresight bias, but delaying JOLs reduced the debiasing effects of practice, thereby moderating the UWP effect (Koriat, Ma'ayan, Sheffer, & Bjork, 2006).

An interesting extension of the notion of foresight bias is the "prediction inflation" phenomenon (Koriat, Fiedler, & Bjork, 2006). When participants make conditional predictions – assessing the probability that a certain outcome will occur given a certain condition—their predictions tend to be markedly inflated (sometimes predicting .60 when the actual probability is .02). This inflation derives in part from backward activation in which the target outcome highlights aspects of the condition that are consistent with that outcome, thus supporting the plausibility of that outcome. One consequence of this process is that alternative outcomes are not conceived to compete as fully as they should. Several

debiasing and training procedures have been explored that alleviate prediction inflation to some extent, but the inflation is generally quite resistant to change (Koriat, 2008).

The importance of metacognitive monitoring is that it affects the regulation of learning, thereby affecting actual memory performance. However, our examination of the results pertaining to the effects of monitoring on regulation has led to a new model of the cause-and-effect relation between metacognitive monitoring and metacognitive control (Koriat, Ma'ayan, & Nussinson, 2006). This model has implications for the relationship between subjective experience and behavior in general. The model addresses the issue that was first raised by William James (1895) with regard to emotional behavior. He asked: Do we run away because we are frightened, or are we frightened because we run away? In the context of metacognition, this question concerns the relationship between monitoring and control processes (Koriat, 2006). The dominant view in metacognition is that monitoring guides and drives behavior. Unlike this monitoring → control (MC) model, however, it was proposed to consider also a control → monitoring (CM) model in which monitoring itself is based on the feedback from control operations. In the latter model monitoring *follows* control operations.

According to the MC model, low JOLs induce greater investment of study time in the same way that fear drives running away. Hence the negative relationship that has been repeatedly observed between JOLs and study time. According to the CM model, in contrast, it is the other way round: Study time is *data driven* rather than goal driven; it is mainly determined ad hoc by the item itself, or more precisely, by the item–learner interaction. Study time is then used by the learner as a cue for the subjective difficulty of the item under the heuristic that the more study time is invested in an item the *less* likely it is to be recalled. According to this line of theorizing, study time has a dual function: It serves a control function and a monitoring function. The MC model focuses on the control function, when the regulation of study time is *goal driven*, whereas the CM model focuses on the monitoring function, when study time regulation is *data driven*. These two models are expected to yield diametrically opposed relationships between JOL and study time: When study time is goal driven, JOLs should increase with study time, whereas when it is data driven, JOLs should decrease with study time. By manipulating the incentive associated with the recall of each item, Koriat et al. (2006) provided evidence for the occurrence of both types of relationship within the same experimental situation. JOLs increased with study time in comparing two levels of incentive (1 point vs. 3 points) but decreased with study time within each incentive level (see Figure 2). Precisely the same pattern was observed between response latency and subjective confidence in problem solving.

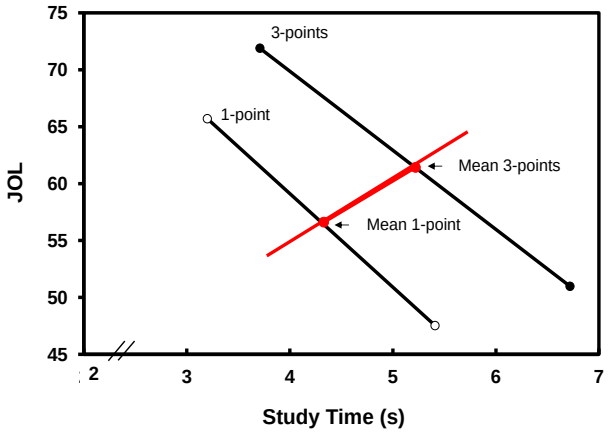

Figure 2

Because the amount of effort invested in different items is conjointly determined by data-driven and goal-driven regulation, an attribution process was postulated in which variations in effort are attributed by the learner to data-driven or goal-driven regulation before the implications for metacognitive judgments are determined. The reality of this process was supported by a study (Koriat & Nussinson, 2009) in which learners were asked to adopt a facial expression that creates a feeling of effort. They were also induced to attribute that effort either to data-driven or to goal-driven regulation. This manipulation was found to determine the direction in which the experienced effort deriving from facial expression affected JOLs.

The proposed *data-driven* regulation implies that easily learned items are better recalled (if JOLs are valid, as was indeed found to be the case). This observation runs counter to the adage Easy Comes, Easy Goes. In a series of studies that focused on trials to acquisition (TTAs) rather than study time, it was found that across items recall decreases with the number of TTAs (Koriat, 2008), supporting the Easily Learned, Easily Remembered (ELER) rule. JOLs were found to incorporate this rule. It was proposed that in general, metacognitive judgments incorporate knowledge about the internal ecology of cognitive processes much as the perception of the external world embodies knowledge about the ecological structure of the environment.

The work on the cause-and-effect relationship between monitoring and control poses a challenge regarding the development of metacognitive processes, and raises new questions that have not been addressed before in the study of metacognition in children A recent project, supported by grant from GIF, extended the contrast between *data-driven* regulation and *goal-driven* regulation to children. The project involved a collaboration between Asher Koriat and Rakefet Ackerman (Haifa) and Wolfgang Schneider (Würzburg) and Kathrin Lockl (Bamberg). The project attempted to trace the development of the intricate interplay between monitoring and control processes. It examined the development of the control-affects-monitoring pattern (CM model), then of the monitoring-affects-control (MC model), and finally of the simultaneous occurrence of both patterns. Several publications came out already from this project. This research is expected to contribute to a greater rapprochement between the developmental and cognitive perspectives on metacognition. So far 7 publications came out of this project: Koriat, Ackerman, Lockl, & Schneider (2009a, 2009b, 2009c), Hoffmann-Biencourt, Lockl, Schneider, Ackerman, & Koriat (2010). Koriat & Ackerman (2010a, 2010b), Ackerman & Koriat (2011).

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c.1.2 The Subjective Confidence in One's Decisions

Recent work by Koriat and his associates has focused on the basis of subjective confidence and on the reasons for their accuracy (Koriat, 2008a, 2008b, 2011; Koriat & Adiv, 2011, in press). Much of the work has been reviewed and summarized in a *Psych Review* paper (Koriat, 2012a) which details a model of subjective confidence.

Introduction

How can we be certain about our own knowledge? Questions about truth and its justification have been the province of philosophers for centuries. They have also concerned statisticians who examined these questions from a normative perspective. In addition, they are important in many applied areas, such as jury decisions, medical diagnosis and expert systems (Dunning, Heath, & Suls, 2004). Of course, in many real-life situations, people assess the probability of future outcomes, and these assessments often have important implications for decisions and behavior (Tversky & Koehler, 1994; Goldsmith & Koriat, 2008).

In experimental research, the subjective confidence in one’s own knowledge has been investigated in a wide range of domains including memory and metacognition, perception and psychophysics, decision- making and choice, eyewitness testimony, social cognition, animal cognition, and neuroscience (see Dunlosky & Metcalfe, 2009). However, as Vickers (2001) noted, "what is remarkable is that, despite its practical importance and pervasiveness, the variable of confidence seems to have played a Cinderella role in cognitive psychology – relied on for its usefulness, but overlooked as an interesting variable in its own right" (p. 148).

The phenomenon that has puzzled cognitive psychologists is that by and large, people know when they know and when they do not know, and can discriminate between correct

answers and wrong answers. The ability to monitor one's own knowledge was described by Tulving and Madigan (1970) in their classical review as "one of the truly unique characteristics of human memory". They argued that "if there is ever going to be a genuine breakthrough in the psychological study of memory... it will, among other things, relate the knowledge stored in an individual's memory to his knowledge of that knowledge" (p. 477).

The project summarized in this section was spurred by several observations that casted doubts about the assumption that people have privileged access to the correctness of their knowledge. In what follows these observations will be described. The model of confidence judgments will be outlined, which meets the challenge raised by Tulving and Madigan. The model and the experimental evidence that supports it open new venues for the study of subjective confidence and its validity. The project has theoretical as well as practical implications.

The Consensuality Principle

When participants choose an answer to 2-alternative, forced-choice (2AFC) general knowledge questions and indicate their confidence, a moderate-to-high confidence-accuracy (C/A) correlation is generally observed, suggesting that people can monitor the accuracy of their answers. However, results reported by Koriat (2008a) provide a straightforward answer to the puzzle of how people know that they know: They don't. The results of several studies indicated that confidence judgments actually correlate with the *consensuality* of the answer – the likelihood that it will be chosen by others – rather than with its correctness. The C/A correlation is simply because the consensually endorsed answer -- the answer chosen by most participants -- is typically the correct answer.

The evidence for this conclusion comes from studies, reviewed by Koriat (2012a), that included a sufficiently large number of items for which most participants agreed on the wrong answer. It was found that for consensually correct (CC) items, in which most participants chose the correct answer, the C/A correlation was positive, whereas for consensually wrong (CW) items, the C/A correlation was negative: People were more confident when they were *wrong* than when they were right. This interactive pattern was observed for a word-matching task in which participants guessed the meaning of words from noncognate languages (Koriat, 1976), for feelings-of-knowing judgments about an elusive memory target (Koriat, 1995), for confidence in 2AFC general-information questions (Koriat, 2008a), for perceptual judgments (Koriat, 2011) and also for the memory of studied sentences (Brewer & Sampaio, 2006; see also Sampaio & Brewer, 2009). It was also observed for the prediction of others' responses (Koriat, in press a).

Some of the results are illustrated in Figure 3. Of course, in none of these studies were participants informed about others' answers. Nevertheless, a participant's confidence in his or her choice increased systematically with the proportion of other participants who made that choice. These results clearly speak against the view that participants have privileged access to the accuracy of their answers (see Schwartz, 1994). Participants are successful in monitoring the correctness of their answers *indirectly*, by relying on some cues that are correlated with accuracy. These cues would seem to underlie the consensuality of the response – the extent to which it tends to be endorsed by the majority of people. The results demonstrate the intimate link between knowledge and metaknowledge (Koriat, 1993): People know that they know because they know. Indeed, for the CW items (see Figure 3, panels A-D), people are "doubly cursed" (Dunning et al., 2003): They do not know, and do not know that they do not know.

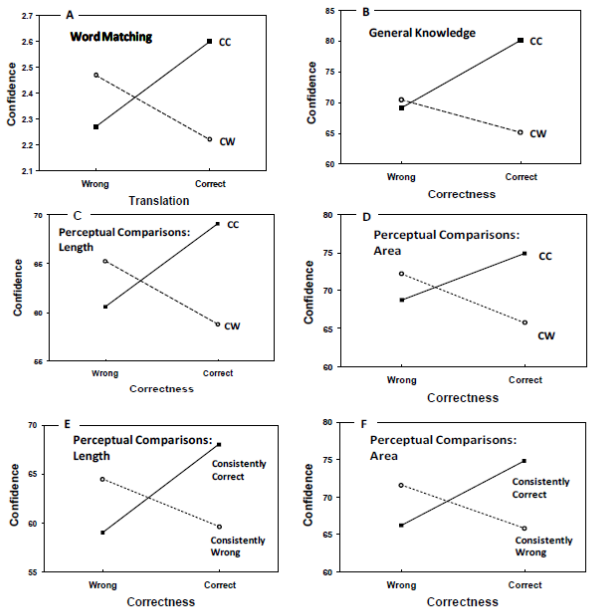

Figure 3

These results may provide insight into people's ability to monitor their own knowledge, and can contribute toward the demystification of this ability. As noted by Koriat (1993) with regard to the feeling of knowing, the assumption that people somehow have direct access to the accuracy of their knowledge has impeded serious efforts toward a deeper understanding of the internal machinery underlying metacognitive judgments and their accuracy.

However, the results also raised some puzzling questions. How is it that my confidence is best predicted by other's choices? Also, in the case of the CW items, why those who "know" the answer (e.g., that the capital of California is Sacramento) are *less* confident than those who choose the wrong answer (Los Angeles)?A general model of subjective confidence has been developed not only to answer these questions but also to provide a principled account for the processes underlying subjective confidence and its accuracy (Koriat, 2011, 2012a; Koriat & Adiv, 2011).

The Self-Consistency Model (SCM) of Subjective Confidence: General Assumptions

Consider the psychological situation of a participant who is to assess confidence in the answer to such questions as "Which city has more inhabitants, Hanover or Bielefeld?" (Gigerenzer, Hoffrage, & Kleinbölting, 1991), or "what is the capital of Australia, Canberra or Sydney?" (Fischhoff, Slovic, & Lichtenstein, 1977). The pertinent clues for the answer must be retrieved from one's own memory rather than (directly) from the outside world. In this respect, the situation is not different from that underlying the assessment of confidence

in beliefs such as "there is a supreme being controlling the universe" (Koriat & Adiv, 2011). So what is the basis of one's degree of certainty in an answer that is retrieved from memory?

The metatheoretical assumptions underlying SCM have been discussed in Koriat (in press b). The first postulate is that although the validation of one's own knowledge is based on retrieving information from memory, participants behave essentially like intuitive statisticians who have to infer the central tendency in a population on the basis of a sample of observations. They base their answer on a sample of considerations retrieved from memory, and their confidence represents the assessed likelihood that a new sample will yield the same choice.

The second postulate is that reliability is used as a cue for validity. Assuming that in answering a 2AFC question, participants retrieve a sample of considerations from memory, confidence depends on the extent to which the chosen answer is *consistently* supported across these considerations.

Thus, SCM adopts the metaphor of an intuitive statistician underlying human decision and choice (Peterson & Beach, 1967; see McKenzie, 2005). Participants choose an answer by sampling information from memory. Each item is associated with a large set ("population") of potentially accessible representations, only a small part of which ("sample") is accessed at any encounter. Once participants settle on an answer and have to assess their confidence in that answer, they do not go over the entire deliberation process again but rely on the gist of the process that was used to determine the choice (Stephen & Pham, 2008). That gist consists of such gross cues as the feeling of conflict or doubt they had experienced in making a choice, the amount of effort invested, and the time it took to reach the choice. These mnemonic cues, which represent the feedback from the process of making a choice, were conceptualized in terms of self-consistency - the balance of evidence in favor of the alternative answers.

The results demonstrating a correlation between confidence and consensuality are interpreted by SCM in terms of the assumption that each general-knowledge item is associated with a population of considerations that is shared by all participants with the same past experience, and that most of these considerations favor the correct answer by virtue of the general adaptation to the environment. This assumption is consistent with ecological approaches to cognition (Dhami, Hertwig, & Hoffrage, 2004) and is also consistent with the *Wisdom-of-Crowds* (WoC) phenomenon, which indicates that information that is aggregated across participants is generally closer to the truth than the information provided by each individual participant (Galton, 1907; Surowiecki, 2005).

Implementation of the Model

The process underlying choice and confidence can be conceptualized as involving a series of replications of the decision process. In each replication a representation is retrieved, its implication for the judgment is evaluated, and an implicit subdecision in favor of one of the two responses is made. The sampling continues until a pre-set sample size has

been reached or until a series of draws yields the same subdecision a number of times in succession (e.g. 3 times, see Audley, 1960). Subjective confidence in that choice is based on the degree of consistency among the subdecisions. Thus, however analytic is the process underlying choice, confidence is based on a simplified portrayal of that process in which each of the representations provides a binary subdecision and all subdecision have the same weight.

The critical property of the population of representations associated with a given item is the proportion of representations favoring the dominant, majority choice. This property was designated p_{maj} (range .5-1.0). For simplicity, a simple version of the model will be considered in which two free parameters were fixed (see Koriat & Adiv, 2011). First, the maximum number of representation accessed for each item (n_{max}) is 7. Second, once a series of draws yields the same subdecision 3 times in succession, the search is terminated, and the outcome of the run-3 sequence determines the overt choice. Thus, the actual sample size, designated n_{act}, will vary between 3 and 7.

Confidence in the choice is assumed to depend on self-consistency, which is inversely related to the sample standard deviation. Koriat (2012a) used $1-\sqrt{\hat{p}\hat{q}}$ as an index of self-consistency (range .5 - 1.0), which is calculated over the actual number of representations sampled (n_{act}). Response latency, in turn, is assumed to increase with actual sample size, n_{act}, that is, the number of representations drawn before an overt choice is made.

To explore the predictions of this model, a simulation experiment was run. It assumed a vector of 9 binomial populations that differ in p_{maj}, the proportion of the majority value, with p_{maj} varying from .55 to .95, at .05 steps. For each population, 90,000 iterations were run. In each iteration, 7 representations were sampled from the population and the majority value in the sample was defined as the overt choice. However, when a sequence of 3 identical values occurred, the sampling was stopped, and the repeated value was defined as the overt choice. Responses were classified as "majority" when they corresponded to the majority value in the population, and as "minority" when they corresponded to the minority value in the population. A self-consistency index and n_{act} were calculated for each iteration, as described above.

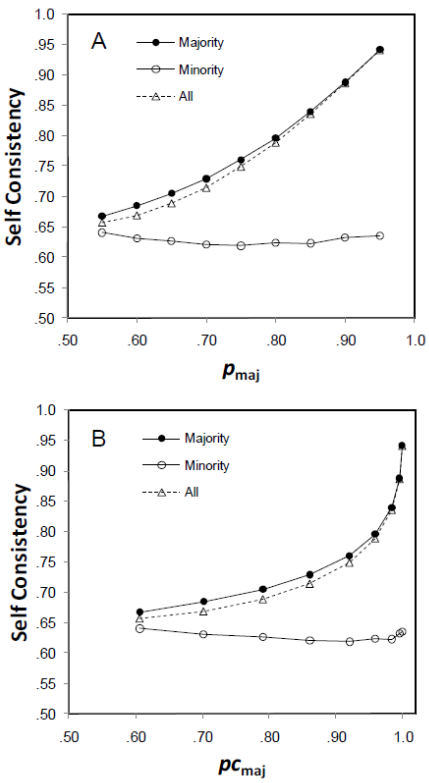

Figure 4

The results of the simulation (Figure 4A) bring to the fore the diagnostic value of the self-consistency index, which is assumed to underlie subjective confidence. Mean self-consistency ("All") increases with p_{maj}. However, self-consistency is systematically higher for majority than for minority choices. Why is that so? The answer lies in the relationship between the mean and the variance when sampling information randomly from a population. To illustrate: With p_{maj} = .70, a sample of 7

representations has a .329 likelihood of yielding 6 or 7 representations that favor the frequent, majority response. In contrast, the likelihood that it will yield 6 or 7 representations that favor the less frequent, minority choice is only .004. In general, then, as long as p_{maj} differs from .50, minority samples should have a lower self-consistency and hence lower confidence than majority samples.

It should be noted that the simulation results for n_{act} mimic very closely the results obtained for self-consistency, so that response latency is expected to decrease with p_{maj}, but for each value of p_{maj}, response latency is longer for minority than for majority choices. Thus, response latency is a frugal cue for self-consistency. The general conclusion from the results is that confidence and response latency are diagnostic of properties of the population of representations as well as those of the specific sample underlying choice.

An estimate of p_{maj} can be obtained from the likelihood of choosing the majority answer, which will be designated pc_{maj}. The theoretical function relating pc_{maj} to p_{maj} can be obtained from the simulation described earlier. pc_{maj} is an accelerated function of p_{maj}. For example, when p_{maj} = .55, samples of n = 7 (with a run-3 stop rule) are expected to lead to a .60 proportion of the likelihood of choosing the majority response. When p_{maj} = .70, the respective pc_{maj} is .86. The data presented in Figure 4A were therefore reorganized to form Figure 4B by using in the *x*-axis the pc_{maj} values corresponding to the p_{maj} values.

There are two ways in which pc_{maj} can be indexed operationally. It can be indexed by the proportion of times that the preferred choice is made by the same participant over repeated presentations. Alternatively, it may be indexed by the proportion of participants making the choice that is preferred by most participants. Because these two properties are assumed to be specific to each item, they will be referred to as "item consistency" and "item consensus", respectively. The assumption, as noted earlier, is that participants draw their sample of representations from a commonly-shared population of representations associated with each item.

The results of several studies generally confirmed the expected pattern for the effects of item consensus using 2AFC items: For word matching, general knowledge, social attitudes, social beliefs, the comparison of the lengths of two lines and the comparison of the areas of two stimuli. In all cases, consensual choices yielded stronger confidence than nonconsensual choices, and the discrepancy between them increased with item consensus (see Figure 5 for illustrative results).

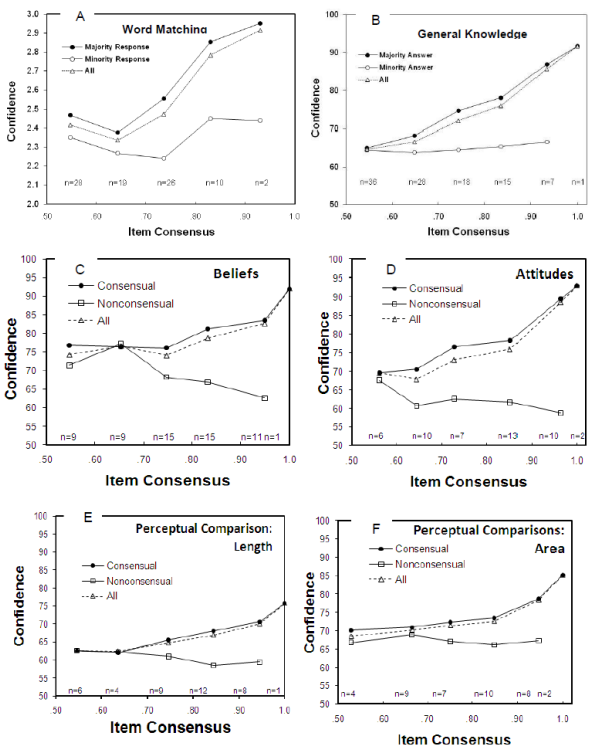

Figure 5

A similar pattern was observed when the same list of items was presented to the same participants several times: Confidence was systematically higher when the person made his/her more frequent choice than when making the less frequent choice ("rare"). As can be seen in Figure 6, this was true for social attitudes, social beliefs, the comparison of the lengths of two lines and the comparison of the areas of two stimuli. A recent study yielded similar results for personal preferences (Koriat, in press a).

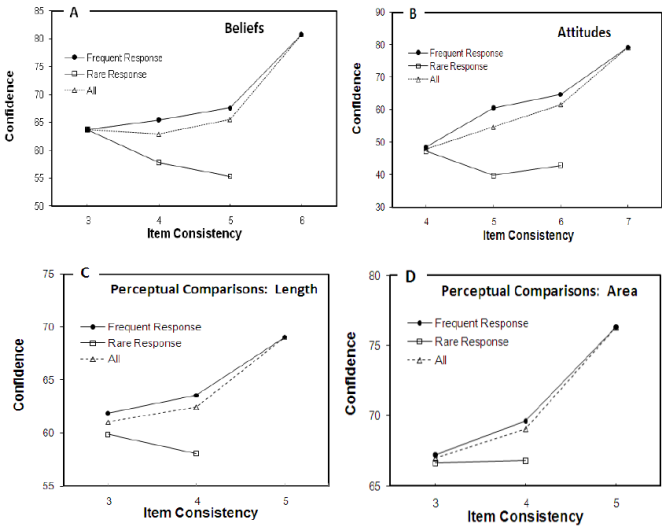

Figure 6

In addition, as expected, confidence in the first presentation predicted the likelihood of making the same choice in subsequent presentations. This observation is consistent with the metatheoretical assumption that confidence in a decision reflects the person's assessment of reproducibility: The likelihood of making the same decision in a subsequent presentation of the item (see Figure 7).

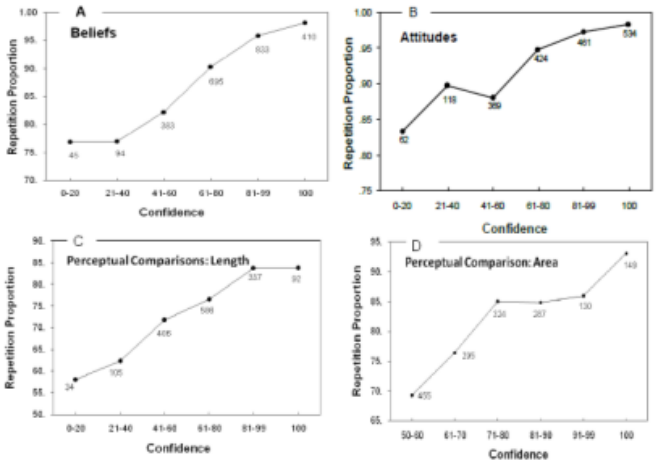

Figure 7

Inter-Individual Differences in Confidence

An important observation that is critical for some of on-going studies concerns the effects of consensuality. These effects were also obtained in a *between-individual* analysis: For each item, those participants who choose the nonconsensual answer express less confidence than those who choose the consensual answer. This pattern too was found across a wide range of tasks even when chronic differences in confidence were neutralized. This observation has important implications in many situations that call for group interactions and group decisions. Note that this pattern of results is what follows from a model that assumes a *random* sampling from a commonly-shared population. By and large, confidence is tuned to "collective wisdom", and when that wisdom is also correct, confidence will also monitor accuracy. Thus, inter-individual differences in confidence are also diagnostic of differences in the consensuality of the choice, and in many cases, they are

also diagnostic of the correctness of that choice (provided that chronic differences in confidence are neutralized).

When Two Heads are Better than One

A recent study that capitalized on this observation was recently completed concerning the comparison between individual and group decisions (Koriat, 2012b). This study was motivated by the finding of a study by Bahrami et al. (2010) that compared individual and dyadic decisions. Participants judged which of two visual stimuli contained an oddball target and then reached a joint decision. The results were clear: "two heads were definitely better than one provided they were given the opportunity to communicate freely" (p. 1081).

The study of Koriat (2012b, with an introduction by Ralph Hertwig, 2012), replicated the 2-heads-better-than-1 (2HBT1) effect in the absence of any interaction between the members of a dyad by selecting on each trial the decision of the more confident member of a virtual dyad. Participants were run individually, and were then paired to form virtual dyads. A simple algorithm for combining judgments across individuals was used, which follows from SCM. In this algorithm -- Maximum-Confidence Slating (MCS) -- for each item, the decision that was made with higher confidence by one member of the dyad was selected, and all selected decisions were compiled to form a dummy high-confidence (D-HC) participant. The low confidence judgments were slated to dummy low-confidence (D-LC) participant. Indeed, as can be seen in Table 1, in that study, as well as in Study 2, which involved general knowledge, MCS yielded better decisions than the best member of a dyad.

Table 1

	HP	LP	D-HC	D-LC
	Study 1			
	67.82%	66.98%	69.88%	64.93%
	Study 2			
Area	78.44%	77.93%	81.44%	74.93%
Population	79.67%	79.41%	81.96%	77.11 %

HP = high performing *LP* = low performing

D-HC = dummy high confidence *D-LC* = dummy low confidence

The MCS algorithm differs from the typical schemes for deriving group-based judgments. These are based on *aggregating* judgments across individuals, whereas MCS is based on *selection*. Indeed, MCS improved accuracy beyond the improvement achieved by the aggregation of responses across individuals. The two studies mentioned also indicated that three-heads are better than two, and of course, MCS can be applied across larger virtual groups.

MCS illustrates the promises of subjective confidence. This algorithm is expected to be beneficial for many domains in which the correct choice is the consensual choice. However, the perils inherent in group decisions derive from situations in which most participants tend to make the wrong decisions. Indeed, the psychological literature is replete with documentations of situations in which participants' perceptions, judgments and beliefs

deviate consistently from the truth. Examples include perceptual and memory illusions, deceptive general-knowledge questions, reconstructive memory errors, illusory truth judgments, and various judgmental biases.

Thus, in Studies 3 and 4, which included CW items, a 2HBT1 effect was observed for CC items whereas for CW items two heads were significantly *worse* than one. The results for the perceptual tasks used in Study 3 (deciding which of two lines is longer or which of two shapes has a larger area) are presented in Table 2.

Table 2

		D-LC	D-HC	HP	LP
		Study 3			
Lines	CC	81.58%	80.59%	85.03%	77.14%
	CW	25.00%	26.31%	17.10%	34.21%
Shapes	CC	83.33%	84.58%	86.67%	81.25%
	CW	28.13%	24.06%	22.50%	29.69%
		Study 4			
	CC	80.57%	79.71%	85.57%	74.71%
	CW	23.08%	22.69%	19.23%	26.53%

In fact, for the CW items, the best accuracy is achieved by selecting for each item the response of the *less* confident participant (*D-LC*). The same pattern was observed in Study 4, which involved general information questions. Thus, because group decisions tend to be dominated by the more confident individuals, reliance on these individual may lead the group astray.

These observations may provide one of the clues to the "groupthink" phenomenon in which a group follows a certain set of patterns that result in disastrous consequences (Janis, 1982). The danger in relying on subjective confidence is that there is no simple rule for telling whether a particular choice situation belongs to the CC or CW category. In fact, the illusory conviction that participants experience in responding to CW items derives from their tendency to apply the same heuristic indiscriminately to all items in computing their subjective confidence. Thus, to the extent that the MCS algorithm captures some of the dynamics that underlies group decisions, social interaction would be expected to amplify the trends that characterize the consensual decisions, making such decisions more accurate when they are basically accurate but making them even less accurate when they are inaccurate in the first place.

In the future, predictions of SCM will be examined in several real-life contexts including group decisions, the Delphi method which has been devised to improve the quality of group decisions (Dalkey, 1969), and economic forecasts. In addition, the work reported in this section has already attracted the attention of philosophers, and indeed its implications for epistemological theories of truth have been explored in recent reports (Koriat, in press b; Koriat & Adiv, under revision).

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c.1.3 The Strategic Regulation of Memory Accuracy and Informativeness

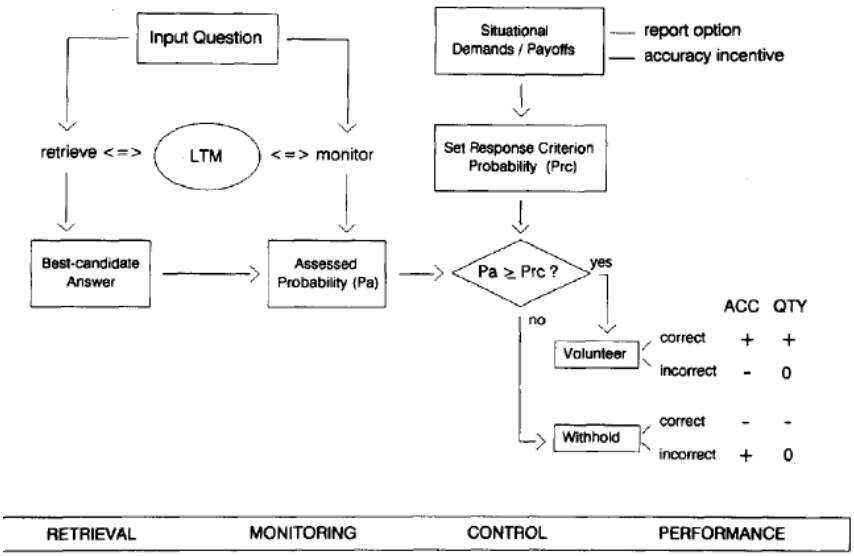
The research on this topic represents a long line of research based on the seminal work of Asher Koriat and Morris Goldsmith (1994, 1996a, 1996b), examining the role of metacognitive monitoring and control processes in the strategic regulation of the quantity and accuracy of the information that people report from memory. Subsequent projects have extended and applied the theoretical framework and methodologies developed in that early work to a broader set of theoretical and applied issues in the area of human memory and metacognition (for reviews, see Goldsmith, Pansky, & Koriat, submitted; Goldsmith & Koriat, 2008; Koriat, Goldsmith, & Pansky, 2000).

c.1.3.1 ***Report Option***

Our initial work on the self-regulation of memory accuracy and informativeness focused on how people use the option of free-report to boost the accuracy of their memory reports. Essentially, people volunteer information that they are confident about and withhold information that they are not sure of. To the extent that subjective confidence is diagnostic of memory accuracy, this selective reporting yields a quantity-accuracy trade-off: Fewer items will be reported but a larger proportion of these will be correct in comparison with forced-report testing.

To help elucidate the mechanisms and performance consequences of the use of report option, we proposed a model that describes the monitoring and control processes involved in the regulation of memory reporting (Koriat and Goldsmith, 1996b, see Figure).

In that model, the rememberer is assumed to monitor the subjective likelihood that each candidate memory response is correct, and then compare that likelihood to a preset threshold on the monitoring output to determine whether to volunteer that response or not. The setting of the control threshold depends on the relative utility of providing as complete a report as possible versus as accurate a report as possible.



An important supplement to the proposed model is an accompanying experimental paradigm and procedure that combines free and forced reporting with the elicitation of confidence judgments to isolate and assess the cognitive and metacognitive components

postulated by the model (for further details, see Goldsmith & Koriat, 2008). Rather than evaluating memory performance in terms of a single overall measure (e.g., percent correct), this *Quantity-Accuracy Profile* (QAP) methodology and its variants (e.g., Higham, 2007, 2011; see Goldsmith, 2011 for a discussion) yields a rich profile of measures, including the joint levels of free-report quantity and accuracy performance, and the underlying determinants of this performance: memory retrieval, metacognitive monitoring, and report control. *Memory retrieval* (uncontaminated by self-control of memory reporting) is indexed by the percentage of correct items (answers) under forced report instructions. Metacognitive *monitoring effectiveness* is indexed in terms of both *calibration bias* (over/under-confidence) and monitoring *resolution* (or discrimination accuracy)—the correlation between confidence in one's answers and the actual correctness of those answers. *Control sensitivity*—the extent to which a person's reporting behavior is related to (guided by) the output of his or her monitoring process—is indexed by the correlation between confidence in an answer and the decision to report it. Finally, *report criterion setting* can also be estimated by identifying the confidence level above which the participant reports her answers, and below which she withholds them.

Studies using this procedure have yielded results consistent with the model: First, the tendency to report an answer is typically very strongly correlated with subjective confidence in the correctness of the answer (e.g., Koriat & Goldsmith, 1996b, Pansky, Koriat, Goldsmith, & Pearlman-Avnion, 2009), suggesting that people rely on their subjective confidence in deciding whether to volunteer an answer or withhold it. At the same time, however, control sensitivity has been found to be systematically lower in specific populations such as elderly adults (Pansky et al., 2009) and schizophrenic patients (Koren, Seidman, Goldsmith, & Harvey, 2006). Interestingly, control sensitivity was found to correlate with measures of executive functioning (Pansky et al., 2009) and measures of clinical awareness and competence to consent (Koren et al., 2006), suggesting a link between control sensitivity and overall levels of metacognitive and executive functioning.

Second, participants given a high accuracy incentive (winning one point for each volunteered correct answer but losing 10 points for each volunteered wrong answer) adopt a stricter criterion than participants given a more moderate incentive (e.g., a 1:1 penalty-to-bonus ratio), suggesting that the strategic regulation of memory reporting is strategically adapted to the emphasis on memory accuracy (e.g., Higham, 2007; Koriat & Goldsmith, 1996b; Koriat, Goldsmith, Schneider, & Nakash-Dura, 2001).

Third, the option to volunteer or withhold responses allows participants to boost the accuracy of what they report in comparison with a forced-report test, but this increase occurs at the cost of withholding some correct answers (e.g., Higham, 2007; Kelley & Sahakyan, 2003).

Finally, the extent of the quantity-accuracy trade-off has been found to depend critically on monitoring effectiveness. Clearly some ability to distinguish between correct and incorrect candidate answers is necessary for the control of memory reporting to yield any benefits at all. Moreover, as this ability improves, greater increases in accuracy can be

achieved at lower costs in quantity, so that at the extreme, when monitoring effectiveness is perfect, there is no quantity-accuracy tradeoff at all. On the other hand, when monitoring ability is poor, the exercise of report option yields little or no benefit in accuracy, and merely reduces the quantity of correct reported information (see, e.g., Higham, 2011 [simulation analyses]; Kelly & Sahakyan, 2003; Koriat & Goldsmith, 1996b; Rhodes & Kelly, 2005).

c.1.3.2 ***Control of Grain Size***

The basic theoretical model and results discussed so far have focused on how people regulate their memory performance when given the option to withhold individual items of information or entire answers about which they are unsure. Control of report option, however, is just one means by which people can regulate their memory reporting. In most real-life memory situations, people do not just have the choice of either volunteering a substantive answer or else responding "I don't know." They can provide a piece of information but indicate that they are not entirely sure about it. They also have the option of controlling the "graininess" or level of precision or coarseness of the information that they provide (e.g., describing the assailant's height as "around 6 feet" or "fairly tall" rather than "5 feet 11 inches").

The considerations and mechanisms underlying the choice of grain size in memory reporting are similar to, though somewhat more complex than, those underlying the exercise of report option. Consider, for example, a witness who wants to fulfill her vow to "tell the whole truth and nothing but the truth." How should she proceed? On the one hand, a very coarsely grained response (e.g., "between noon and midnight") will always be the wiser choice if accuracy (i.e., the probability of including the true value—telling nothing but the truth) is the sole consideration. However, such a response may not be very informative, falling short of the goal to tell the whole truth. On the other hand, whereas a very fine grained answer (e.g., 5:23 p.m.) would be much more informative, it is also much more likely to be wrong. A similar conflict is often faced by students taking open-ended essay exams: Should one attempt to provide a very precise-informative answer, but risk being wrong, or try to "hedge one's bet" by providing a coarser, less informative answer, and risk being penalized for vagueness? In both of these examples, control over grain size can be seen to involve an accuracy-informativeness tradeoff similar to the accuracy-quantity tradeoff observed with regard to the control of report option.

How does one find an appropriate compromise between accuracy and informativeness in choosing a grain size for his or her answers? One simple strategy is to provide the most finely grained (precise) answer that passes some preset report criterion (in terms of assessed probability correct). Thus, for example, our earlier witness might try to answer the question to the nearest minute, to the nearest 5 minutes, 10 minutes, 15 minutes, and so forth, until she is, say, at least 90% sure that the specified answer is correct. Goldsmith, Koriat, & Weinberg-Eliezer (2002) called this the satisficing model of the control of grain

size: The rememberer strives to provide as precise-informative an answer as possible (without being overly precise; cf. Grice, 1975), as long as its assessed probability of being correct satisfies some reasonable minimum level. Note that this model is similar to the one presented earlier with regard to report option: As with report option, the assessed probability-correct of each answer that is volunteered must pass a report criterion, and the setting of the criterion level should depend on the relative incentives for accuracy and informativeness in each particular situation.

As in the study of report option, the challenge in the study of the control of grain size is to find a way to allow participants to control the grain size of their answers while also obtaining information about the underlying metacognitive mechanisms and performance consequences. A productive approach has been to adapt the "free-forced" paradigm used for report option, in which participants are required to answer questions at a grain size specified by the experimenter, while also being given the option to choose the grain size that they would prefer to provide under either implicit or explicit incentives for accuracy and informativeness.

We now summarize and discuss some of the main findings and conclusions that have emerged with regard to the control of grain size in memory reporting.

1. Rememberers are able to monitor the correctness of their best-candidate answers at different grain sizes, but differences in grain size appear to be tied to systematic differences in monitoring effectiveness. In general, monitoring resolution has been found to be moderately high for both fine-grained and coarse-grained answers, with a tendency for lower resolution for the coarse-grained answers (e.g., Goldsmith, Koriat & Pansky, 2005; Luna, Higham, & Martin-Luengo, 2011). In addition, although the general finding of overconfidence applies to the monitoring of precise answers, people tend to be much less overconfident and sometimes even underconfident in the correctness of their coarse-grained answers (e.g., Goldsmith et al. 2002; Luna et al., 2011; Weber & Brewer, 2008). In an interesting operationalization of grain control called the "plurality option," Luna et al. (2011) found that although reported coarse-grained answers, were more likely to be correct than reported fine-grained answers, confidence was lower for the former than for the latter, yielding an apparent dissociation between confidence and accuracy across grain sizes. One account of this pattern is that participants do not sufficiently adjust their subjective probability assessments to accommodate differences in the a-priori (baseline) probabilities that an answer will be correct at the different grain sizes. Such a tendency toward underconfidence in coarse-grained answers may hinder the effectiveness of the grain control process, biasing it toward the choice of fine grained answers.

2. Memory monitoring guides the grain control decisions. As with the control of report option, the basic assumption of the metacognitive model of grain control is that the choice of grain size is based on subjective confidence in the correctness of one’s candidate answers. Indeed, in line with the satisficing model described earlier, very high correlations have been found between confidence in one’s best-candidate fine-grained answer and the decision to provide that answer rather than a more coarse-grained answer (e.g., Goldsmith

et al., 2002, 2005; Weber & Brewer, 2008). Of course the grain control decision could conceivably be based not only on confidence in one's fine-grained candidate answer but also on confidence in alternative coarse-grained candidate answers, or perhaps on the relative gain in confidence when moving from the fine-grained to a more coarse-grained answer (as predicted by a "relative utility maximizing model"; see Goldsmith et al., 2002). Results so far indicate that the grain control decision is based primarily on confidence in the fine-grained answer, in line with the simple satisficing model.

3. Control over grain size enhances the accuracy of reported information, at a cost in the informativeness of the reported information (accuracy-informativeness trade-off). Perhaps the most basic finding is that when given the option to choose the appropriate grain size for their answers, participants are not guided solely by the desire to be correct—in which case they would always choose to provide a coarse grained answer, nor solely by the desire to be informative—in which case they would have always choose to provide a precise/fine-grained answer. Instead, participants tend to choose the coarse-grained answer (sacrificing informativeness for accuracy) when the more precise answer is unlikely to be correct. By sacrificing informativeness in this calculated manner, participants generally improve their accuracy substantially compared to what they would have achieved by providing the fine grained answers throughout (e.g., Goldsmith et al., 2002, 2005; Luna et al., 2011; Pansky & Nemets, 2012; Weber & Brewer, 2008). The control of grain size is far from optimal, however, apparently because of imperfect monitoring: There are still many cases in which fine-grained answers are provided even though they are wrong, and coarse-grained answers are provided even though the fine-grained answer is correct.

4. The control of grain size in memory reporting is strategic. A key assumption of the metacognitive model of grain control is that the grain size of reported information is determined not only by the grain size of the information that is available and accessible in memory, but also on strategic control: Holding the quality of the accessible information constant, people may choose to report the information either more precisely or more coarsely, and they do so based on their subjective assessment of the likely correctness of the information and in light of implicit or explicit incentives for accuracy and informativeness. In support of this idea, studies manipulating the incentives for accuracy and informativess have found that participants do in fact strategically adjust their grain control criterion, requiring lower levels of confidence for reporting fine-grained answers and providing more of such answers when a premium is placed on informativeness, and vice versa when the premium is placed on accuracy (e.g., Goldsmith et al., 2002, 2005).

5. The control of grain size is constrained by a minimum-informativeness criterion: when respondents are unable to provide an answer that is both sufficiently accurate and sufficiently informative, they prefer to withhold the answer entirely (if report option is available), or violate the confidence criterion, if necessary to provide a reasonably informative answer. According to social and pragmatic norms of communication, people are expected not only to be accurate in what they report, but also to be reasonably informative (Grice, 1975). What, then, should a rememberer do if achieving the desired

level of likely correctness requires her to provide a ridiculously coarse answer such as "the assailant was between 5 and 7 feet tall" or "the French revolution occurred sometime between the years 1000 and 2000"? Ackerman and Goldsmith (2008) examined the control of grain size in answering either easy or very difficult general-knowledge questions, and found that when knowledge of the answer was very poor, such that a minimum-confidence criterion and a minimum-informativeness criterion could not be jointly satisfied ("unsatisficing" knowledge), respondents tended to violate the minimum-confidence criterion, choosing to provide relatively precise but low-confidence answers. However, in the Ackerman and Goldsmith (2008, Experiment 4) study, when rememberers were allowed simultaneous control over both grain size and report option (the option to respond "don't know"), they utilized the don't-know option to avoid violating either the minimum-confidence or minimum-informativeness criterion, though some precise low-confidence answers were still reported.

Ackerman and Goldsmith (2008) speculated that there may also be social-pragmatic norms that prohibit overuse of the don't-know option, because this too may be seen as being uninformative or uncooperative. Several other studies have also examined the joint control of grain size and report option, and the division of labor between them (e.g., Evans & Fisher, 2011; Weber & Brewer, 2008).

c.1.3.3 ***Extensions and Applications***

The strategic control of memory accuracy and informativeness is an important topic of research in its own right, but is also of interest because of the role that such control plays in a variety of memory research domains and topics. The application of the metacognitive framework to examine how rememberers regulate their memory reporting as well as the performance consequences of such regulation, has yielded new insights with regard to several important memory topics and phenomena, such as (a) the effectiveness of different questioning and testing procedures in eliciting accurate memory reports (e.g., Koriat & Goldsmith, 1994; Evans & Fisher, 2011; Luna et al., 2011; Pansky & Nemets, 2012; Perfect & Weber, 2012; Weber & Perfect, 2012), (b) the credibility of children's witness testimony (e.g., Koriat, Goldsmith, Schneider, & Nakash-Dura, 2001; Roebers & Fernandez, 2002; Roebers & Schneider, 2005), (c) the stability and decline of memory accuracy over time (e.g., Evans & Fisher, 2011; Goldsmith et al., 2005), (d) memory decline in old age (e.g., Kelley & Sahakyan, 2003; Pansky et al., 2009; Rhodes & Kelley, 2005), (e) cognitive and metacognitive impairments related to schizophrenia and psychoactive medication (e.g., Koren et al., 2004, 2005, 2006), (f) encoding–retrieval interactions and the encoding specificity principle (e.g., Higham, 2002; Higham & Tam, 2005), and (g) psychometric and scholastic testing (e.g., Higham, 2007; Notea-Koren, 2006).

Here we focus on one important extension of the framework that is presently being pursued in ongoing projects at the Minerva Center.

c.1.3.4 ***Quality Control in Memory Retrieval and Reporting: Front-End and Back-End Mechanisms***

This project is being conducted in collaboration with Prof. Larry L. Jacoby of Washington University in St. Louis, and was initially funded by a 4-year grant from the U.S.-Israel Binational Science foundation to Prof. Goldsmith and Prof. Jacoby. It stemmed from interaction between these researchers that took place at the DIP workshop held in Heidelberg, in July, 2004, at which Prof. Jacoby was an invited guest. Some of this work was conducted as part of Dr. Vered Halamish's Ph.D dissertation, partly supported by the Minerva Center.

Jacoby and colleagues (e.g., Jacoby, Shimizu, Daniels, & Rhodes, 2005) have promoted a useful metaphor for thinking about memory: Quality control in manufacturing can be achieved either by a post-production monitoring process, which identifies and screens out defects, or by investing in improved production techniques, so that fewer defects are produced in the first place. Building on this metaphor, in this project we are examining both "front end" (pre-retrieval) and "back end" (post-retrieval) quality-control processes involved in memory retrieval and reporting, and their contribution to the accuracy of the information that is ultimately reported.

As part of the project, we have extended the Koriat and Goldsmith (1996b) framework to include both front end and back end mechanisms of metacognitive monitoring and control. These mechanisms have been incorporated into an integrative theoretical framework called *Metacognitively Guided Retrieval and Report* (*META-RAR*; Goldsmith, Jacoby, Halamish, & Wahlheim, 2009; see also the general schematic framework presented by Koriat, Goldsmith, & Halamish, 2008). In addition to the back-end monitoring and control mechanisms included in the original Koriat and Goldsmith (1996b) model, which monitor the likely correctness of one's best-candidate answer in order to decide whether to report it or not, the new framework includes two additional components: (1) *production control*—a front-end mechanism that chooses an appropriate retrieval strategy and sets up (constrains) the retrieval query; (2) *candidate monitoring*—an additional back-end component, involved in monitoring the information that comes to mind until a best-candidate answer is reached.

A new assessment methodology was developed to isolate and measure the individual contributions of each component to cued-recall accuracy and quantity performance. This methodology, called *RAR-QAP* (*Retrieval-and-Reporting Quantity-Accuracy Profile*; Goldsmith et al., 2009), is essentially an adapted and expanded version of Koriat and Goldsmith's original (1996b) QAP methodology, based on a new *Retrieve-and-Report* (RAR) paradigm designed to open up the black box of retrieval and examine its contents. This new procedure provides information about each candidate answer that comes to mind, in addition to the best-candidate answer that is provided under forced-report instructions. The primary measure used to index the quality of the memory production (retrieval)

process, independent of candidate monitoring, is the percentage of items for which the target (rather than a nontarget) is the first candidate answer that comes to mind (under uninhibited recall instructions, in which subjects are explicitly instructed not to screen out any candidates that come to mind).

The empirical investigation so far has centered on control of the production process, examining both controlled and uncontrolled factors that influence production quality, and the contribution of production quality to memory accuracy. The first study (Halamish, Goldsmith, & Jacoby, 2012) focused on the control of production quality through *source constrained recall*. Source constrained retrieval was recently demonstrated in recognition memory by Jacoby et al. (2005): Rememberers spontaneously processed recognition cues in qualitatively different ways (deeply or shallowly), in a manner that fit the original (source) encoding task. Here we asked whether source constrained retrieval might also occur during cued recall, and if so, would it lead to enhanced production, post-production monitoring, or both? In one experiment (which did not use the new RAR-QAP methodology), participants read one list of unrelated pairs, and then encoded another list in either a deep (pleasantness comparison) or shallow (syllable comparison) incidental encoding task (between participants). In a subsequent cued-recall test, cues from both lists were intermixed. Importantly, a final recognition test was conducted in which participants were asked to recognize cues from the first (read) list that had appeared on the preceding cued-recall test. As predicted, recognition of these read cues was better following deep than shallow encoding of the second, processed list, reflecting the fact that on the cued-recall test, participants strategically reinstated the incidental encoding task that had been used on the processed list to constrain their memory search.

A second experiment was designed to examine whether the strategic reinstatement of encoding operations, revealed in the preceding experiment, does in fact take place during candidate production as a strategy for constraining retrieval, and whether such reinstatement might enhance post-retrieval monitoring as well. Toward this goal, the RAR-QAP procedure was used to separately tap production and monitoring. In this experiment, participants incidentally encoded one list of unrelated pairs with depth of encoding manipulated within participants (the encoding task alternated every four pairs). On a subsequent cued-recall test, in addition to the cue word (and target stem), participants in one group were also provided with source information, indicating the type of operation (deep or shallow) that had been used to encode each item, while no source information was given to participants in the other group. In this way, depth of encoding, which was uncontrolled at retrieval, and source information, which allowed the strategic use of source constrained retrieval, were independently manipulated.

The results revealed that as expected, encoding depth affected production quality, with better production quality for deeply encoded items. More importantly, the results yielded a controlled effect of source constrained retrieval on production quality: Participants used the produced source information to constrain retrieval, which improved the production quality of deeply encoded items (but not of shallowly encoded items). A similar pattern was

observed for candidate monitoring, indicating that both front-end production and back-end monitoring components made unique contributions in mediating the effect of source-constrained retrieval on free-report memory accuracy performance.

A second study (Halamish & Goldsmith, in preparation) focused on the control of production through the strategic choice between two broad production strategies: *direct-retrieval*—a deliberate attempt to "home in" on the target representation in episodic memory, using relatively specific and constraining retrieval cues, and *generate-recognize*—trying to "cast a wide net" by using less specific episodic cues and relying more on semantic memory to generate a set of candidates from which the target can be identified. We examined whether rememberers spontaneously choose between these strategies based on their implicit, metacognitive knowledge of the relative proportions of weakly related and strongly related word pairs in the studied list, and the consequences of this choice for production quality and memory accuracy.

Participants studied a list of associated cue-target word pairs, comprised of both strongly and weakly related pairs intermixed. The proportion of list pairs that were strongly related (75% vs. 25%) was manipulated between participants, with half of the pairs (critical pairs) being identical in the majority-strong and majority-weak lists. We hypothesized that metacognitive awareness that the majority of encoded pairs were strongly related would increase the tendency to adopt a generate-recognize strategy, whereas awareness of the opposite list structure (majority weak) would reduce this tendency. Therefore, production quality (and consequently free-report quantity and accuracy) was expected to be better for strongly related critical pairs in the majority-strong than in the majority-weak condition, whereas the opposite pattern was expected for weakly related pairs. Results using the RAR-QAP procedure supported this hypothesis for the weakly-related items but not for the strongly related items, presumably because direct-retrieval was more effective than generate-recognize in eliciting weakly related targets, whereas the two strategies were equally effective in eliciting strongly related targets. A subsequent experiment confirmed this idea, yielding the predicted effect of list structure for the strongly related items at a longer retention interval, when direct retrieval would be less efficient.

Overall, the results obtained so far (including the results of studies not mentioned here) indicate that production quality can be influenced by both controlled (source constrained retrieval; production strategy) and uncontrolled (encoding depth, cue-target associative strength and retention interval) retrieval factors, and that this has important consequences for both recall accuracy and quantity performance. Moreover, the results showed that front-end production quality makes a unique contribution to memory accuracy, beyond the contribution of the back-end monitoring and report-control components, and revealed several dissociations in the effects of various factors on these components. This work, conducted as part of a growing effort to examine the controlled aspects of remembering and their role in regulating memory accuracy, highlights the potential utility of the META-RAR framework and the RAR-QAP methodology for investigating various memory

phenomena and memory disorders, and the underlying cognitive and metacognitive components that mediate them.

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c.2 Visual Perception and Attention

Prof. Kimchi, Dr. Yeshurun, Prof. Goldsmith, and Prof. Norman

A great deal of research has been conducted in the context of the Minerva Center on a diversity of central topics in the area of visual perception and attention. This report presents a selective review of some of the unique contributions of the Minerva researchers in this area, organized around four general topics concerning visual perceptual organization, object and face perception, mechanisms of visual attention, and applications to human factors.

c.2.1 Visual Perceptual Organization

The ease and speed with which we perceive a coherent visual world belies the sophistication of the visual system and its emergent behaviors. One of the challenges the visual system faces is that of perceptual organization – the structuring of the bits and pieces of visual information into coherent units that eventually we experience as environmental objects.

Many modern theories of visual perception have treated perceptual organization as a unitary phenomenon that operates at a single, early, preattentive stage, in a bottom-up fashion (e.g., Marr, 1982; Neisser, 1967; Treisman, 1988). Also, organization based on Gestalt principles was assumed to be, if not innate, fully functional in early infancy. The research conducted by Prof. Kimchi and her associates has challenged several aspects of the traditional view and has led to a newly emerging view that perceptual organization is not a monolithic entity but rather represents a confluence of multiple processes that vary in time course, attentional demands, and developmental trajectory, and are not immune to influence from past experience (Kimchi, 2003, 2009, in press; Behrmann & Kimchi, 2003).

Using behavioral methods with normal adults, children and neurological patients, we have attempted to reveal the principles and the processes underlying visual perceptual organization. This issue has been addressed from different but complimentary perspectives:

- Microgenetic analysis of perceptual organization: Investigating the time course of perceptual organization – what processing occurs during the stream of visual processing. To this end, we have used mainly (but not exclusively) a version of the primed matching paradigm, examining the time course of the organization of hierarchical stimuli (few- and many-element stimuli), and the time course of grouping by different cues, including color similarity, proximity, closure, collinearity, and familiarity.
- Ontogenesis of perceptual organization: Investigating the development of organizational processes in children. Using stimuli and procedures (adapted to children) similar to and as rigorous as the ones used in research on adult perception, which allow determining both the rate of development and when abilities reach an

optimal level, we have examined age-related changes in the organization of hierarchical stimuli and in grouping of shape by perceptual closure, proximity and collinearity.

- The relation between perceptual organization and visual attention: Investigating whether perceptual grouping and figure-ground segmentation can be achieved without visual attention, using an inattention paradigm with indirect online measures of unattended processing. Another project focuses on investigating the effects of perceptual organization on automatic deployment of attention.

c.2.1.1 Micorgenesis of Perceptual Organization

Microgenesis of perceptual organization refers to the time course of the development of the percept in adult observers. This microgenetic analysis is important for understanding the processes underlying organization, rather than just the final product of these processes.

The main technique that we have used to study microgenesis of perceptual organization is an adaptation of the primed matching paradigm originally developed by Beller (1971). In this paradigm the observer is presented with a prime followed immediately by a pair of test figures to be matched for identity. Responses to "same" test pairs are faster when the figures in the pairs are similar to the prime than when they are dissimilar to it. This paradigm enables us to assess implicitly the observer’s perceptual representations. We reasoned that if we vary the duration of the prime and construct test figures that are similar to different aspects of the prime, it enables us to probe changes in the representation over time – that is, to examine the time course of perceptual organization.

Time Course of Perceptual Organization of Hierarchical Patterns

Our earlier microgenetic studies examined the time course of grouping multiple elements that varied in number and relative size into global configurations (Kimchi, 1998). The primes were elements (e.g., circles) grouped into a global configuration (e.g., global diamonds). The "same"-response test pairs were either similar to the elements of the prime (and dissimilar to the global configuration) or similar to the prime’s global configuration (and dissimilar to the elements). In addition, a neutral prime (an X) served as a baseline (control) condition for the two types of test pairs (Figure 1A).

The amount of priming is defined by the difference in "same" RT to an element-similarity test pair versus a configuration-similarity test pair after seeing the prime, minus the baseline RT difference to these test pairs in the control condition. Priming of the configuration should produce priming values of greater than zero and priming of the elements should produce priming values of less than zero.

The results (Figure 1B) showed priming of the global configuration of many-element stimuli at brief exposures, but priming of the local elements only at longer exposures. The converse pattern was observed for the few-element stimuli: here the relatively large elements were primed at brief exposures and the global configuration was primed at longer exposures.

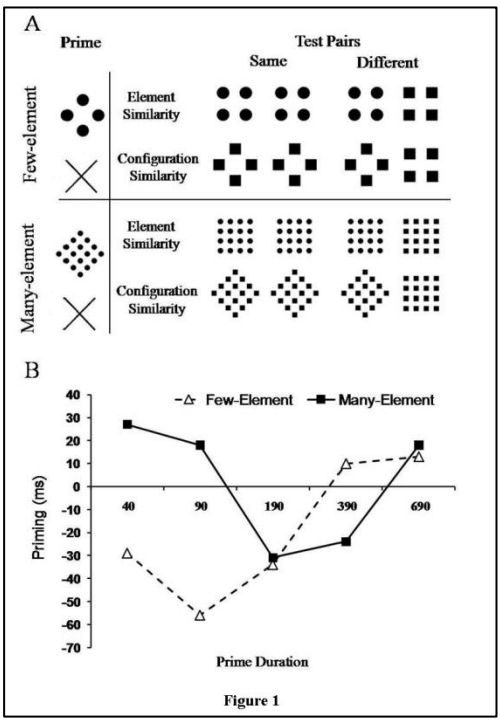

Figure 1

Results concerning the accessibility of the global configuration and local elements of few- and many-element patterns to rapid search (Kimchi, 1998, Kimchi, Hadad, Behrmann & Palmer, 2005) converged with the primed matching results. The global configuration of many-element patterns was accessible to rapid search, whereas the local elements of such patterns were searched inefficiently. For the few-element patterns, search for local elements was fast and efficient, whereas the global configuration was searched less efficiently.

These findings suggest that grouping many relatively small elements into a global configuration differs from grouping a few relatively large elements: The former process is rapid and effortless, whereas the latter consumes time and requires attention. The individuation of elements also differs for few versus many elements: few large elements are individuated rapidly and effortlessly, whereas the individuation of many small elements occurs later and demands attention. Kimchi (1998, Kimchi et al., 2005) suggested that early and rapid grouping of many small elements and individuation of a few large elements are desirable characteristics for a system whose one of its goals is object identification and recognition, because many small elements in high proximity to one another are likely to be texture elements of a single object, whereas a few large elements are likely to be several discrete objects or several distinctive parts of a complex object.

Our work (Behrmann & Kimchi, 2003) with two individuals who suffer from visual object agnosia, in which they are unable to recognize even familiar common objects presented to them in the visual modality, revealed a significant impairment in the ability to apprehend a multi-element stimulus as a whole with a specific shape, despite the preserved ability to do simple grouping. These results suggest that the failure to exploit these more complex, configural processes gives rise to a deficit in object recognition.

Time Course of Perceptual Grouping

The grouping principles, as formulated by the Gestalt psychologists, hold only when everything else is equal, i.e., when they are the only rule that applies and no other grouping factors are present. Perceptual organization, however, is clearly determined by the simultaneous operation of several grouping principles (e.g., Koffka, 1935). Therefore, an important issue concerns the integration of multiple grouping factors and the rules governing the combination of different principles. In addition, different groupings may involve different processes even when grouping is guided by a single grouping principle. For example, in some cases the grouping involves just a process of unit formation or clustering that determines which elements belong together and are segregated from other elements; in other case, grouping involves also a process of shape formation or configuring that determines how the grouped elements appear as a whole based on the interrelations of the elements (Koffka, 1935).

Hadad and Kimchi (2008) addressed the issue of the combination of multiple factors by investigating the time course of grouping of shape by perceptual closure and its interaction with spatial proximity and collinearity, using primed matching. Their primes were line segments grouped by closure into *spindle*-like shapes. The gaps between the closure-inducing contours varied in size and, depending whether that gaps occurred at straight contour segments or at point of change in contour direction, collinearity was either present or absent. In the absence of collinearity, early priming of the shape was observed for spatially close fragments, but not for spatially distant fragments. When collinearity was available, the shape of both spatially close and spatially distant fragments was primed at brief exposures. These results suggest that spatial proximity is critical for the rapid grouping of shape by perceptual closure in the absence of collinearity, but collinearity facilitates the rapid grouping of shape when the closure-inducing fragments are spatially distant (see also Kimchi, 2000). In addition, shape priming persisted over time only when the collinear fragments were spatially close, suggesting that a stable representation of shape depends both on collinearity and spatial proximity between the closure-inducing fragments.

Raspurker-Apfeld and Kimchi (2007) examined the microgenesis of groupings that varied in the processes involved in the grouping, with a focus on the processes of segregation and shape formation, using the primed-matching paradigm. Their primes were dot matrices grouped by lightness similarity into columns/rows or into a shape (square/cross or triangle/arrow). The results showed priming of the columns/rows under short prime durations, whereas priming of the square/cross (or triangle/arrow) was observed only under longer prime durations, indicating that grouping by lightness similarity into columns/rows was accomplished faster than grouping by lightness similarity into a shape. These results indicate that even when guided by the same principle, groupings can vary in their time course, demonstrating that the time course of grouping depends not only on the Gestalt principle that guides the grouping as has been previously shown (e.g., Ben-Av & Sagi, 1995; Kurylo, 1997), but also on the processes involved in the grouping and the conditions prevailing for each process.

Influence of Past Experience on Perceptual Grouping

Past experience can influence the perceived organization of visual stimuli: Phenomenologically, a very fragmented image is perceived initially as a random array of pieces, but once recognized, it is perceived as an organized picture. A well known example is the Dalmatian dog. The question is, however, whether past experience exerts a direct influence on perceptual organization or only on the output of organizational processes. The traditional and widely prevailed view has been that grouping and figure-ground segregation must precede object recognition because it requires a candidate object on which to work (e.g., Marr, 1982; Neisser, 1967). In this view, perceptual organization is accomplished on the basis of low-level, bottom-up cues without access to object representations in memory.

Kimchi and Hadad (2002) provided evidence for the effect of past experience on perceptual grouping. Primed matching was used to examine the microgenesis of the perceptual organization for familiar (upright letters) and unfamiliar (inverted letters) visual configurations that vary in the connectedness between their line components (Figure 2). Subjects were asked to judge whether two intact letters were the same or different. The target letters were preceded by a briefly presented letter prime and the exposure duration of the letter prime varied (40-690 ms). We found that a connected letter prime similar to the target letters sped up "same" judgments both when the prime and targets were upright and when they were inverted. However, when the prime letters were constructed of disconnected segments, only upright-letter primes facilitated judgments at brief exposures, whereas inverted-letter primes facilitated responses only at longer exposures, suggesting that past experience with upright letters enabled the subjects to quickly group the segments into the letter configuration. Vickery and Jiang (2009) demonstrated that a short learning period (as opposed to a life-long experience with letters as in Kimchi and Hadad's study) can also influence grouping. These findings are incompatible with the traditional feed-forward view that assumes that perceptual organization is accomplished solely on the basis of bottom-up cues and is immune to influence from past experience. Rather, it suggests an interactive model of perceptual organization in which both image-based (e.g., connectedness) and object-based properties, including aspects of object memories, contribute to early organization.

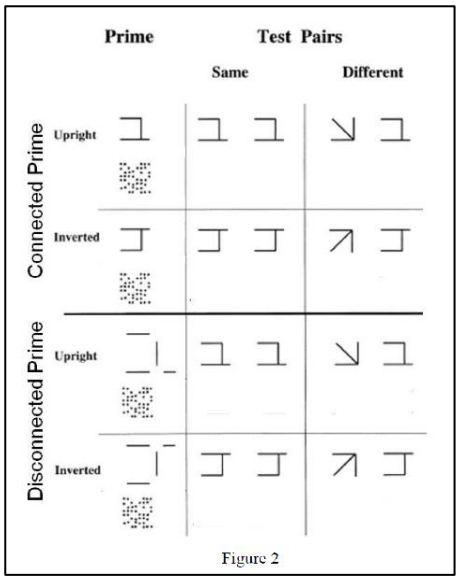

Figure 2

c.2.1.2 Ontogenesis of Perceptual Organization

Much of the research on the development of perceptual organization in human suggests that infants have a wide range of organizational abilities. Several studies demonstrated that infants are capable of grouping visual elements into unitary structures in accord with both classical and modern organizational principles, though some principles have an earlier functional onset than others (e.g., Quinn & Bhatt, 2006).

Studies of older children, however, suggest that there is a protracted developmental trajectory for some perceptual organization abilities, even those that appear to emerge during infancy (e.g., Hadad & Kimchi, 2006; Kovacs, 2000; Kimchi et al., 2005).

Development of Perceptual Organization of Hierarchical Patterns

The microgenetic results prompted the questions of whether grouping in many-element patterns differs developmentally from that in few-element patterns, and whether individuation in many-element patterns differs developmentally from that in few-element patterns. Kimchi and her colleagues (Kimchi, et al., 2005) examined these questions by comparing the performance of 5- to 14-year-old children and young adults on few- and many-element hierarchical displays in two tasks: visual search and speeded classification.

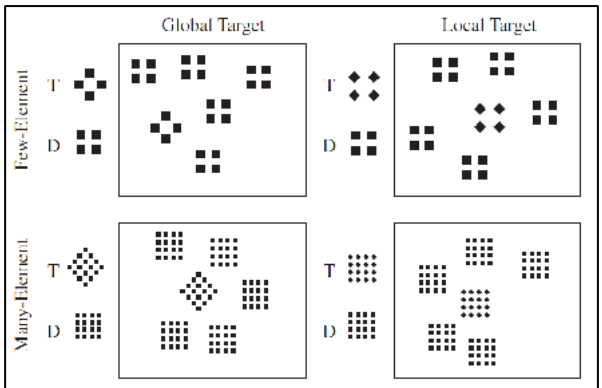

Figure 3

In the visual search study, participants searched as quickly and accurately as possible for a diamond shape among a variable number of square shape distractors. The target was present either at the local level (local target) or at the global level (global target) of either few- or many-element patterns (Figure 3). The primary dependent variable was search rate, defined as the slope of the best-fitting linear RT function over the number of items in the display. Target search is considered efficient and effortless if the time to detect the target is independent or nearly independent of the number of items in the display. If the time to detect a target increases as the number of items in the display increases, search is considered inefficient and effortful.

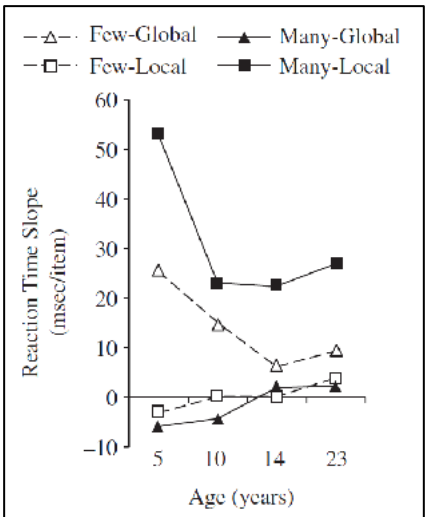

Figure 4

The results (Figure 4) show different age trends in search rates for global and local targets in the many- versus the few-element displays. Search for global targets in the many-element displays and for local targets in the few-element displays was efficient and effortless and did not vary with age. Search

for local targets in the many-element displays and global targets in the few-element displays was inefficient, effortful, and improved with age.

In the classification study, participants were presented with an array of five columns of few- or many-element patterns. The patterns in the central column contained elements similar to the elements of the patterns on one side but had a configuration similar to that of the patterns on the other side (incongruent displays). The task was to indicate whether the central column belonged with the patterns on the left or right side on the basis of similarity in global configuration (global classification) on some trials, or on the basis of similarity in local elements (local classification) on the other trials. The classification results converged with the search results, showing differential age-related changes in classification speed and accuracy for few- versus many-element stimuli.

These results show that age trends differed for the perception of global configuration and local elements depending on the specific nature of the stimuli. Search rates for global targets and accuracy of global classification improved with age for the few-element patterns, but did not change with age for the many-element patterns. Search rates for local targets and accuracy of local classification improved with age for the many-element patterns, but no age-related changes were observed for the few-element patterns. These differential age-related improvements were observed mainly for the transition from ages 5 to 10.

These findings may help resolve an apparent contradiction in the developmental literature. Enns, Burack, Iarocci, & Randolph (2000) used few-element patterns and found age-related improvements in search rates for globally-defined but not for locally-defined targets. On the other hand, Mondloch, Geldart, Maurer, & de Schonen (2003) used many-element patterns and found age-related improvements for local but not for global processing. Thus, depending on the nature of the stimuli used, the different studies tapped into different processes that emerge along different developmental trajectories.

Interestingly, however, in contrast to the early maturation of grouping many small elements observed by Kimchi et al. (2005) in visual search and classification tasks, Scherf, Behrmann, Kimchi, & Luna (2009), using a primed matching task, showed age-related improvement in the ability to encode the global shape of the many-element patterns at the short prime durations, which continued through adolescence. A possible account for this apparent inconsistency suggests that the different tasks may require different representations for successful performance – crude versus more refined, which depend on relatively rudimentary ability to group elements into a shape versus more mature ability, respectively.

Taken together, the results from these studies suggest that children and adolescents are capable of grouping many small elements to a certain degree, which may support some global information and figural perception, but the full process of integrating local elements into coherent shapes to the extent of facilitating shape identification appears to develop late into adolescence. This long developmental trajectory of the ability to integrate the local

details of a visual scene into coherent shapes coincides with what is known about the structural and functional development of the ventral visual pathway (Gogtay et al., 2004).

Developmental Trends in Utilizing Closure for Grouping of Shape: Effects of Spatial Proximity and Collinearity

The microgenetic results suggest that adults utilize closure and its combination with collinearity and proximity to organize fragmented image contours into shapes. What is the developmental course of this ability?

Hadad and Kimchi (2006) addressed this question by comparing the performance of 5- and 10-year-old children and young adults in a visual search task. Participants searched as quickly and accurately as possible for a concave target among a variable number of convex distractors. The basic stimuli were composed of two unconnected line segments. The line segments were the same for the concave and convex stimuli but their placement relative to each other differed, bending inward for the concave stimuli and outward for the convex ones. Therefore, the discrimination between target and distractors required grouping of the contour segments into coherent two-dimensional shapes.

We first compared children's and adults' utilization of closure in grouping of shape by examining search performance for open versus closed stimuli. The results show age-related changes in search rate, which depended on the stimulus involved. Search for closed stimuli was equally efficient in all age groups, whereas search for open stimuli was inefficient and improved with age. These findings suggest that closure plays a similar role in grouping of shape for young children and adults.

Having demonstrated that young children are as good as adults in deriving the shape of a closed, connected figure, we turned to examine the ability of children to utilize closure for grouping of fragmented contours as a function of the spatial proximity between the closure-inducing fragments and the presence or absence of collinearity. As in the previous experiment, participants searched for a concave target among a variable number of convex distractors. Target and distractors were disconnected line configurations in which the spatial proximity between the line segments varied, and, depending on the location of the gaps, collinearity was present or absent (Figure 5).

The results revealed reliable developmental differences in search rates that depended on both stimulus (collinear or non-collinear) and gap size. For non-collinear stimuli, search for the shape of spatially close line segments was equally efficient and the shape of spatially distant line segments was searched equally inefficiently, for all age groups. When collinearity was available (i.e., collinear stimuli), search

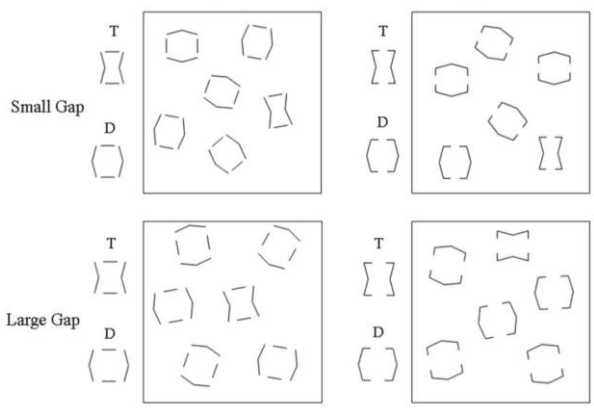

Figure 5

for the shape of spatially close lines was equally efficient for all age groups. However, when the line segments were spatially distant, younger children's search was inefficient and improved significantly in the transition from ages 5 to 10.

Taken together, these results indicate that both children as young as 5 years of age and adults can use closure to organize fragmented contours into a shape in an equally efficient manner, provided that the closure-inducing line segments are spatially close. However, when the closure-inducing line segments are spatially distant, yielding relatively weak closure, 10-year-olds and adults, but not 5-year-olds, can utilize collinearity, when available, to enhance closure for the perceptual grouping of shape.

Theoretical Implications

Our developmental studies have demonstrated that even processes that appear to emerge early in life may have a long developmental course, so that the ultimate level of functioning is attained only in late childhood or adolescence. Thus, although infant research suggests that infants are sensitive to the global configuration of hierarchical stimuli (Ghim & Eimas, 1988), the ability to group multiple elements into a global shape continues to develop, and adult-like performance is not observed before the age of 10. Similarly, although infant research suggests that infants are sensitive to good continuation (Quinn & Bhatt, 2005), the ability to group fragments by collinearity matures between ages 5 and 10.

Some of the developmental changes in perceptual organization abilities may depend on preprogrammed maturation of the visual system. Other aspects of perceptual organization, however, may be acquired through learning and experience. In particular, a protracted developmental trajectory was shown for grouping of a coherent, integrative global shape (e.g., Enns et al., 2000; Hadad & Kimchi, 2006; Kimchi et al., 2005; Scherf et al., 2009, for review, see Kimchi, in press). Note, that some developmental changes in organizational abilities may be a function of developmental improvements in other processes, such as flexibility of attention.

Correspondence between Microgenesis and Ontogenesis?

A particular way of viewing the relation between adult perception and perceptual development was proposed by Werner (1948, 1957). Werner suggested the orthogenetic principle, according to which there is an underlying unity in the pattern of change in perceptual development (ontogenesis) and in the emergence of a percept over time (microgenesis): In both cases perception proceeds from a more global, undifferentiated state to a state of increased differentiation and hierarchical organization.

Independent of whether or not this specific direction of developmental change is supported by empirical findings, comparisons between microgenesis and ontogenesis may provide insights into the underlying principles and mechanisms of perception, without assuming a particular developmental change a priori (cf. Enns, et al., 2000).

Generally speaking, our study of developmental change at the two different time scales converge on the view that perceptual organization is a multiplicity of processes. But, is there a correspondence between microgenesis and ontogenesis of organizational processes?

Our results suggest that there is no necessary correspondence between microgenesis and ontogenesis. Our results further suggest that the comparison between these two developmental courses should be made with caution.

The comparison between the microgenetic and ontogenetic results concerning grouping and individuation of multiple elements in the organization of hierarchical stimuli (Kimchi, 1998; Kimchi et al., 2005) appears to suggest a correspondence between ontogenetic and microgenetic change: The processes that exhibited different developmental trajectories were the ones identified by microgenetic analysis as differing in time course and attentional demands: the rapid and effortless grouping of many small elements and the individuation of few large elements appeared to mature at a relatively early age, whereas the time-consuming and effortful grouping of few large elements and the individuation of many small elements develop with age. There is a caveat, however. The adult-like grouping of many small elements observed with the younger children in visual search may not reflect the same level of functioning as the fast and early grouping observed in adults in the primed matching task, as suggested by the findings of Scherf et al. (2009). As noted earlier, different tasks may tap different levels of functioning of an organizational ability. Consequently, a finding of a correspondence between microgenesis and ontogenesis may be misleading, particularly when the microgenetic and the ontogenetic results are based on different tasks.

The comparison between the microgenetic and ontogenetic results concerning grouping of shape by perceptual closure (Hadad & Kimchi, 2006, 2008) suggests no correspondence between ontogenetic and microgenetic change. The microgenetic results indicate rapid grouping of shape by closure both for spatially close and spatially distant collinear fragments. The ontogenetic findings, on the other hand, indicate that only older children and adults, but not 5-year-olds, are able to use collinearity to enhance closure when the closure-inducing fragments are far apart, suggesting a longer developmental progression in long-range grouping by collinearity. Thus, equally rapid groupings for adults can nevertheless show different developmental trajectories. This finding is actually not surprising. It suggests that once an organizational ability is matured, it is readily applied in adult perception. We are planning to conduct further research to examine whether a correspondence between microgenesis and ontogenesis exists for some organizational processes and not for others.

c.2.1.3 Perceptual Organization and Visual Attention

Perceptual organization – the processes structuring visual information into coherent units – and visual attention – the processes by which some visual information in a scene is selected – are crucial for the perception of our visual environment and to visuomotor behavior. Recent research points to important relations between attentional and organizational processes. Several studies demonstrated that perceptual organization constrains attentional selectivity, and other studies suggest that attention can also constrain perceptual organization. We have focused on two aspects of the relationship between perceptual organization and attention. The first addresses the question of whether or not perceptual organization can take place without attention. The second issue addresses the question of whether perceptual organization can affect the automatic deployment of attention (for review, see Kimchi, 2009).

Can Perceptual Organization Occur without Attention?

Kimchi and Raspurker-Apfeld (2004) investigate grouping under inattention, using Russell and Driver's (2005) inattention paradigm. On each trial, two successive displays were briefly presented, each comprising a central target matrix surrounded by elements (Figure 6). The task was to judge whether the targets were the same or different. The organization of the background elements stayed the same or changed, independently of the targets. In two critical conditions, the background elements were organized by color similarity into columns and rows, and into square and cross. Changes in the background grouping of columns/rows produced congruency effects on the matrix-change judgments, even though participants reported no or little awareness of the background grouping. No effect of the background was observed for grouping of shape, however.

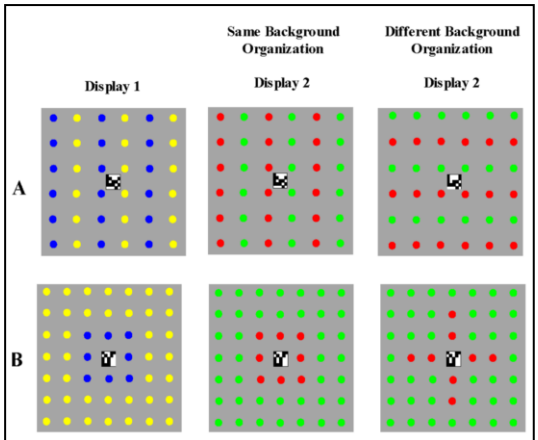

Figure 6

The results for the grouping of columns/rows by color similarity suggest that this grouping was accomplished without focal attention. Further support came from a study in which we used this method to test individuals with hemispatial neglect (Shomstein, Kimchi, Hammer, & Behrmann, 2010). In this study, patients (and matched controls) performed the target change-detection task on a matrix presented entirely to their intact side of space, and the task-irrelevant grouped elements (columns and rows by color similarity) appeared simultaneously on the unattended side. Changes in the grouping of the neglected task-irrelevant elements produced congruency effects on the target change judgments to the same extent as in the control participants even in patients with severe attentional deficits, suggesting that the grouping was accomplished in the absence of attention.

The difference between the results for the columns/rows and for the shape by common color (Razpurker-Apfeld & Kimchi, 2004) is of particular interest because both groupings were guided by the same principle of similarity in color, but nevertheless the former took place under inattention, whereas the latter did not. Complexity of shape formation per se — forming a shape (e.g., a square or a cross) versus forming lines (columns or rows) — cannot account for this difference because grouping of shape occurred under inattention when no elements segregation was involved. Rather, it is grouping that involves both segregation and shape formation that appeared to require attention. We hypothesized that in this case there was a need to resolve figure-ground relations between groups — designating one of the groups as ‘‘figure’’, and this may demand attention. We are currently investigating this hypothesis.

The question of whether or not figure-ground segmentation can occur without attention is unresolved. Early theorists assumed it can, but the evidence is scant and open to alternative interpretations. To examine whether figure-ground segmentation can take place without attention, we adapted Russell and Driver’s (2005) inattention method. In our study (Kimchi & Peterson, 2008), the target matrix appeared on a task-irrelevant scene of alternating regions organized into figures and grounds by convexity. The backdrop region on which the matrix appeared could be convex (figure) or concave (ground). On each trial two successive displays were briefly presented and the task was to judge whether the central matrices are the same or different. The figure-ground organization of the scene backdrop stayed the same or changed across the two successive displays, independently of whether or not the target matrix changed. Changes in the scene backdrop’s figure-ground organization produced reliable congruency effects on target-change judgments: Target-different judgments were more efficient when backdrop organization changed across the two displays than when it remained the same, and target-same judgments were more efficient when backdrop organization stayed the same than when it changed. These results could not be due to the backdrop's changes in convexity/concavity per se: performance was less efficient on trials where the backdrop region on which the matrix appeared changed from ground to figure – a new figure (a "new object") appeared in the target's backdrop region – than on trials where the backdrop region changed from figure to ground; changes in convexity/concavity per se would have the same effect for these two types of trials, because in both types of trials convex and concave regions changed their location across successive displays. These congruency effects arose even though, when probed with surprise questions, participants could report neither the figure-ground status of the region on which the matrix appeared nor any change in that status. When attending to this region, participants reported its figure-ground status and changes to it highly accurately. These results strongly suggest that some figure-ground segmentation can occur without attention.

Our findings are seen to suggest that some forms of grouping and figure-ground segregation can take place without focal attention, whereas other forms of organization require controlled attentional processing, depending on the processes involved in the

organization and the conditions prevailing for each process (see Kimchi, 2009, for a review).

The Effects of Perceptual Organization on the Spontaneous Deployment of Attention

The critical role of perceptual organization in designating potential objects raises an important issue concerning the relations between perceptual organization and attention: When some elements in the visual scene are organized by Gestalt factors into a coherent perceptual unit (an "object"), is visual attention automatically deployed to the object? Presumably, favoring a coherent perceptual unit that conforms to Gestalt factors is a desirable characteristic for a system whose one of its important goals is object identification and recognition, because these units are likely to imply objects in the environment.

To examine whether an object by itself captures attention, it is crucial that the object has no abrupt onset or any other unique transient, and that the object is irrelevant to the task at hand so there is no incentive for the observer to deliberately attend the object. To that end, we employed displays composed of several elements. On some trials a subset of the elements grouped by Gestalt factors into an "object". The object was task irrelevant and unpredictive of the target. In one study the target was one of the elements (Kimchi, Yeshurun & Cohen-Savransky, 2007) and in another study, a vernier target was added to the elements display (Yeshurun, Kimchi, Sha'shoua, & Carmel, 2009). We found that response to targets in the object area was faster on trials with an object present than on trials with no object, but slower for targets in a non-object area. These findings demonstrate that an object, by itself, can capture attention automatically, in a stimulus-driven manner.

Currently, we are investigating the object properties that are necessary for a spontaneous attraction of attention to the object. For instance, in one experiment we examine whether a similar automatic capture of attention would emerge even when symmetry is the sole organization factor. Other experiments explore the factors of collinearity and closure. In another study we manipulate the elements' contrast polarity to test whether the effectiveness of this spontaneous attentional capturing depends on the goodness of the emerging object.

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c.2.2 Object and Face Perception

c.2.2.1 *Face Perception: Componential and Configural Processing*

This project investigated the relationship between component and configural information in face processing, using a strategy that is not commonly used in the context of face perception. The approach we have taken is derived from the notion that a face is a multi-dimensional visual object that has both component and configural properties, and the critical question is whether configural properties dominate component properties in object identification, discrimination, or classification (Garner, 1978; Kimchi, 1992, 1994, 2003).

In one study we examined whether the discriminability of isolated facial components predicts the discriminability of whole faces composed of these components (Kimchi & Amishav, 2010). We reasoned that if the individual components are the only contributor to performance, then the discrimination of the faces should be determined by the discriminability of the components. If, however, configural properties dominate component properties in the discrimination of faces, then the discrimination of faces with dissimilar configural properties should always be easier than the discrimination of faces with similar configural properties, *regardless* of the discriminability of the components. Following this logic, we first obtained the discriminability of facial components (eyes, noses, and mouth) presented in isolation, using forced-choice discrimination tasks (Experiment 1). We then embedded these components in whole faces, so that faces differed only in a single component, and obtained performance in discrimination tasks with the faces (Experiment 2). By comparing the pattern of performance across Experiments 1 and 2 we could determine whether the faces are the sum of their components. The critical experiment was Experiment 3, in which the components used in Experiments 1 and 2 (the most discriminable and the least discriminable ones) were embedded in whole faces, such that faces differed only in components (i.e., similar configural properties) or in both components and spatial relations between the components (i.e., dissimilar configural properties). Examining the effect of component discriminability on discrimination performance of faces with similar configural properties vs. faces with dissimilar configural properties allowed us to assess the relative dominance of components and configural properties. We also obtained the discrimination of faces differing only in the configural properties (Experiment 4); by comparing performance across Experiments 3 and 4, we could reach further insights into the relations between components and configural properties. The results showed that when upright faces varied only in components, with spatial relations between components held constant across faces, their discrimination was predicted by the discriminability of the components. This was true both for faces that differed in a single component and for faces that differed in three components, indicating that in the absence of configural variation, upright faces are the sum of the components. Facial components do not interact with one another; rather, they are processed independently in parallel. The presence of configural variation, however, facilitated the

discrimination of faces with the more difficult-to-discriminate components, above and beyond what would be predicted by the componential or configural discriminability. These results suggest interactive processing of component and configural properties when the two types of properties are of similar discriminability (none of which is very high).

In a second study (Amishav & Kimchi, 2010) we examined how componential information and configural information interact during face processing, adapting Garner's (1974) speeded classification paradigm. This paradigm examines the ability to process one dimension of a multidimensional visual stimulus, while ignoring another dimension, using selective attention measures, and provides a powerful test of perceptual separability between stimulus dimensions. When classifying upright faces varying in components (eyes, nose, and mouth) and configural information (inter-eyes and nose-mouth spacing), observers were unable to selectively attend to components while ignoring irrelevant configural variation, and vice versa (indexed by symmetric Garner Interference). Performance with inverted faces showed selective attention to components but not to configural information (indexed by asymmetric Garner interference). When faces varied only in components, spatially distant or spatially close, selective attention to different components was possible (nearly zero Garner interference). These results suggest that facial components are processed independently, and that components dominate the processing of inverted faces. However, when upright faces vary in componential and configural information, as in natural faces, the processing of componential information and the processing of configural information are interdependent, with no necessary dominance of one type of information over the other.

Recently, we compared how configural and featural information interact during face processing in a group of individuals with congenital prosopagnosia (CP) and matched controls (Kimchi, Behrmann, Avidan, and Amishav, in press). We adopted Amishav and Kimchi’s (2010) version of Garner’s speeded classification task described above. We replicated the finding that normal observers evince symmetric Garner interference as revealed by the failure to selectively attend to features without being influenced by irrelevant variation in configuration, and vice versa, indicating that featural and configural information are integral in normal face processing. In contrast, the CPs showed no Garner interference: they could attend to configural information without interference from irrelevant variation in featural information, and they could attend to featural information without interference from irrelevant variation in configural information. The absence of Garner interference in CP provides strong evidence that featural information and configural information are perceptually separable and processed independently by CPs, implying that CPs do not perceive faces holistically. This result not only elucidates the underlying perturbation in CP but also confirms that intact face processing is characterized by the integrality of configural and featural information.

c.2.2.2 ***The Perception of Object Continuity***

The world we perceive is stable and continuous despite changes and disruptions in the visual information resulting from movements of the observer, movements of objects, brief occlusion, saccades and blinks. To achieve perception of object continuity the visual system must be able to establish correspondence between objects viewed across such disruptions. A critical question concerns the nature of the information used by the visual system to solve the problem of object correspondence.

The important role of spatiotemporal information in guiding object continuity is well documented; the role of surface features, however, is controversial. Some findings indicate that object correspondence is based solely on an object's spatiotemporal information (e.g., Kahneman et al., 1992) whereas others suggest that surface features can also guide object continuity (e.g., Hollingworth & Franconeri, 2009). These latter findings, however, are open to alternative interpretations as reflecting strategic effects induced by task demands. We examined whether surface features can be used to establish object correspondence when spatiotemporal information is ambiguous (induced by unpredictable change in an object's trajectory under brief occlusion), using the object-reviewing paradigm and controlling for task demands. Our results show object-specific preview benefit (OSPB) – a standard index of object continuity – only when an object's spatiotemporal properties were congruent across brief occlusion (Experiment 1). No OSPB was observed when spatiotemporal information was ambiguous (Experiment 2) or discontinuous (Experiment 3) and the object's color was the only cue for correspondence. These results suggest that only spatiotemporal information, but not surface features information, can guide object continuity across brief perceptual disruptions for objects in motion (Pirkner & Kimchi, 2011; Kimchi & Pirkner, submitted).

Currently we examining whether a combination of features can guide object continuity when spatiotemporal information is ambiguous.

c.2.2.3 ***Object Recognition and Attention***

Research on object recognition has focused mainly on bottom-up processes that analyze the visual input; the potential role of top-down processes has been relatively neglected (Peissig & Tarr, 2007). We propose a framework that views object recognition as discrimination between probable alternatives—an iterative process in which bottom-up and top-down processes interact, and in which attention plays a critical role.

In the first part of this project, we tested three core hypotheses derived from this framework: (1) In the course of object recognition attention is directed to *distinguishing features*—those that are diagnostic of object identity. (2) The distinguishing features are context dependent. (3) Top-down attention to distinguishing features can compete with and ultimately override bottom-up attentional capture by salient non-distinguishing features (Baruch, Kimchi, & Goldsmith, 2012). Observers discriminated between artificial fish and differences in the allocation of attention to distinguishing and non-distinguishing features were examined using primed-matching (Experiment 1), visual probe (Experiments 2, 4, 5),

and spatial cuing (Experiment 3) methods. The results supported the hypotheses, showing that (a) recognizing a fish primed its distinguishing features but not its other features; (b) during the fish recognition process, visual probe detection was superior for probes presented at the location of a distinguishing than a non-distinguishing feature; (c) fish recognition was faster when attention was pre-allocated by a transient cue to the location of a distinguishing than a non-distinguishing feature; (d) different features of the same fish were attended, depending on the stimulus set;(e) attention was deployed to distinguishing features even in the presence of a competing salient non-diagnostic feature.

The second part of this project addressed the iterative nature of the object recognition process (Baruch, Kimchi, & Goldsmith, in preparation). In two experiments observers discriminated between sets of artificial fish. A secondary visual-probe detection task was used to measure changes in the spatial distribution of attention over time. The probe was displayed on 50% of the trials adjacent to a local fish feature for a short duration at several SOAs. In Experiment 1, the fish varied in several local distinguishing features. We assumed that only one feature could be attended at a time and hypothesized that attention would be allocated in the most diagnostic sequence: first to a feature that discriminated between two general classes of fish and then, based on its value, to a second distinguishing feature that would conclusively identify the specific fish. In Experiment 2, fish recognition could be based on either of two distinguishing features, one much more discriminable (perceptually) than the other. On some of the trials, the more discriminable feature was occluded. We hypothesized that attention would be directed initially, by default, to the more discriminable feature, and when this feature was occluded – redirected to the alternative feature. In general, the observed pattern of spatial allocations of attention over time, indicated by probe detection rate at the different locations as a function of SOA, accorded with the predictions, supporting the idea that – when necessary – object recognition is an interactive iterative process in which attention plays a crucial role.

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c.2.3 Attentional Mechanisms

c.2.3.1 *Spatial Attention*

The importance of the selection processes termed attention is rarely doubted. By giving priority to relevant information over non-relevant information, these processes help us comprehend the overwhelming amount of visual information confronting us at any given moment. The main objective of the research conducted by Dr. Yeshurun and her associates is to reveal the nature of the mechanisms underlying spatial attention – the selective processing of information at a given location in space, and understand how it aids perceptual processes. In particular, they study the effects of spatial attention on temporal and spatial aspects of perception as means to further our understanding of both the attentional mechanisms and perceptual tradeoffs –tradeoffs between the temporal and spatial components of visual perception and tradeoffs between integration and segregation processes

Transient Attention and the Interplay between the Spatial and Temporal Domains of Visual Perception

The main objective of this project is to further our understanding of the interplay between the temporal and spatial components of visual perception, via the investigation of attentional effects on both the spatial and temporal aspects of perception. Several studies revealed the effects of transient spatial attention on various temporal processes including degradation of temporal resolution (Yeshurun & Levy, 2003; Yeshurun 2004) and motion perception (Yeshurun & Hein, 2011), prolongation of perceived duration (Yeshurun & Marom, 2008) and prolongation of visible persistence. To account for these various attentional effects, as well as previous finding suggesting that attention enhances spatial resolution (e.g., Yeshurun & Carrasco 1998), Yeshurun has proposed an attentional mechanism that facilitates spatial segregation and temporal integration but impairs spatial integration and temporal segregation. Thus, attention helps performance when tasks such as spatial gap detection (e.g., Carrasco, Williams & Yeshurun, 2002; Yeshurun & Carrasco 1999) require fine spatial segregation or when tasks such as typical visible persistence tasks require integration across time. Yet, when there is a need for spatial integration, as is the case with some texture segmentation tasks (e.g., Yeshurun & Carrasco, 2000), or fine temporal segregation as with flicker detection tasks and motion, attention degrades performance.

Currently, we are employing various experimental and computational procedures to gather further evidence in support of this attentional mechanism and a possible physiological implementation of this mechanism suggesting that transient attention favors parvocellular over magnocellular neural activity. For instance, one of the current projects looks for deferential attentional effects on selective adaptation to information of high vs. low spatial frequency. Because the processing of high frequency is associated with parvo

activity and the processing of low frequency is associated with magno activity, if transient attention favors parvo over magno activity it should magnify adaptation effects with high frequency but minimize them with low frequency. Another project combines peripheral precueing with the pulsed and steady pedestal paradigms. These paradigms bias processing towards the parvo and magno pathway, respectively. As predicted by the hypothesis that transient attention favors parvo over magno processing, attending the relevant location improved accuracy with the pulsed but not the steady pedestal paradigm (Yeshurun & Sabo, 2012).

Are Transient and Sustained Attention Adaptable?

Some of our previous studies suggest that spatial attention can sharpen spatial resolution. This resolution enhancement was found even when it lead to performance impairment (e.g., Yeshurun & Carrasco 1998, 2000). The goal of this study was to investigate the adaptability of transient attention: Can attention either enhance or decrease resolution? To explore which conditions would facilitate each outcome, we systematically manipulated the size of the attentional cue. This manipulation revealed that transient attention can not adapt its operation in accordance with the size of the cue, apart for when the cue equals the target size (Yeshurun & Carrasco, 2008).

Additionally, we tested whether we can get an attentional effect on texture segmentation by manipulating sustained attention, a conceptually-driven, controlled component of attention. In contrast to the effect of transient attention on texture segmentation, sustained attention enhanced performance regardless of target eccentricity (its distance from fixation), suggesting that it may optimize performance by either enhancing or decreasing spatial resolution at the attended location (Yeshurun, Montagna & Carrasco, 2008).

Predicting Visual-Search Performance by Quantifying Stimuli Similarities

One of the prominent research paradigms in the field of attention is the paradigm of visual search in which the observer has to look for a predefined target presented among non-relevant distracters. Although this paradigm was employed by numerous studies, there is still no consensus regarding the factors mediating visual search performance. In this project, we extended two computational models that were previously suggested for computer-vision to account for internal-noise, and evaluated their ability to predict human search performance. We asked observers to perform an orientation-search or a color-search, and we systematically manipulated distracters' homogeneity and target-distracters similarity. We compared our models to several prominent computational models of visual search. In comparison to these previous models, our models' predictions were the closest to human performance (Avraham, Yeshurun & Lindenbaum, 2008).

Currently, we are working on extending our models to also account for the effect of spatial proximity. Previously, we only took into account feature-wise differences. In the extended model the pair-wise feature differences are replaced by a distance measure that is a superposition of the feature-wise difference and the spatial distance. This change enables

the model to predict, for instance, that visual search is easier when the stimuli are spatially clustered by similarity than when the same stimuli are randomly located. Accordingly, our current experiments include a manipulation of both features similarity and spatial arrangement. Preliminary results suggest that the spatial distance between elements has a slightly stronger effect on performance than that of the feature differences

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The Effects of Perceptual Load in Central and Peripheral Regions of the Visual Field

The perceptual load model claims that attentional selectively depends on perceptual load. Selectivity is high with high load, but low with low load. Previous studies only manipulated load levels at task-relevant regions. In this project, perceptual load was orthogonally manipulated in both relevant (central) and non-relevant (peripheral) regions, by varying the similarity between the target and non-target letters and the non-target letters' heterogeneity. The participants had to identify a target-letter appearing in a central circle of letters. A distractor-letter, appearing in a peripheral circle, was compatible, neutral or incompatible with the target. As expected, increasing peripheral load deteriorated performance, but only with low levels of central load. The pattern of distractor interference did not follow the model's predictions because distractor interference under high load levels was occasionally found. The expected pattern of results emerged only when the spatial uncertainty regarding the distractor position was low, implying that spatial uncertainty plays an important role in attentional selectivity (Marciano & Yeshurun, 2011).

Currently, we are looking at the more applied aspects of perceptual load, particularly driving. In one such study, we evaluate the effects of perceptual load on driving performance, in a driving simulator, with and without a Collision Avoidance Warning System, and in another study we test the potentially distractive effects of road billboards. Perceptual load on the road (e.g., vehicles' congestion) and the road sides (e.g., pedestrians' number) is manipulated, while critical events occur on the road (e.g., a leading car suddenly slows down) or are initiated from its sides (e.g., a pedestrian crosses the road unexpectedly). Preliminary results regarding the warning system suggest that at least in one condition (low levels of load in both regions) the system acts like a two-edged sword: On the one hand it decreased accidents with entities on the road, but on the other hand it increased accidents with entities arriving from the road sides. I addition, it appears that billboards indeed have considerable effects on various aspects of driving like response time or number of accidents, but their effect is modulated by perceptual load (Marciano & Yeshurun, 2012).

The Effects of Transient Spatial Attention on Spatial and Temporal Crowding

The identification of a peripheral target surrounded by flankers is often harder than the identification of an identical isolated target. This phenomenon is termed spatial crowding. In this research project we examined whether crowding, and particularly its spatial extent, is affected by the allocation of transient attention to the target location. We measured orientation identification of a rotated T with and without flankers. The distance between the

target and the flankers and their eccentricity varied systematically. We manipulated attention via peripheral precues. We found, at all eccentricities, a significant attentional enhancement of identification accuracy. Most importantly, we found a significant attentional reduction of the critical distance (i.e., the target-flankers distance at which the flankers no longer interfere with target identification). These attentional effects were found regardless of the presence or absence of a backward mask and whether the attentional cue was informative or not. These findings suggest that attention reduces the spatial extent of crowding, possibly by narrowing the region over which information is integrated (Yeshurun & Rashal, 2010).

Currently, we are looking at temporal crowding – crowding that occurs when the target is surrounded by other stimuli in time rather than space. Previously, temporal crowding was only studied at the fovea, and only a low level of temporal crowding was found. Here, we test whether higher levels of temporal crowding can be found when the target appears at the periphery, and further evaluate the relationships between spatial and temporal crowding. Once this is established we intend to add manipulation of spatial, and possibly temporal, attention to test whether corresponding attentional effects can be found with temporal crowding as was found for spatial crowding.

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c.2.3.2 The Control of Visual Attention to Objects and Space in a Dynamic, Interactive Framework

The research of Prof. Goldsmith and Dr. Yeari described in this section is based on a view of visual attention as a dynamic, flexible, and interactive process, in particular, the view that (a) attention is a continuous process of selection from among hierarchically organized perceptual-object (grouped-array) representations, (b) that attentional selection itself acts to change the (hierarchical) organization of the visual information, (c) that attention may "navigate" within the scene either by orienting (shifts of attention between locations/objects at the same hierarchical level), focusing (zooming in or out to more local/global levels of object structure or space), or both, and (d) that subsequent selections and chosen modes of navigation are contextually dependent on previous selections.

The research has three main branches: (1) the role of spatial focus of attention in object-based attentional selection, (2) strategic versus automatic control of object-based attentional selection, and (3) object-based and space-based attentional navigation of hierarchically structured displays.

The Role of Spatial Focus of Attention in Object-Based Attentional Selection

A great deal of research has examined whether visual attention is directed to unparsed regions of space (i.e., space-based attention) or to perceptual objects formed by preattentive segmentation and grouping processes (i.e., object-based attention; see, e.g., Chen, 2012). In support of the space-based view, detection and identification responses are generally faster and more accurate for targets presented at spatially cued locations than at other locations, with the differences increasing as the cue-target distance is increased (e.g., Eriksen & St. James, 1986). Other work, however, supports the object-based view. For example, in a highly influential adaptation of the spatial cueing paradigm, in which each of the four potential target locations is encompassed by one of two different rectangle objects, Egly, Driver, and Rafal (1994) found that detection of targets on invalid-cue trials was faster when the uncued and cued locations were at opposite corners of the same rectangle object than when they were at equally distant corners of two different objects. This object-based effect (same-object advantage) was in addition to a space-based effect (same-location advantage), by which detection at the cued location was faster than detection at the uncued location within the same object.

Subsequent studies, using various adaptations of the Egly et al. (1994) paradigm, have revealed that object-based effects are not observed under all conditions (for a review, see Chen, 2012). Of particular relevance to the present line of work, some findings have suggested that object-based attention might be modulated by the mode of attentional control, endogenous versus exogenous. Macquistan (1997), for example, observed a same-object advantage using exogenous, peripheral cueing, by which attention is captured automatically, but not using endogenous, central-arrow cueing, by which attention is directed voluntarily to the target location. This pattern was taken to imply a possible interdependence between mode of control (exogenous vs. endogenous) and mode of selection (object-based vs. space-based).

However, pointing to a potential confound between type of cue and the spatial distribution of attention (focused or spread) while processing the cue, Goldsmith and Yeari (2003) put forward a different explanation of the general pattern, in terms of an *attentional focusing hypothesis*: Under peripheral-exogenous cueing, participants presumably spread their attention broadly over both rectangle objects while waiting for the (uninformative) cue and target to appear. Being encompassed within the focus of attention, these objects should have viable perceptual representations that are capable of influencing the subsequent deployment of attention to the cued location. By contrast, under endogenous-central cuing, participants are likely to focus their attention more narrowly on the central display region while preparing for and processing the direction of the arrow cue. This could create a state of inattention (Mack & Rock, 1998) with respect to the rectangle objects, degrading their perceptual-object representations to the point that they no longer affect the subsequent allocation of attention.

Goldsmith and Yeari (2003) examined this idea in a series of experiments in which type of cueing and initial spatial focus of attention were orthogonally manipulated. The results

indicated that initial spatial focus—not type of cueing—was the critical factor modulating object-based effects: Object-based effects were observed under endogenous cueing when auditory cues allowed participants to maintain an initially diffuse attentional setting (Experiment 2), when central-arrow cues were accompanied by explicit instructions to spread attention while waiting for and processing the cue (Experiment 3), and when peripheral-cue and central-arrow-cue trials were randomly intermixed in the same block, so that the most expedient strategy would be to adopt a common, spatially diffuse attentional setting for all trials (Experiment 4). Conversely, object-based effects were attenuated under exogenous cueing when the task required participants to focus their attention narrowly on a small, centrally presented "go/no-go" cue prior to the onset of the exogenous peripheral cue (Experiment 5).

Beyond refuting the suggested interdependency between mode of spatial cueing and mode of attentional selection, Goldsmith and Yeari's (2003) findings bring to the fore the crucial role of the initial spatial distribution of attention in determining the representation and organization of perceptual objects (e.g., Kimchi & Razpurker-Apfeld, 2004; Mack & Rock, 1998), which in turn may modulate object-based effects. The crucial role of perceptual organization in modulating object-based effects was also examined in a subsequent study (Goldsmith & Yeari, in preparation) in which object quality (e.g., salience and uniform connectedness) were manipulated, in addition to the initial spread of attention. The results indicated that an initially broad distribution of spatial attention is neither necessary nor sufficient for object-based attention to occur, highlighting the mutual interaction between visual attention and perceptual organization: When the quality of the object is poor (e.g., no uniform connectedness), attention is entirely space-based despite an initially broad attentional distribution; when object quality is moderate (uniform connectedness without salient contours and surfaces), object-based attention depends on an initially broad spatial distribution; when object quality is high (uniform connectedness and salient contours and surfaces), object-based attention is observed regardless of the initial spatial distribution. Another recent study (Goldsmith & Yeari, 2012) has also shown that object-based attention occurs despite central arrow cueing, when the arrow cue is large and salient enough to be processed spontaneously with attention spatially spread across the display.

Strategic Versus Automatic Control of Object-Based Attentional Selection

To what extent do people have strategic control over the mode of attentional selection-object versus space? Under conditions that spontaneously yield object-based visual attention, can people strategically choose to adopt a space-based mode (e.g., selecting only part of a grouped object), or is object-based selection "automatic"? Yeari and Goldsmith (2010) hypothesized that object-based attention is the "default" mode of allocation (a partially automatic process), that occurs even when there is no present strategic advantage to this mode (this idea is based on the assumption that there is general evolutionary advantage in attending to objects; see e.g., Yantis & Jonides, 1996). However, in those

conditions in which there is clear strategic advantage to space-based attention over object-based attention, attention will be space based.

A series of experiments supported this idea: In an adapted spatial cueing paradigm, Yeari and Goldsmith (2010) had participants focus initially on a central arrow cue that was part of a perceptual group (Study 1) or uniformly connected object (Study 2), encompassing one of the potential target locations. The cue always pointed to an opposite, different-object location. By varying cue validity, the strategic incentive to prevent the spread of attention to the entire cue-object, and consequently to the same-object location, was manipulated: With invalid cueing and (consequently) equal probability of targets at same-object and different-object locations, a same-object target identification advantage was observed. With highly valid cueing and targets much more probable at the different-object location than at the same-object location, the same-object advantage disappeared. Object-based attention was thus found to be a default mode, that may be ecologically adaptive, but that can be overridden by strategic control when there is a strong immediate benefit in doing so.

Additional experiments are now being conducted to examine the generality of these findings, and to reveal the mechanisms by which object-based attention is strategically modulated.

Object-Based and Space-Based Attentional Navigation of Hierarchically Structured Displays

Another challenging question that can be asked with regard to the interaction between perceptual organization and attention concerns the manner in which people attend to hierarchically structured objects and visual displays. In our research (e.g., Yeari & Goldsmith, 2011), we take a dynamic approach to the examination of attention to hierarchical displays. We do not ask whether or how people can attend to one level of structure or another (cf. research conducted within the global-local paradigm), but rather, how people "navigate" their attention between targets at different levels: To attend to a local part of an object, does one first select the global object and then zoom in (focus) on the local part in an object-based manner (i.e., in a manner that is sensitive to object structure), or does one simply zoom in on the target location in a purely space-based manner (i.e., in a manner that is sensitive only to changes in the diameter of the attentional "beam")? The same question can be asked when one is already focused on a local part, and now must zoom out (defocus) to attend to the global object. More complex scenarios can also be examined, for instance, in navigating from the global level of one stimulus to the local level of a neighboring stimulus—a movement which presumably involves a combination of both orienting (shifting attention between spatial locations or perceptual objects at the same hierarchical level) and focusing.

The key to our experimental approach is to include (for some displays) an intermediate level of object structure. For instance, a global *S* shape might be composed of intermediate-level *square* shapes, which are in turn composed of local *H* shapes. In a *focusing* task, the

subjects are required to first respond to the global shape (S), and then to the local shape (H), *in a single trial*. Conversely, in a *defocusing* task, the subjects are required to first respond to the local shape, and then to the global shape. The main question we asked is whether the presence of an intermediate level of object structure would increase focusing/defocusing latencies (yielding evidence of an object-based mode of focusing) and/or whether focusing latencies are a function of the magnitude of the change in the spatial diameter of the focus (yielding evidence of a space-based mode of focusing). Our results (Yeari & Goldsmith, 2011) indicate that both types of effects are present, supporting an "object-based spatial" model of attentional focusing, similar to the commonly held object-based spatial view of attentional orienting. With respect to the navigation of attention between different levels of two different hierarchically structured objects, here too our results (Yeari & Goldsmith, in preparation) suggest that attention follows at least a partly object-based hierarchical route. In fact, even when shifting between the local level of one object to the local level of another object, our results suggest that attention first defocuses to a more global level of the origin object, then shifts to a global level of the destination object, and finally refocuses to the local level of the destination object.

Additional experiments are now being conducted to examine the navigation of attention in visual search among hierarchically structured objects, and whether hierarchical object-based navigation represents a mandatory or default navigational mode.

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c.2.4 Perception, Attention and Human Factors

c.2.4.1 The Effects of Time Limitations on Target Identification

This study was carried out by Dr. Peerly Setter, Dr. Hadas Marciano, and Prof. Joel Norman in 2004.

Aiming at making image interpretation more efficient, we studied the effects of limiting exposure durations on performance. Two psychophysical experiments were performed examining the performance of 36 expert image analysts. The targets were presented at three image quality levels. The results suggest that limiting the exposure duration of an image to four seconds does not impair the performance of the analysts, i.e., four seconds suffice for identification in an image interpretation task, no matter what the quality of the image. This finding suggests that limiting the exposure duration during actual image interpretation would be beneficial since it would shorten the total amount of time needed for interpretation while not lowering the probability of correct identification.

Take away message – Sometimes unlimited time is not necessary in order to obtain the best results. When someone is an expert at what s/he does, making a quick decision might yield equivalent outcomes.

c.2.4.2 A Study of Human Stereoscopic Eye-Movements to Provide Data for Stereo Computer Vision Models

This study was carried out in 2006 by Dr. Pe'erly Setter and Prof. Joel Norman and was supported by a grant from the Caesarea Edmond Benjamin de Rothschild Foundation Institute for Interdisciplinary Applications of Computer Science (C.R.I.), University of Haifa.

Eye movements were measured in both eyes of human observers simultaneously in order to examine the vergence mechanism while viewing stereoscopic stimuli. Random dot stereograms were used in order to study pure binocular mechanisms with no involvement of monocular cues. It was found that the subjects fixated for a very brief amount of time on the display screen and then gradually shifted their fixation to a point in front of the screen. This was true even when the stereoscopic stimulus was behind or on the screen. The point of final fixation varied as a function of the location (disparity) of the stereoscopic stimulus; the closer the stimulus to the observer the nearer the fixation. This phenomenon is known as fixation disparity (FD), and our results best fit the hypothesis that FD is due to the tendency of the human vergence mechanism to revert to its natural resting point. In the realm of computer vision, stereoscopic active vision calls for changes in the cameras' vergence and the results of the present study point to further studies needed to connect between stimulus disparity and vergence responses. These studies will help in improving computerized stereoscopic vision.

c.2.4.3 ***Improving the Efficiency of X-Ray Luggage Screening with a 3-D Stereoscopic Display***

This study was carried out in 2006 by Dr. Pe'erly Setter and Prof. Joel Norman and was supported by a grant from the Center for Security Science and Technology - The Technion.

Scanning baggage at airports, post offices and border crossing points is done using Xray scanners, which display a radiograph of the baggage contents. This type of scanning is especially problematic, since the human screener is placed under an extreme workload due to the fact that a great number of objects have to be checked in a short time, and because the scanned objects vary in size and shape. Another difficulty in x-ray scanning stems from the fact that x-ray scanners produce a non-natural picture that differs greatly from that obtained by visible light. Further difficulty arises from the fact that the display appears as a flat 2-D picture; that is, objects in different planes are displayed in one plane, which makes it harder to differentiate individual items from the many of objects in the display. In light of the above, it is of great importance to investigate whether the addition of a dimension of depth by a stereoscopic display of an x-ray scan may significantly improve the process of scanning and the screener's ability to detect different objects.

Stereoscopic depth perception results from the fact that the human eyes are located at the front of the head, and the projections of a point far from or near to the fixation point fall at different locations relative to the fovea (the sensitive spot on the retina). The brain deciphers the relative depth of a certain point relative to the fixation point, according to the locations of the projections of that point on both retinas. Thus, one can exploit this method of the human depth perception for artificial displays of stereoscopic pictures.

In the present study screeners were shown x-ray scans of a hand-bag with diverse contents, half of which contained one suspicious object: a knife, a gun, a hand grenade, or a

plastic bomb The scans were of two types: standard scans (2-D scans, of the sort used in today's scanning equipment), and 3-D stereoscopic displays. The stereoscopic images were made for us by the English company 3DX-Ray Limited, Image Scan Holdings plc. The aim of the research was to assess the efficiency of stereoscopic as opposed to 2-D viewing. We measured the scan time needed to detect the suspicious object and the accuracy of detection.

There were significant differences in the performance of experienced screeners with the two types of displays. The percentage of detection of suspicious objects was considerably higher with the stereoscopic displays (80% vs. 53%). This was also the case when the detection rate was based on accurate recognition of the exact object (64% vs. 47%). These results indicate that the use of stereoscopic displays may reduce the number of misses of suspicious objects. However, it should be noted that the rate of false alarms in the stereoscopic displays was also higher than in standard 2-D displays. As a result, the percentage of detections plus false alarms was substantially higher in the stereoscopic displays compared to standard displays. The consequence of this would be longer queues during security inspections if stereoscopic displays were to be used.

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c.2.4.4 Testing a Method to Attenuate Visual Fatigue Stemming from Use of Stereoscopic Displays

This study was supported by a grant from the Medical Division of the Israel Defense Forces and carried out by Dr. Pe’erly Setter, Noam Ra’anan, and Prof. Joel Norman in 2008.

Many studies point to the advantages of stereoscopic 3D displays for military tasks. However, prolonged viewing of such displays often causes visual fatigue among many viewers. The scientific literature points to the conflict between the two oculomotor mechanisms, accommodation and vergence, as responsible for this fatigue. These two mechanisms normally work in tandem, one yoked to the other, but in stereo displays this pairing is breached and this is seen as the cause of the fatigue.

The present study tested the hypothesis that adding a collimating lens to a stereo display will alleviate stereo fatigue caused by lengthy viewing. The idea was that by presenting the stereo images near infinity (with the aid of the collimating lens) the conflict between the two oculomotor mechanisms will be decreased. It was tested on 11 observers who performed a visual search task in a stereo display for 45 minutes in each of two separate sessions. In one session the stereo display was viewed through the collimating lens and in the other session the same task was carried out but without the lens. The fatigue was assessed with objective measures that included the Critical Fusion Frequency (CFF), and the resting points and the near points of both the vergence and accommodative mechanisms. In addition, the observers filled in a subjective questionnaire on their fatigue.

These objective and subjective measures were administered both before and after the visual search task in each session.

The results indicated that the collimating lens attenuated visual fatigue. The objective measures exhibited an increase in fatigue without the lens. A decrease of 5% in the CFF is considered a sign of visual fatigue. Without the lens, the decrease was 7% while with the lens it was only 3.7%. The other measures also pointed to greater fatigue without the lens, but these results were not statistically significant (possibly due to the small sample size). It was found that the resting point of accommodation came nearer without the lens than with it. The near point of vergence became more distant without the lens than with it.

The subjective questionnaire consisted of 16 fatigue characteristics that the observers were asked to rate. Overall, we did not find significant difference in the fatigue reports with and without the lens. Several specific questions did yield more fatigue without the lens.

c.2.4.5 ***Visual Fatigue and Video Display Terminals***

This study was supported by the USAF Air Force Research Laboratory in 2009 and carried out by, Noam Mor, Prof. Joel Norman, and Dr. Pe'erly Setter.

This study included three experiments aimed at gaining understanding of the causes of visual fatigue (VF) resulting from continuous work in front of a computer screen. In the literature review it was seen that many earlier studies pointed to the involvement of the accommodative and vergence oculomotor systems in visual fatigue. The tonic states of both these systems, Tonic Accommodation (TA) and Tonic Vergence (TV), were implicated in explanations of VF. In the present study eight objective measures of physiological changes and a subjective visual discomfort questionnaire were utilized. In all three experiments all of these were presented before and after a continuous two-hour VF task. The physiological measures included Pupil Diameter (PD), Near Point of Accommodation (NPA), Near Point of Convergence (NPC), Tonic Accommodation (TA), Tonic Vergence (TV), Critical Flicker Frequency (CFF), Visual Acuity, (VA), and Astigmatism. The subjective visual discomfort questionnaire consisted of a list of 15 symptoms of VF to be rated by the subjects.

Three different tasks were used in the experiments. In the first experiment an unending computer game was programmed to consist of highly complex and cluttered color displays. In the second and third experiments the subjects read a short novella with interspersed questions to check that the subjects actually read the materials. The font size used in the third experiment was much smaller than that used in the second experiment.

The first two experiments yielded relatively little evidence of VF and of the accompanying subjective visual discomfort. The first experiment did indeed yield a significant increase in the subjective discomfort questionnaire after the VF task as compared to that before, and a significant nearing of TA (in the left eye) after as compared

to before. However, those were the only before-after differences found. The questionnaire and TA in the left eye were also significantly correlated, the larger the before-after difference on the questionnaire the nearer the TA after the VF task. The only significant before- after difference found in the second experiment was that the Interpupillary Distance (IPD) was smaller after the VF task, indicating that the TV had come closer.

The third experiment yielded more signs of VF: There was a significant decrease in CFF after the VF task; the TA in both eyes was closer after the task and the same was true for the TV. The subjective questionnaire also yielded a significant increase in visual discomfort after the task as did 9 separate items (out of 15). The analysis of correlations produced interesting results. For example, it was found that higher VA before the VF task yielded fewer reports of visual discomfort. The many other significant correlations pointed to the involvement of TV, TA, and CFF in the complaints of the subjects after the VF task (see discussion of Experiment 3 and General Discussion for further details).

As in earlier studies, the present study also found evidence for the involvement of Tonic Vergence (TV) and Tonic Accommodation (TA) in states of visual fatigue. Our data pointed to the fact that the involvement of the two is somewhat different. Changes in TV were clearly related to subjective discomfort, while changes in TA were evident as a result of performing the VF task, but not as clearly related to actual reports of discomfort. It is, of course, plausible that the changes in accommodation did affect performance (poorer acuity?) without causing symptoms of visual discomfort, but there was no measure of performance in the present study. The critical flicker frequency (CFF) was also related to visual fatigue in the present study, but we feel that the observed decreases in CFF after the VF task were probably due to a mixture of both general mental fatigue and visual fatigue.

To sum up, the extent of VF in the three experiments was less than we had expected. We suspect that this is due both to the much improved present-day computer screens (LCD vs. CRT), and to the fact that the student subjects in our experiments, unlike students who participated in such experiments ten or more years ago, had a lot of everyday experience with computer use and nearly all had a computer of their own. In spite of this we obtained some very interesting results: We performed a multiple regression analysis on the sum of the differences on the 9 questionnaire items that yielded significant difference before and after the VF task, and found that four physiological measures taken before the VF task could account for about 80% of the variance in visual discomfort. Those four measures were Visual Acuity (VA), CFF, Pupil Size (PS) and IPD, with VA by far the largest contributor to the high multiple correlation. It should be noted that visual acuity was measured with the subjects wearing their glasses, indicating that those who suffered most from VF were the subjects with improper corrections in their glasses or subjects whose vision was not perfect but not corrected. If visual acuity was not corrected there was a strong propensity to complain about visual fatigue. This led us to recommend that all personnel whose job requires many hours in front of a computer screen should be tested for visual acuity, and if it is deficient they should get new glasses. These people should also be

required to undergo periodic examination of their vision. A follow up study looking at the ability of the four variables to predict complaints of visual discomfort and performance decrement is called for.

c.2.4.6 Navigating Internet Maps and Sites Using a Translucent Zoom

This study was supported by a grant from the Israel Internet Association to Prof. Joel Norman and Dr. Hagit Hel-Or (Dept. of Computer Science, U. of Haifa) and was carried out by Dr. Hadas Marciano and Dr. Pe'erly Setter of the Ergonomics and Human Factors Unit of the IIPDM. A Hebrew Technical Report was submitted in January 2012, and an English article is currently being prepared.

In many instances Internet users are faced with the problem of needing to both view large global details (e.g., the overall structure of a road map) and small local details (e.g., the names of streets). These often are on very different size scales not allowing simultaneous viewing of both. To overcome this difficulty various types of magnifiers have been introduced. These magnify a given area of the large display but because they are opaque they also occlude the area beneath thus causing the user to become disoriented. The present study aimed at testing a partially transparent magnifier, the translucent zoom, and comparing it to opaque magnifiers.

Two experiments were conducted to test the performance of participants with this new magnifying tool, the translucent zoom. The participants performed the tasks using each one of two magnifiers: translucent and opaque zooms and their performance on each was compared. In the first experiment 20 participants underwent two one-hour experimental sessions. Their task was to navigate a pathway within a computerized map. Performance was superior on most of the measures of performance with the translucent zoom. The second experiment also tested 20 participants in two one-hour experimental sessions. The task in this experiment was to search for a word in a complex internet page. Unlike the first experiment the translucent zoom did not yield superior performance. These findings suggests that for complex tasks that require the understanding of a wider context (as in the map navigation task of Experiment 1), the translucent zoom is beneficial. In contrast, when the understanding of the wider context is not essential (like in the internet search task used), it seems that the translucent zoom is not useful, and even can be harmful because of the clutter it creates.

The Effect of Billboards on Driving as a Function of Type of Billboard and its Size

This study was supported by a grant from the Israel Road Safety Authority to Prof. Joel Norman, Dr. Pe'erly Setter, Dr. Yaffa Yeshurun, and Dr. Hadas Marciano, all of the IIPDM, and to Tomer Toledo, of the Transportation and Geo-Information Engineering Department of the Faculty of Civil and Environmental Engineering, Technion - Israel Institute of Technology.

A final Hebrew report was submitted in 2011 and it appears in the Authority's research reports website:
http://www.rsa.gov.il/InformationResearchCenter/ResearchSurveyCenter/Documents/2009 2010/REPORT_Accident_Billboard.pdf

Several papers that will present the findings are in preparation. One has already appeared:

Marciano, H. & Yeshurun, Y. (2012). Perceptual load in central and peripheral regions and its effects on driving performance: advertizing billboards. *Work, 41,* 3181-3188.

The study was comprised of two experiments in a driving simulator that examined the effects of billboards (roadside signs) on drivers' performance. They focused on the following questions: 1. The effects of load on the road and its sides. 2. The effects of billboard size. 3. The effect of billboard type: static, dynamic (that alternate between three advertisements), and video. The participants drove in scenarios that simulated a suburban road, where events occurred unexpectedly and required a quick response to prevent an accident. The events occurred on the road (for example, a leading car moves into one's lane and decelerates) or on the side of the road (for example, a pedestrian runs into the road). The first experiment examined four variables: load on the road, load on the sides of the road, the location of the critical event, and the presence and size of billboards. The second experiment examined the effects of the type of billboard: no billboard, static, dynamic, and video. Various measures of driving performance served to assess the results (e.g., response times to events, deviation from the lane) as well as eye movement measures (dwell times).

The findings of the first experiment demonstrated the importance of manipulating the perceptual load on the road and on its sides, and the location of critical events. The findings indicate that billboards of the two sizes used attract attention, and are liable, under varying load conditions, to cause the deterioration of driver performance. The most problematic load condition, as far as billboards are concerned, occurred when the load on the road was low and the load on the sides was high. The eye-movement findings indicated that the presence of billboards yielded significantly shorter dwell times on objects that could bring about an accident. Furthermore, it was found that the attraction of attention to the billboards was apparently not volitional and hard to avoid. Moreover, it was hard to disengage attention from the billboard when the critical event began.

The results of the second experiment indicated that all three types of billboards, static, dynamic, and video attract attention, with the video attracting the most, the dynamic somewhat less, and the static the least of the three. This attraction of attention is liable to be harmful when an event occurs at a different location than the billboard (e.g., on the road in the present experiment), but might also be helpful if the event occurs in the vicinity of the billboard (e.g., events on the side of the road in the present experiment), but this is a rare occurrence in reality.

The study, as a whole, shows that under certain circumstances (e.g., when the load on the road is low but the load on its side is high) the attraction of attention by billboards is liable to have a negative effect on driving and even to cause accidents. On the other hand, when the load in both locations is low, it would seem that billboards do not significantly affect the driver. A small billboard attracts more attention than a big one, and video more than dynamic billboards, which in turn attract more attention than static ones. Looking at billboards significantly impaired the search pattern for different hazards, and what is worse, it is not always easy to divert ones' fixation from the billboard even after a critical event has occurred. We recommend avoiding the placement of attention attracting billboards (in this study: small, dynamic, or video billboards) in regions with low perceptual load on the road and high perceptual load on its sides.

c.3 Decision Making: Prof. Erev, Prof. Yechiam, and Prof. Norman

c.3.1 Decisions from Experience

Classical studies of human decision making tend to focus on "decisions from description." They examine how people decide when they can rely on a complete description of the incentive structure. The upper panel in Figure 1 presents the experimental task in a typical study of decision from description. The main motivation to this narrow focus was the attempt to use the rationality assumption as a benchmark. The most influential papers in that research stream (e.g., Allais, 1953; Kahneman & Tversky, 1979; Fehr and Schmidt, 1999; Bolton & Ockenfels, 2000) present interesting deviations from rational choice, and elegant refinements of the rational models that capture these deviations. Gigerenzer and Selten (2001) broadly refer to this line of research as the "subjective expected utility correction project." The study of decisions from experience (Barron & Erev, 2003; Hertwig et al., 2004) complements the classical approach with a focus on decisions that are made based on incomplete description of the incentive structure. That is, situations in which people have to rely on their past experience. The lower panel in Figure 1 presents the experimental task in a typical study of pure decisions from experience using the "clicking paradigm."

a. Decision from description -- the decisions under risk paradigm:

Please select one of the following prospects:

○	Win 4000 with probability 0.80 0 otherwise (probability 0.20)
○	Win 3000 with certainty

b. Decisions from experience -- the clicking paradigm:

The current experiment includes many trials. Your task, in each trial, is to click on one of the two keys presented on the screen. Each click will be followed by the presentation of the keys' payoffs. Your payoff for the trial is the payoff of the selected key.

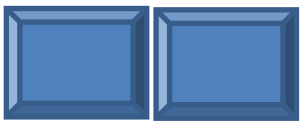

Figure1. The typical instructions screen in studies of decisions from description (using the "decisions under risk paradigm"), and studies of decisions from experience (using the "clicking paradigm").In the decisions under risk paradigm the subjects receive a complete description of the payoff distributions, and no feedback. Each selection moves the subject to the next task.

In the clicking paradigm, the subjects do not receive a description of the payoff distribution, and have to rely on the available feedback. In the experiments described in Section 3.1, the feedback was complete: It included information concerning the payoffs from both keys. In the experiments described in Section 1.2 the feedback was partial: only the payoff from the selected option was revealed.

Our investigations of decisions from experience highlight four classes of potentially interesting observations. First, there are large differences between decision from experience and decisions from description (Barron & Erev, 2003; Hertwig et al., 2004; Hertwig & Erev, 2009; Erev & Greiner, 2012): The two lines of decision research reveal very different behavioral regularities. The significance of this "experience-description gap" is demonstrated by the effect of rare (low probability) events. Experimental studies reveal that people exhibit oversensitivity to rare events in decisions from description (Kahnemna & Tversky, 1979), and the opposite bias when they rely on experience (see Barron & Erev, 2003). This gap suggests that the common efforts to use models that were calibrated to capture decisions from description in order to address decisions from experience can lead to mismatched conclusions.

A second line of observations emerges from the attempt to develop descriptive models of decisions from experience. Our investigations reveal the main properties of decisions from experience are surprisingly robust. Some of these regularities are common to animal and human decisions in the lab, and can be documented in the analysis of decisions of investors in the stock market. Two international choice prediction competitions that we have organized suggest that models that capture six basic properties of decisions from experience can be used to derive useful ex-ante predictions of behavior in wide set of situations. The best models share the assumption that people tend to rely on small set of past experiences in similar situations. Thus, unlike the popular reinforcement models, the best models assume reliance on episodic memory. In addition the leading models distinguish between the role of working and long term memory.

A third line of observations comes from studies of individual differences in decisions from experience. The results reveal robust and consistent individual differences that allow useful prediction of behavior in natural setting. For example, the pattern of decisions from experience allows discrimination between different groups of neuropsychological patients (Yechiam et al., 2005), and discrimination between different groups of jailed criminals (Yechiam et al., 2008). In addition, investigation of individual differences in decision from experience shed light on apparent inconsistencies between behavior and brain activities. For instance, Leland & Grafman (2005) and others have noted that individuals with lesions in prefrontal cortical areas often behave similarly to healthy individuals in decisions from description. The findings in decisions from experience suggest that the key impairment in this well known neurological syndrome involves learning and in particular extreme recency which may lead to risk taking under some conditions (Yechiam et al., 2005; Hochman, Yechiam, & Bechara, 2010).

A fourth line of observations concerns arousal processes in response to gains versus losses in decisions from experience. The gap between increased arousal following losses along with loss neutral behavioral choices gives rise to an attentional theory of losses that extends to a variety of situations and conditions.

A final cluster of observations involves the practical human factors implications of the basic properties of decisions from experience. One line of implications involves rule enforcement. The observation that decisions from experience reflect reliance on small set of past experiences implies that the probability of punishment is much more important than the magnitude of punishment. The gentle COP (gentle continuous punishment) policy can be most effective. A second line of implication involves the effect on the interfering cues on perceptual decisions. One example involves the effect of road advertisements on derivers' decisions.

c.3.1.1 ***The Experience-Description Gap***

Kahneman and Tversky (1979) demonstrate that two of the best known violations of mainstream economic theory, the tendency to buy both insurance and lotteries (Friedman & Savage, 1948), and the Allais paradox (Allais, 1953 and see a description in the next section), can be explained as indications of overweighting of rare events. Their influential analysis includes two steps: They first replicated the classical violations using the "decisions from description" paradigm presented in the upper panel of Figure 1, and then proposed a model (prospect theory) that captures the two phenomena. Prospect theory captures the two phenomena with the assumption of a weighting function that reflects oversensitivity to rare events (events whose probability is below 0.25).

Barron and Erev (2003) have examined if the phenomena documented in this decisions under risk paradigm, also emerge in the clicking paradigm. Their original hypothesis was that experience will reduce the magnitude of the deviations from maximization. The results surprised them: In several of the problems that they examined, experience did not enhance maximization. In some cases experience led to a reversal of the deviations captured by prospect theory: It leads to underweighting of rare events. This pattern is known as the experience-description gap (see review in Hertwig & Erev, 2009).

Problems 1 and 2 demonstrate the evidence for underweighting of rare events in decisions from experience. These problems were studied by Nevo and Erev (2012) using the clicking paradigm, described in the lower panel of Figure 1, with complete feedback. The participants faced each problem 100 trials, and were paid (in Shekels) for one randomly selected trial:

Problem 1:

S	0 with certainty	[S-rate = 43%]
R	+1 with probability 0.9; -10 otherwise (EV = -0.1)	

Problem 2:

S	0 with certainty	[S-rate = 72%]
R	+10 with probability 0.1; -1 otherwise (EV = +0.1)	

Notice that in Problem 1, the safer option has higher expected value, but the participants tend to select the gamble. Problem 2 reflects the opposite risk preference: The gamble has higher expected value, but the participants tend to select the safer option. As noted by Barron and Erev this pattern can be a reflection of insufficient sensitivity to the rare and extreme outcomes (the extreme outcomes that occur in 10% of the trials). Thus, the participants behave as if they believe that "it won't happen to me." Study of the same problems using the decision from description paradigm (Top panel in Figure 1) reveals the opposite pattern.

The Reversed Certainty Effect (Reversed Allais Paradox)

A clear demonstration of the significance of the difference between decisions from experience and decisions from description is provided by the study of variants of Allais' (1953) common ratio problems. Expected utility theory (von Neumann & Morgenstern, 1947) implies that if prospect B is preferred to A, then any probability mixture (B, p)[1] must be preferred to the mixture (A, p). In his classic research, Allais (1953) found a clear violation of this prediction. He constructed an example in which the more risky of two prospects becomes relatively more attractive when the probability of winning in both prospects is transformed by a common ratio. Kahneman and Tversky (1979) refer to this pattern as the "certainty effect." Barron and Erev (2003) demonstrate that decisions from experience (in the clicking paradigm with incomplete feedback) reflect the opposite pattern. We chose to demonstrate this effect here in a study that uses the clicking paradigm with complete feedback (this study was run by Barron & Erev but was not reported in their paper). The study considers the following problems (these problems are variants of the problems used by Kahneman and Tversky, 1979):

[1] The "Probability mixture" (B,p) means: win Prospect B with probability p; win 0 otherwise.

Problem 3:

S	3 with certainty	[S-rate = 36%]
R	4 with probability 0.8; 0 otherwise (EV = 3.2)	

Problem 4:

S	3 with probability 0.25; 0 otherwise (EV= 0.75)	[S-rate = 51%]
R	4 with probability 0.2; 0 otherwise (EV = 0.80)	

The results reveal a reversed certainty effect. The Safe option (S) was less attractive in Problem 3-- when it was associated with certainty-- than in Problem 4 -- when it was not. This pattern is consistent with the assertion that in decisions from experience the least likely events (probability of 0.2) are underweighted.

Additional studies of the certainty effect reveal an apparent difference between rats, bees and human subjects. MacDonald, Kagel, and Battalio (1991) show that rats exhibit the original certainty effect: They studied variants of problems 3 and 4 with payoff in caps of water, and found *more S* choices when S provides medium pay with certainty. In contrast, Shafir et al. (2008) show that honey bees exhibit the reversed certainty effect. Their study examined variants of problems 9 and 10 with payoff in term of percentage of sugar in water reward, and found *less S* choices when S provides medium pay with certainty. Shafir et al. suggest that the difference can be related to perceptual noise (rather than to a specie effect): According to this accounts the rats (but not the bees) had difficulty in discriminating the medium and high payoffs, and for that reason preferred S in the variant of Problem 3. The value of this explanation was demonstrated in a study with human subjects that reveal that a reduction of the clarity of the feedback (in a study of Problem 3 and 4) leads to the emergence of the original certainty effect.

Underweighting and Overestimation

The suggestion that people underweight rare events appears to be inconsistent with previous research that demonstrates overestimation of rare events (e.g., Viscusi, 2002; Erev et al., 1994). For example Viscusi (2002) found that smokers and nonsmokers tend to overestimate the probability that smokers will develop lung cancer. Barron and Yechiam (2009) examined if this difference is mediated by different settings (e.g., clicking vs. smoking), or different tasks (deciding or estimating). They studied Problem 5 using the clicking paradigm with complete feedback, and one addition: Starting at trial 201, the participants were asked to estimate the probability of the rare outcome (1 point with probability 0.15) before each choice. The results reveal a strong tendency to prefer the risky prospect (R) in all 400 trials (mean R-rate of 79%). This result is consistent with underweighting of rare events. The estimations, on the other hand, reflected

oversensitivity to rare events. The average estimate (of the 10% event) was 21%. Thus, participants appear to exhibit over-sensitivity to rare events in estimation, and under-sensitivity to rare events in choice.

Problem 5:

R	3 with probability 0.85, 1 otherwise	[R-rate= 79%]
S	2.7 with certainty	

The Sampling Paradigm and Robustness to the Number of Repeated Gamble Realizations

Hertwig et al., (2004; Herwig & Erev, 2009) note that the "experience-description gap" summarized above can be attributed to three differences between the experimental paradigms: the source of the information (experience or description), the number of repeated realizations of the gambles (one or many), and the stakes (low real payoffs, versus high hypothetical payoffs). To evaluate the role of the three factors, they examined some of the problems considered by Barron and Erev (2003) under two conditions: one-shot decisions from description, and one-shot decisions from experience.

The two conditions differed only with respect to how the decision makers learned about the options' outcomes and likelihoods. In the *description* group, options were described as in Kahneman and Tversky's studies.

In the *sampling* group, the information describing the options was not displayed. Instead, participants were shown two buttons on the computer screen and were told that each button was associated with a payoff distribution. Clicking on a given button elicited the sampling of an outcome (with replacement) from its distribution. In Problem 3, for example, drawing from one distribution led to the outcome "4" in 80% of all draws and to the outcome "0" in 20% of all draws. Sampling from the other distribution always resulted in the outcome "3". Participants could sample however often they wished. By repeatedly experiencing the contingency between choices and outcomes, participants could gradually acquire knowledge about the options' payoff structure. Once they stopped sampling, they indicated their preferred option, and, after completing all problems, participants received monetary payoffs according to their choices and the outcomes of the draws.

The observed choice proportions in the sampling group exhibit the pattern observed under the clicking paradigm. That is, the participants behave "as if" they underweight rare events. The correlation between the sampling and the clicking results was 0.92. The observed choice proportion in the description group exhibits the pattern predicted by prospect theory- the participants behave "as if" they overweight rare events. The correlation between the sampling and the description group was -0.67. These results (and similar findings reported in Weber et al. , 2004; Ungemach et al., 2008; Erev et al., 2010a; Hau et al., 2008; and in reviews by Hertwig & Erev, 2009) suggest that the

tendency to underweight rare events in decisions from experience is not driven by the number of repeated realizations of the gambles.

Robustness to Prior Information

Yechiam et al. (2005, and see Lejarraga & Gonzalez, 2011; Marchiori et al., 2012) have examined the effect of prior information of concerning the payoff distributions on the tendency to underweight rare events in the clicking paradigm. Thus, they examined the joint effect of description and experience. Their results reveal that the initial behavior reflects high sensitivity to the rare events, and the emergence of underweighting of rare events with experience. The proportion of behavior consistent with overweighting of rare events was 60% in the first trial, and only 30% after the after 10.

Sensitivity to Expected Values

An extreme interpretation of the results summarized above would be to hypothesize that decision makers tend to neglect rare events; i.e., in most cases they fail to consider these events. Ert and Erev (2012) show a shortcoming of this extreme explanation by examining the following problems:

Problem 6:

H	2.52 with certainty	[H-rate = 40%]
L	2.53 with probability 0.89; 2.43 otherwise	

Problem 7:

H	2.52 with certainty	[H-rate = 72%]
L	2.53 with probability 0.89; 2.03 otherwise	

The results show a deviation from maximization consistent with underweighting of rare events in Problem 6, but not in Problem 7. This pattern suggests that the rare events are not neglected. When they are sufficiently important they are taken into account.

The Sampling and Weighting Explanation

Erev, Ert & Yechiam (2008) show that the tendency to underweight rare events can be explained with the assertion that people relay on small samples of past experiences (see similar ideas in Fiedler, 2000; Kareev, 2000). For example, a subject that relies on a sample of four past experiences will prefer the negative EV gamble "-10 with probability 0.1, +1 otherwise" over "0 with certainty" in 56% of the trials (because 65% of the samples of size 4 do not include the 10% event). The observed sensitivity to the expected value (Problem 7) can be explained with the assertion that the small sample is only one of

the factors that determine the attractiveness of the different alternatives. A second factor is the grand mean: The average payoff from selecting this option over all previous trials.

The Mere Presentation Effect

Erev, Glozman and Hertwig (2008) show that one of the contributors to the experience-description gap is a mere presentation effect. This effect is similar to the White bear effect (Wegner et al., 1987). When people are asked not to think of a white bear," a white bear comes to our mind. Similarly, when people face with a description of a payoff distribution the extreme outcomes get more attention than optimal. Erev et al. demonstrate that this hypothesis can shed light on the condition that determine the weighting of rare events in a wide set of situations.

Overconfidence Triggers Initial Overweighting

Another contributor to the experience-description gap is presented by Marchiori et al. (2012). They demonstrate that the initial overweighting of rare events when people rely on description and experience can be a reflection of overgeneralization from situations in which people decide based on subjective probability estimates. Subjective probability estimates tend to reflect overconfidence; for example, studies of probability estimates reveal that event estimated by "5%" occur in about 20% of the times (Erev, Wallsten & Budescu, 1994). Thus, overweighting the 5% outcome tends to be reinforcing. Experience eliminates this bias, and can lead to the opposite bias.

Super-Underweighting of Rare Events with Foregone Payoffs

The tendency to underweight rare events is particularly strong in situations involving foregone payoffs, namely knowledge of what would have happened had the other choice alternative been chosen. (Yechiam and Busemeyer, 2005; 2006). For example, in Yechiam and Busemeyer (2006), we examine a risky alternative with equiprobable outcomes (.5 to lose -1 or 4) compared to a risky alternative with much rarer and larger loss (.95 to lose 2, .1 to lose -20). Both of these alternatives were compared to a higher expected value choice (-2). An exacerbated tendency to take risk only emerged and was maintained for hundreds of trials for the risk with the rare event in a condition with foregone payoffs. This finding suggests that the tendency to underweight rare event in decisions from experience is not due to under-sampling (participants in the foregone payoffs conditions actually saw more incidents of the negative rare event and yet they took more risk).

c.3.1.2 ***The Basic Properties of Decisions from Experience, and Alternative Models***

We chose to take two steps in order to facilitate the development and the evaluation of descriptive models of decisions from experience. The first involves an attempt to clarify the most robust properties of these decisions by replicating them using a standardized paradigm (Hertwig & Ortmann, 2002): the clicking paradigm described in Figure 1. Second, we organized choice prediction competitions in which we challenge other researchers to develop models that outperform our baseline models. The main results of this research are summarized below.

The Payoff Variability Effect

Myers and Sadler (1960) studied decisions from experience using a "card flipping" paradigm. In each trial of their studies, the participant saw one side of a card and had to decide whether to accept the payoff written on that side (the safe alternative), or the payoff written on the unobserved side of the card (the riskier option). Participants received feedback concerning their payoffs after each choice (the card was flipped only if the participant chose the riskier option). The results revealed that an increase in the payoff variability of the risky option (the variability of the payoff distribution on the unobserved side) reduced the proportion of choices that maximized expected payoff.

Erev and Haruvy (2012) replicated this pattern in the clicking paradigm with the study of Problems 8, 9 and 10 (the H-rate in the brackets on the right are the proportion of H choices over all trials, EV is the expected value of the gamble):

Problem 8:

H	1 with certainty	[H-rate: 96%]
L	0 with certainty	

Problem 9:

H	+11 with probability 0.5 -9 otherwise (EV = 1)	[H-rate: 58%]
L	0 points with certainty	

Problem 10:

H	0 with certainty	[H-rate: 53%]
L	9 with probability 0.5 -11 otherwise (EV = -1)	

Notice that Problems 8 and 9 involve a choice between alternative H, with an EV of 1 shekel, and alternative L, with an EV of 0. The higher EV maximization rate (H-rate) in Problem 8 (96%) compared to Problem 9 (58%) can be described as indication of risk or loss aversion: H was less attractive (in Problem 9) when it increased the variance and was associated with losses. However, this "risk and/or loss aversion" explanation is inconsistent with a comparison of Problem 9 and Problem 10. In Problem 10, risk aversion and loss aversion implies maximization (H choices). The results show H-rate of only 53%.

Chasing, the Big Eyes Effect, and Contingent Loss Aversion

One reasonable explanation of the results in Problems 8, 9 and 10 involves the assertion of large individual difference in risk attitude and/or in the attitude toward losses. For example, the aggregated results are consistent with the hypothesis that about half the participants are risk averse, and the other half are risk seekers. However, this explanation has important shortcomings. One clear shortcoming is the fact that the correlation between the R-rate in Problems 9 and 10 is not large. A more interesting shortcoming is suggested by studies that examine investment decisions. These studies show that investors tend to "chase" past returns. That is, they tend to invest in assets that led to high earnings in the past. Grosskopf et al. (2006) shows that this "big eyes effect" implies that payoff variability can lead most agents to behave as if they are risk and/or loss seekers. Ben Zion et al. (2010) clarify the robustness of this observation in a study that focuses on the following problem:

Problem 11:

R1	4x (EV=0)	
R2	2y –2x (EV = 0)	
S	x+y+5 (the mean of R1 and R2 plus 5, EV = 5)	[S-rate = 25%]

Where x is a draw from a normal distribution with a mean of 0 and standard deviation of 300 (x~N(0,300)), and y is a draw from a normal distribution with a mean of 0 and standard deviation of 10 (y~N(0,10)).

Ben Zion's et al.'s study can be described as a simulation of a simplified investment task. Options R1 and R2 simulates two risky stocks, and Option S simulates an attractive index fund that provides the mean of R1 and R2 plus a small bonus. Thus, Option S has the highest mean and lowest variance. The experiment used the clicking paradigm with complete feedback. In addition, the participants received a complete description of the payoff rule. The description emphasized the fact that S provides the mean of R1 and R2 plus 5.

The results reveal random choice in the first trial (S-rate of 33%), and a decrease in the tendency to select S with experience. That is, experience with the high payoff variability investment problem impaired maximization. The S-rate in the last block of 20 trials was

only 18%. This value is much lower than the 50% rate implied by the assertion that about half of the participants are risk and/or loss averse, and lower that the 33% implied under random choice.

The Correlation Effect

Diederich and Busemeyer (1999) highlight an important boundary condition for the payoff variability effect. When the payoffs of the different alternatives are positively correlated, the availability of information concerning foregone payoffs eliminates the payoff variability effect. In the extreme case in which Alternative H dominates L in all trials, payoff variability has little effect. Grosskopf, Erev and Yechiam (2006) demonstrate the robustness of this "correlation effect" in the clicking paradigm. They focused on the following two problems:

Problem 12 (r=200, n=10, FB=complete, accumulated payoffs, 10 units=.01 Shekel)

H	N(120,10) +c_t (EV= 120)	[H-rate: 75%]
L	N(100,10) +d_t(EV = 100)	

Problem 13 (same procedure as in Problem 4)

H	N(120,10) +c_t (EV= 120)	[H-rate= 98%]
L	N(100,10) +c_t (EV= 100)	

The exact payoffs were the rounded sum of two terms: A draw from a normal distribution with a mean of 100 or 120 and standard deviation of 10, and (c_t or d_t) a draw the distribution (-50 with p = 1/3; 0 with p=1/3; +50 otherwise). The values of c_t and d_t were independent. Thus the payoffs of the two alternatives are positively correlated in Problem 5, but are not correlated in Problem 4. The feedback after each trial was complete: The participants saw the obtained and the foregone payoffs. The final payoff was the sum of the obtained payoffs with the conversion rate of 1 Shekel per 1,000 points. The results show a clear correlation effect. The correlation increased the maximization rate from 75% (in Problem 4) to 98% (in Problem 5). Thus, when the correlation is high subjects can learn to maximize expected return.

The Very Recent Effect

Analysis of the effect of recent outcomes on choice behavior in probability learning tasks led Estes (1964, and see review in Lee, 1971) to conclude that the most common pattern is positive recency: Decision maker are more likely to select the alternative that led to the best outcome in recent trials. A clear example of positive recency in the clicking paradigm is provided in the analysis of the contingent choice rate in Problems 9 and 10. The probability of risky (R) choices is larger, in these problems, after high payoff from R than after low payoff from R. The overall R-rates are 64% after high payoff, and 40% after low payoff.

An extension of this analysis to other recent outcomes reveals an interesting pattern. To describe this pattern let Best-Reply-L be the choice rate of the alternative that led to the best outcomes exactly L trials before the current trial. The results reveal a large qualitative difference between Best-Reply-1 and the other values. The decrease in the effect of recent outcomes appears to be sharp. Best-Reply-1 reflects a strong recency effect, but Best Reply 2 and 3 are not larger than the mean value. Indeed, Best Reply 3 is the lowest point in the best reply curve. Nevo and Erev (2012) refer to this pattern as the "very recent effect."

Surprise-Triggers-Change

Additional analyses of the effect of recent outcomes led Nevo and Erev (2012) to detect two robust deviations from positive recency. One deviation was documented after positively surprising outcomes. For example, the rate of repeated R choices in Problem 2 was 79% after a loss (the payoff -1), and only 61% after a gain (payoff of +10). A second indication of negative recency is observed after a negatively surprising forgone payoff (payoff from the option that was not selected). For example, the rate of a switch from S to R in Problem 1 was 31% after a forgone loss (the payoff -10), and only 21% after a forgone gain (payoff of +1). This, and similar observation (including regularities that have been documented in the stock market) can be explained with the assertion that surprise triggers change.

The Hot Stove Effect

Mark Twain (1897 and see Denrell & March, 2001) asserts that after sitting on a hot stove lid, a cat is likely to avoid sitting on stove lids even when they are cold. Yechiam and Busemeyer (2006) support this assertion in a simple experiment. Their results demonstrate that when the feedback is limited to the obtained payoff, experience increases risk aversion. This pattern "hot stove pattern" can be explained as a logical consequence of the inherent asymmetry between the effect of good and bad experiences. Good outcomes increase the probability that a choice will be repeated and for that reason facilitate the collection of additional information concerning the value of the alternative that has yielded the good outcome. Bad outcomes reduce the probability that the choice will be repeated, and for that reason impair the collection of additional information concerning the value of the alternative that has yielded the bad outcome. As a result, the effect of bad outcomes is stronger (lasts longer) than the effect of good outcomes. Since options with a high variability are more likely to produce bad outcomes, the hot stove hypothesis predicts a decreasing tendency to choose such options.

Response to Patterns

Biele, Erev and Ert (2009) examined how people adjust to dynamic environments by considering the following problem:

Problem 14:

S	0 with certainty
R	+1 if the state is H -1 if the state is L

The decision maker in this problem is required to choose between a safe prospect (S) that maintains the status quo, and a risky prospect (R), whose payoff depends on the state of nature. The exact state is determined using a symmetric two state Markov process. The state in the first trial was determined randomly, and then it was changed after 5% of the trials (thus, in 95% of the cases, the state was not changed). Biele et al. (2009) documented highly adaptive decisions. The observed behavior approximated the ex post optimal strategy. The participants learned to repeat risky choices after a high payoff, and to explore with low probability (about 7%) after low payoff.

Quantitative Summary: Inertia, Sampling and Weighting (I-SAW)

The attempt to capture the current results with a simple model (see Erev et al., 2008; Biele et al., 2009; Nevo & Erev, 2012) demonstrate the value of a model referred to as I-SAW (Inertia, Sampling and Weighting). I-SAW assumes a distinction between three response modes: exploration, exploitation and inertia. Exploration is assumed to imply random choice, inertia implies repetition of the last choice, and exploitation implies a selection of the alternative the led to the best payoff in similar situations in the past. The computation of the value of each alternative is assumed to be based on weighting of the average payoff over all trials, and the average payoff in a small sample of the most similar trials. In addition, I-SAW assumes a tendency to sample the most recent experience, and a decrease in inertia when the outcomes are surprising. Surprise is measured by the gap between the obtained and expected payoff (Schultz, 1998).

The Technion Prediction Tournament: Individual Decisions with Limited Feedback

Erev et al. (2010a) present a choice prediction competition designed to facilitate the development and comparison of models of decisions from experience under limited feedback.[2] The organizers of the competition (the first three co-authors of that paper) ran two large experimental studies using the clicking paradigm without information concerning forgone payoffs. Each study focused on 60 randomly selected problems. All

[2] In addition to this competition, Erev et al. organized a competition that focuses on decision from description, and a competition that focuses on decisions based on free sampling. The comparison of the three competitions clarifies the robustness of the experience-description gap.

the problems involved a choice between a safe prospect that provides a medium payoff (referred to as M) with certainty, and a risky prospect that yields a high payoff (H) with probability Ph, and a low payoff (L) otherwise. Thus, the basic choice problem is:

S: M with certainty

R: H with probability Ph; L otherwise (with probability 1-Ph)

The four parameters (M, H, Ph and L) were randomly selected with a well defined algorithm that implies: (1) The possible payoffs were between -30 and +30 Shekels (1 Shekel equaled about $0.3); (2) L < H; (3) M was between L and H in 95% of the problems; and (4) the difference between the expected values of the two prospects was relatively small. Twelve of the 120 problems that were examined are presented in Table 1.

The first study, referred to as the estimation experiment, was run in March 2008. Each of the 60 problems was faced by 20 subjects for 100 trials. Each subject played 12 games, and the payoffs (in Shekels) were determined by a randomly selected trial. In April 2008 the organizers posted the result and the best baseline models that they could find on the web (see http://tx.technion.ac.il/~erev/Comp/Comp.html) and challenged other researchers to predict the results of the second study. The second study, referred to as the competition experiment, was run in May 2008 using the same experimental method as the estimation experiment but different randomly selected problems and different subjects. The results of the competition study were not revealed until September 2nd 2008.

Researchers participating in the competitions were allowed to study the results of the estimation study. Their goal was to develop a model that would predict the results (the mean choice proportion over all choices in each problem) of the competition study. The model had to be implemented in a computer program that reads the payoff distributions of the relevant gambles as an input and predicts the proportion of risky choices as an output. The submission deadline was September 1st 2008. The submitted models were ranked based on the Mean Squared Deviation (MSD) between the predicted and the observed choice proportions.

ENO (Equivalent Number of Observations)

One advantage of the MSD criteria used here is its relationship to traditional statistics (like regression, t-test and the d-statistic) and its intuitive interpretation. These attractive features are clarified with the computation of the ENO (Equivalent Number of Observations) order-maintaining transformation of the MSD scores (see Erev et al., 2007). The ENO of a model is an estimation of the size of the experiment that has to be run to obtain predictions that are more accurate than the model's prediction. For example, if a model's prediction of the probability of risky choices in a particular problem has an ENO of 10, this prediction is expected to be as accurate as the prediction based on the observed proportion of risky choices in an experimental study of that problem with 10 participants.

Results

The models evaluated in the competition can be classified in two main classes: The first includes instance-based models like I-SAW that assume reliance on small samples of experiences. The second include models like reinforcement learning with a normal error terms that do not assume memory of and/or reliance on specific experiences. About half of the baseline models and half of the submissions belong to each class. The results reveal a large advantage of the instance-based models. The best baseline model was a predecessor of I-SAW. The ENO of this best baseline was 47.2. In the current context the predictions of this model are almost identical to the predictions of the refined model, I-SAW, with the parameters : ε_i~U[0,.20], w_i~U[0,1], ρ_i~U[0,.6], π_i~U[0,.6], and μ_i drawn from integers 1 to 14.

The winner of the competition was an instance-based model that assumes an ACT-R[3] cognitive architecture (submitted by Stewart, West and Lebiere). Like the best baseline and I-SAW, the winning model builds on the instance based learning model proposed by Gonzalez et al. (2003) and implies reliance on small samples of experiences. The winner had slightly lower ENO (32.5) than the best baseline (the baseline models did not participate in the competition).

The Market Entry Game Competition: Social Interaction with Complete Feedback.

Erev et al. (2010b) organized a choice prediction competition that focuses on 4-person market entry games under limited prior information. The experimental subjects were informed that they play a market entry game, and have to select between a risky entry to the market and a safer decision to stay outside the market.

The payoffs depended on a realization of a binary gamble (the realization at trial t is denoted G_t, and yields "H with probability Ph; and L otherwise"), the number of entrants (E), and two additional parameters (k and S). The exact payoff for player i at trial t was:

$$V_i(t) = \begin{cases} 10 - k(E) + G_t & \text{if i enters} \\ \text{round}(G_t/S) \text{ with } p = .5; -\text{round}(G_t/S) \text{ otherwise} & \text{if i does not enter} \end{cases}$$

The parameters H, Ph, L, k and S where randomly drawn under certain constraints (e.g., the expected value of the gamble was zero, the mean entry rate at equilibrium was 0.5).

The participants did not receive a description of the payoff rule, and had to rely on a complete feedback (obtained and forgone payoffs) after each trial. The organizers run an estimation study with 40 games, and a competition study with 40 additional games.

The results of the estimation study were published in May 2010, and the submission deadline was September 2010. The analysis of the estimation study suggests that results exhibit the basic learning phenomena documented in individual choice task and summarized in section 1.1. In addition, the results show high initial entry rate: 66% in the

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[3] ACT-R (Adaptive Control of Thought—Rational) is general theory of cognition (see Anderson & Lebiere, 1998).

first trial. Comparison of several baseline models highlights the advantage of I-SAW over other models. Best fit was provided with a slight modification of the "strategy set simplification assumption": The best baseline model is I-SAW with the assumption of an initial tendency to entry the marker in 66% of the trials.

Twenty-five teams participated in the competition. The submitted models included reinforcement learning, neural networks, ACT-R, and I-SAW like sampling models. The results reveal a large advantage of sampling models that assume reliance on small samples and surprise-triggers-change. Indeed, all the ten leading submissions belong to this class of models. The winner of the competition (Chen et al., 2011) is a variant of I-SAW that adds the assumption of bounded memory. The runner up (Gonzalez et al., 2011) quantifies the similar assumptions in a refinement of the instance based learning model (Gonzalez et al., 2003).

The ENO of I-SAW (in predicting the average payoff, a statistic that captures the entry rate and implied coordination level) in the last block of 25 trials was 42.2. As in the first competition, traditional "normal error term" reinforcement learning models did not do well. It seems that the main reason for their failure here involves the co-existence of "underweighting of rare events" and relatively weak recency effect.

c.3.2 Individual differences

In an initial set of studies we sought to demonstrate that experience-based decisions provide good assessment tools for identifying consistent individual differences. A second set of studies then more systematically examined the consistent constructs of decision under risk in decisions from experience. A final line of studies examined more generally what factors make people take risk consistently, as opposed to being more affected by context and task related factors.

Decisions from Experience as Assessment Tools

Most models of individual difference focus on attitude to descriptive incentive structure (e.g., risk; ambiguity; work) and to not address consistent individual differences in the process by which people learn to respond to such incentive structures. We have demonstrated that decisions from experience allows discrimination between different groups of psychiatric patients (Yechiam et al., 2005), and discrimination between different groups of jailed criminals (Yechiam et al., 2008). Moreover, the component process that appears to be distinct in these populations is quite often associated with learning.

For example, a re-analysis of Bechara et al.'s (1994) classic results of patients with orbitofrontal lesions shows that the component processed impaired in this population is not risk attitude per se but rather involves extreme recency, or over-dependency on a small recent sample of trials (Yechiam et al., 2005; Hochman et al., 2010). A related

example was observed with incarcerated criminal offenders (Yechiam et al., 2008). While a variety of criminal populations performed more poorly (and took more risk) in the Iowa Gambling task, the reasons for this were disparate. Some populations, most notably those convicted for assault, murder and other violent crimes, were not characterized by a different risk attitude compared to a control population, but rather by elevated recency as well.

Similar findings were observed for the effect of some psychoactive drugs. Specifically, we found that many drug of abuse, including cocaine and cannabis, affect recency in addition to risk attitude (Yechiam et al., 2005). The strongest effect was observed for cannabis. Chronic marijuana abusers performed similarly to brain lesioned patients in the Iowa Gambling task, but again the main reason for this involved extreme recency. By contrast, for cocaine and alcohol the difference between addicts and controls was mediated by decreased weighting of potential losses. Acute administration of marijuana and alcohol produced the same results (Lane, Yechiam, & Busemeyer, 2006).

A related and parallel effort involved devising the methodology of modeling individual differences using reinforcement learning algorithms. When analyzing complex tasks such as the Iowa Gambling task reinforcement learning models are used in a novel fashion. Traditionally, reinforcement learning models used for analyzing performance in decisions from experience have been applied to predict group averages (see e.g., Roth & Erev, 1995). We have studied the application of these models at the individual level as well, and have developed new statistical techniques for model assessment (e.g., Yechiam & Busemeyer, 2008; Yechiam & Ert, 2007; Yechiam & Rakow, 2011). These techniques include a new method for assessing the generalizability of model predictions that is also useful for assessing the adequacy of tasks for evaluating individual differences.

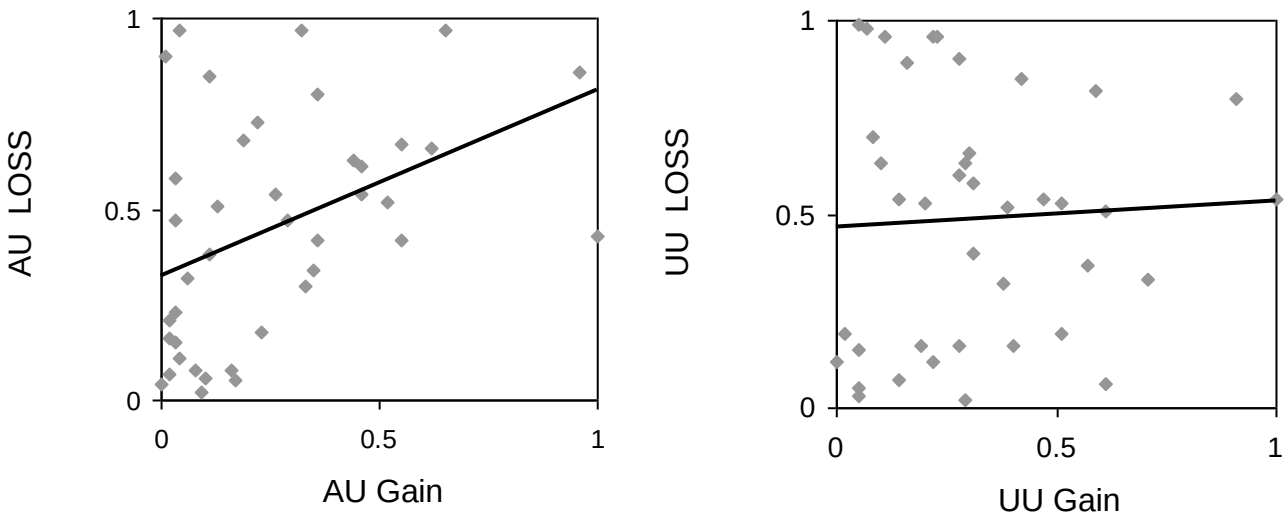
Towards the Building Blocks of Risk Taking

A second avenue of research in examining individual difference in the context of decisions from experience has been to evaluate the basic constructs that are consistent at the individual level. This was done by using two major indices of consistency: Inter-task consistency (Ert & Yechiam, 2010; Yechiam & Ert, 2011; Koritzky & Yechiam, 2010) and temporal consistency (Yechiam & Telpaz, in press).

This effort was theoretically driven by three major accounts of what drives risk taking behavior: 1) The classical economic approach which views risk as the sensitivity to differences in variance. 2) The latent- components approach suggesting the importance of sensitivity to losses and diminishing sensitivity to marginal increases in payoffs, and 3) Risk acceptance, relating to the willingness to accept probable outcomes over certainty. For example, to contrast the second and third approach we examined whether people are consistent for gambles in the gain and loss domain,

We observed positive consistency across the gain and loss domains, namely those who took risk with gains also took risk with losses (See Figure 2). This suggests that the consistent latent factor across domains is not diminishing sensitivity to payoff magnitude

(which predicts a negative correlation since discounting large gains leads to risk aversion and discounting large losses leads to risk seeking). Rather, these results show that people are consistent in their risk acceptance, the tendency to prefer a fixed outcome to a risky one or vice versa. We suggested that the construct labeled as risk acceptance should be more weakly defined as sensitivity to strong signals of risk such as in deciding between constant versus probabilistic outcomes. More generally, this finding denotes a deviation between population models of decision making and consistent latent constructs within the individual At the population level there is risk seeking in the loss domain and risk aversion in the gain domain, which is consistent with the work of diminishing sensitivity. At the individual level, however, risk acceptance is the consistent construct.



Domain	Condition	Alternative: Payoff	P(H)
Gain	Avoidable Uncertainty (AU)	L: win 600 H: 50% to win 1200, 50% to win 0	0.26
Gain	Unavoidable Uncertainty (UU)	L: 50% to win 500, 50% to win 400 H: 50% to win 890, 50% to win 10	0.31
Loss	Avoidable Uncertainty (AU)	L: lose 600 H: 50% to lose 1200, 50% to lose 0	0.45
Loss	Unavoidable Uncertainty (UU)	L: 50% to lose 500, 50% to lose 400 H: 50% to lose 890, 50% to lose 10	0.49

Figure 2: Top: Payoff structure in four tasks comparing the gain and loss domains and proportion of selection from the risky alternative H. Bottom: Correlations between the proportion of risky choices across 60 trials in these tasks. From Yechiam & Ert (2011).

A second interesting finding which can be observed in Figure 2 is that risk acceptance rather than mere economic risk sensitivity is the consistent construct. As observed in the right hand side of Figure 2 given the same differences in the variance of the alternatives, people took risk consistently across the gain and loss domains when the risk was avoidable but not when it was not avoidable.

Factors Affecting Behavioral Consistency

We also directly compared the consistency of risk taking in experience and description based tasks (Yechiam & Ert, 2011). Examination of similar problems in description based tasks revealed much lower consistency across domains (as found previously, e.g., by Schoemaker, 1990). Thus, the results suggest that experience contributes to elevating the consistency of risk-related constructs. A follow-up study (Koritzky & Yechiam, 2010) suggested that this may be due to description-based tasks having more response bias due to social desirability.

As noted above, we also examined the consistency across different sessions to answer related questions. The main results showed (a) More consistency for risk acceptance than for diminishing sensitivity across time (Yechiam & Ert, 2011). b) The consistency for risk acceptance was much higher when the risk included losses (Yechiam & Telpaz, in press). In Yechiam and Telpaz's (in press) study, 130 participants performed the following two experiential decision tasks in two sessions that were administered 6 weeks apart:

Mixed condition

S	Get 0 with certainty	P(S) = 0.57
R	50% to win 200, 50% to lose 200	

Gain condition

S	Win 200 with certainty	P(S) = 0.66
R	50% to win 400, 50% to get 0	

Loss condition

S	Lose 200 with certainty	P(S) = 0.59
R	50% to lose 400, 50% to get 0	

The study included a Mixed condition with symmetric gains and losses, which can be used to evaluate whether the effect of losses on behavioral consistency are contingent on loss aversion. To explore the effect of losses on behavioral consistency, the test-retest reliability was calculated for each choice task. This analysis showed that behavioral consistency was much higher with losses (Mixed domain task $r = 0.36$, $p < .01$; Loss task $r = 0.26$, $p < .01$; Gain task: $r = 0.12$; $p = .16$).

A re-analysis we did (in Yechiam & Hochman, 2012) on a longitudinal study by Levin et al. (2007) also demonstrates this point. In an impressive study, Levin, Hart, Weller, and

Harshman (2007) studied the consistency of risk taking behavior in a task known as the cups task across a three-year period. This was assessed for a sample of children as well as for their parents. The cups task contains both descriptive and experiential information concerning the payoffs. Participants are shown the outcomes hidden behind a cup and choose between obtaining sure outcomes or guessing the location of the "outcome cup" among several identical cups. Following each choice, the participants received feedback. The cups task was administered in a Gain and a Loss condition, with each condition containing six items differing in expected value ratios and risk levels. A re-analysis comparing the gain and loss conditions shows the following results for the consistency across three years. For the adults the correlation was 0.49 for the Loss condition ($p < .01$) and only 0.12 for the Gain condition ($p = 0.34$). For the children the correlations were 0.44 ($p < 0.01$) and 0.32 ($p = 0.01$), respectively. Thus, these findings also indicate increased consistency for losses (though perhaps suggesting that it may be less pronounced in children).

We also established an effect of losses on the consistency between physiological predispositions and risk taking levels (Yechiam & Telpaz, 2011). Several personality theories have suggested that people exhibiting lower levels of internal arousal would seek external stimulation by taking risk (e.g., Zuckerman, 1990). A similar prediction is made in theories of trait anxiety (e.g., M.W. Eysenck, 1992). We found that the negative correlation between pre-task pupil diameter and risk taking is significant only in decision tasks that include losses (Yechiam & Telpaz, 2011). In a new study (Telpaz & Yechiam, 2012) we find similar results for hemispheric asymmetry. Studies of the EEG Frontal Asymmetry (FA) have shown that greater relative left frontal activity characterizes individuals with high behavioral activation sensitivity (BAS; Harmon-Jones & Allen, 1997), and, in one instance, lower behavioral inhibition sensitivity (BIS; Sutton & Davidson, 1997). Similarly to arousal, it has been argued that behavioral inhibition is highly associated with risk taking behavior. Our initial results show that this correlation between FA and risk taking only emerges for risks with losses. These results have been instrumental in establishing a novel theory of losses (see next section).

c.3.3 Attentional Theory of Losses

The special role of losses on behavioral consistency, as evidenced by the common use of losses in decision making assessment (e.g., Bechara et al., 1994; Lejuez et al., 2001) suggests that they have unique psychological and physiological consequences. Yet Erev, Ert, and Yechiam (2008) found that in decisions from experience individuals do not exhibit loss aversion (i.e., give loss more subjective weight than equivalent gains). We approached this curious pattern by first examining whether indeed losses lead to more arousal than gains in experience based tasks simultaneously with no loss aversion. We then constructed an attentional model of losses and demonstrated how it can account for the extant finding involving losses in a variety of domains, including individual differences.

Losses and Arousal

In several experiments we have found that in decisions from experience, individuals simultaneously showed no loss aversion but at the same time exhibited increased arousal following losses compared to gains. For example, in Hochman and Yechiam (2011) we examined two experience-based choice tasks with the following payoff structure:

Mixed (gains and losses) condition

S	50% to win 1, 50% to lose 1	P(S) = 0.54
R	50% to win 2, 50% to lose 2	

Gain condition

S	50% to win 2, 50% to win 4	P(S) = 0.49
R	50% to win 1, 50% to win 5	

Throughout the task, the unique autonomic responses following gains versus losses were assessed by measuring the participants' pupil diameter (PD) (see Granholm & Steinhauer, 2004) and Heart Rate (HR). There were 60 selections in each condition. Each led to the presentation of the obtained outcome from the current selection. Since the Mixed condition includes symmetric gains and losses, loss aversion implies that people will avoid option R in order to evade the higher possible losses. However, in contrast to this prediction, we found that participants were indifferent between the two alternatives, and exhibited no risk aversion in the Mixed condition. The learning curves for the different conditions appear in Figure 2 (top pane).

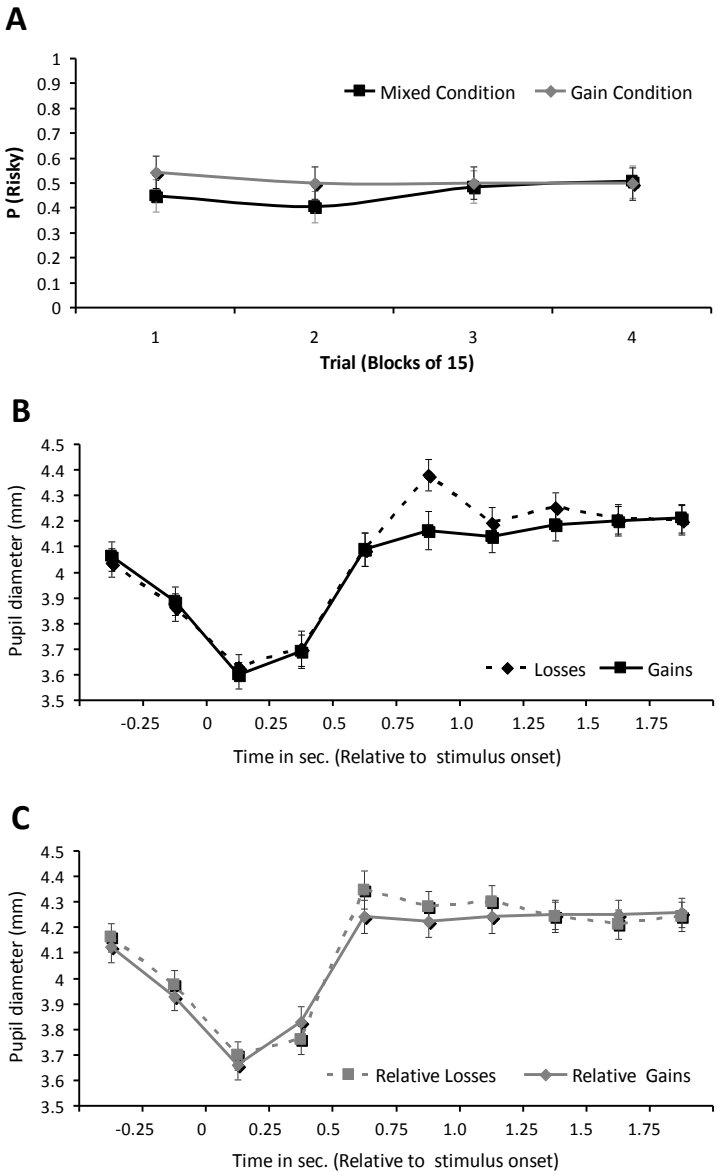


Figure 3: Hochman and Yechiam's (2011) Experiment 1 results. (A) Proportion of participants selecting the risky option in the Mixed and Gain conditions (blocks of 15 trials). (B) Average pupil diameter in the Mixed condition as a function of the event type (gain versus loss). Time zero denotes the outcome presentation onset. Significant differences are marked by black dotted lines. (C) Average pupil diameter in the Gain condition as a function of the event type (relative gain versus relative loss)

By contrast, autonomic arousal, as indexed by PD and HR, was significantly higher in response to losses than to equivalent gains (the PD results are presented in Figure 3, bottom two panes). Moreover, no significant correlations were found between the participants' arousal following losses compared to gains and their tendency to avoid the risky option in any of the physiological indices. This pattern of results suggests that while an asymmetry in response to losses versus gains was observed in autonomic arousal, it was not associated with loss aversion.

In a different experiment, Hochman et al. (2010b) replicated these findings in a choice task that enabled participants to avoid losses (the safe alternative was a fixed low-magnitude positive payoff). Participants selected between gaining 1 with certainty and a risky option producing 8.5, 6, 3.5, -1.5, -4, or -6.5 with equal probability (of 1/6). The

mean proportion of selections from the safe alternative was 0.48, implying that participants did not avoid the option that incurred losses. Still, increased peripheral vasoconstriction (a sympathetic measure of arousal; Gayton, 1977) was observed following losses compared to gains.

Losses and Event Related Frontal Negativity

One of the most studied phenomena in event related potentials is the error-related negativity (ERN). The ERN is a frontocentral deflection in event-related cortical potentials appearing around 200 ms post-stimulus, considered to denote the outcomes of an early evaluation process that is especially attuned to potential threats (Hajcak & Foti, 2008). Originally, an increased ERN was found after errors compared to successful responses (Falkenstein, Hohnsbein, Hoormann, & Blanke, 1991; Gehring et al., 1993). Subsequently, an increase in feedback-related ERN (fERN) was found in decisions from experience after getting losses, compared to equivalent gains (Gehring & Willoughby, 2002; Masaki et al., 2006; Nieuwenhuis et al., 2004; Yeung & Sanfey, 2004). The fERN phenomenon implies that sensitivity to losses appears in a very early evaluation process. Gehring and Willoughby (2002) suggested that evaluative impressions giving greater weight to losses than gains in the frontal cortical networks contribute to the subsequent representation of "instant utility". This implies consistency between these evaluative processes and the behavioral decision bias of loss aversion (Kahneman & Tversky, 1979). A curious phenomenon is that in Gehring and Willoughby's (2002) study, which was the first to demonstrate the fERN, the participants actually did not avoid the choice alternative incurring the highest losses. Their study involved repeated choices between an alternative producing +5 or -5 US cents with equal likelihood and a second alternative producing +25 or -25 cents with equal likelihood. On average, the alternative incurring +25 or -25 was selected 58% of the time, on average. Loss aversion, by contrast clearly implies that in choice between a pair of alternatives with symmetric gains and losses, individuals should prefer the alternative producing lower losses (Kahneman & Tversky, 1979). This seems to imply a dissociation between brain activation pattern and behavioral decisions (Yechiam and Aharon, 2011; Yechiamj & Hochman, in press).

An alternative explanation of the pattern in Gehring and Willoughby (2002) and subsequent studies is that the fERN is related to a behavioral phenomenon similar to loss aversion known as "loss avoidance", the tendency to reduce the likelihood of potential losses (Cachon & Camerer, 1996). Recall that in Gehring and Willoughby (2002) and followup studies the probability of losses and gains was identical (.50) in both choice options; therefore participants could not reduce the likelihood of losses by switching away from the high loss alternative. Under this explanation the fERN involves the recognition of potential losses as a sign of avoidance but this is translated to behavioral decisions only as long as losses can be avoided to a certain extent. However, in Yechiam, Telpaz, and Hochman (2012) we replicated the pattern of an extensive fERN simultaniously with no

loss aversion even in a choice problem where participants could reduce the likelihood of losses.

An Attention-Based Theory of Losses

We have found the observed gap between experiential behavior on the one hand and autonomic arousal and frontal activation on the other hand puzzling given the fact that arousal was previously posited to be a mechanism guiding behavior (Damasio, 1994; Loewenstein, Weber, Hsee, & Welch, 2001), and was found to be correlated with behavioral responses to incentives (Heitz, Schrock, Payne, & Engle, 2008; Richter & Gendolla, 2009). As described next, our interpretation of this gap is that while losses have no effect on the subjective weighting of outcomes, they do lead to an attentional orienting response, as evidenced by the increase in arousal.

Under our attentional model (Yechiam & Hochman, in press), losses do not have a larger effect than gains on subjective evaluations, but they do increase the allocation of attentional resources to the task. The model's two basic arguments are as follows: (a) Losses lead to an orienting response characterized by a momentary increase in arousal, which results in sustained attention. (b) The heightened attention increases the sensitivity to the task reinforcements and decreases random responses. This model capitalizes on the argument that losses signal an important situation for the organism's immediate survival and therefore increase attention (Rozin and Royzman, 2001; Taylor, 1991) but it suggests that when gains and losses are presented concurrently the attentional effect of losses is not specific to the loss component, and extends to other outcomes besides losses.

Implications of the Attentional Model

The model has several interesting implications that go beyond decisions from experience and extend to decisions under risk and to riskless decisions implicated in task performance and in economic transactions.

1. *Implication to Performance in Riskless Decisions*

The arguments of the present model suggest two distinct lines of predictions concerning the link between losses and task performance. These two classes of predictions depend on whether losses and gains are presented intermittently. When *gains and losses are separately presented in different conditions* one group of participants receives (probabilistic or riskless) gains and the other receives losses. Since gains and losses are separated, an increase in task attention is predicted only in the loss condition, which leads to increased sensitivity to payoff (i.e., to the losses) in this condition. As a result, losses are predicted to modulate behavior more than gains. In line with this prediction, it has indeed been demonstrated that compared to pleasant outcomes, unpleasant events tend to evoke relatively more attention as well as stronger and longer-lasting changes in mood and emotion (Baumeister et al., 2001; Rozin & Royzman, 2001; Taylor, 1991). Also this is consistent with the extant literature on the positive effect of losses on performance in

simple cognitive tasks (e.g., Dickinson, 2004; Costantini & Hoving, 1973; Ganzach & Karshai, 1995).

When *gains and losses are presented simultaneously or subsequently within a close time range*, the effect of losses on attention is posited to be non-specific to the losses that produced it. Consequently, and in contrast to the loss aversion assumption, losses are not assumed to be weighted differently from gains, and when gains and losses are equal in magnitude no loss aversion is predicted to emerge. This is consistent with findings in simultaneous performance problems where trials of losses and no losses are repeatedly exchanged, showing no difference in learning (e.g., Magoon & Critchfield, 2008; Rasmussen & Newland, 2008).

2. *Implications to Performance in Economic Exchange Situations*

Several economic phenomena involving riskless choices have been suggested to be due to loss aversion, most prominently the endowment effect (Kahneman, Knetsch, & Thaler, 1990) and asymmetric price elasticity (Hardie, Johnson, & Fader 1993). The asymmetric price elasticity refers to the finding that people cut back purchases following a price increase to a greater extent than they increase purchases following a price decrease (Putler, 1992; Hardie et al., 1993). Under the current attentional model, the asymmetric price elasticity may emerge because it is embedded in a situation where (financial) losses are not simultaneously or concurrently presented with gains. Hence, the increased attention induced by losses only affects the response to these losses. Specifically, a price increase focuses consumers' attention on what they might lose from the purchase, while a price decrease focuses their attention on what they might gain out of it; consequentially, people are more sensitive to the change in the incentive structure in the loss frame condition (and this condition has a larger effect on their purchasing behavior).

3. *Implications to Risk Taking*

In decisions under risk and uncertainty gains and losses are presented simultaneously or subsequently within a close time range. Therefore, under the current attentional model the effect of losses on arousal is diffused to other task outcomes, including gains. This is consistent with the finding of Erev et al. (2008) showing no loss aversion in decisions from experience. Curiously, a review of the decisions from description literature also shows that in many cases the effect of losses on risk taking is not significant or smaller than what might be expected based on prospect theory. In a review of the literature we (Yechiam and Hochman, in press) suggested that in fact loss aversion surfaces only with very high payoffs, where it is driven in part by risk aversion; and in daily situation where losses are also cues that the person could be conned (Ert & Erev, 2008). There are some exceptions such as the study of Brooks and Zank (2005) who used a large battery of 96 lotteries of the form (x, 33%; 0, 33%; -x, 33%) or (y, 33%; 0, 33%; -y, 33%) with losses running up to £9. The average rate of selections from the safe alternative in their study was 0.63. Still, if this amounts to loss aversion then it is indeed weak evidence for it, in

terms of the departure from loss neutrality. We do not propose that the asymmetric response to losses does not exist; Rather, our attentional model implies that it is much weaker and often insignificant in situations where gains and losses are presented together. Table 1 summarizes the relevant studies.

Table 1: Studies that examined the effect of losses using the choice paradigm with alternatives having symmetric expected values (i.e., similar to the .50, x, .50 –x format). The studies are organized according to the decision task type: experience versus description based decisions. LA = Loss aversion: the rate of the high variance option was significantly lower than 50%. Y = Yes, N = No.

Experience	LA	Description	LA
Katz, 1964	N	Battalio et al., 1990	N
Gehring and Willoughby, 2002	N	Thaler and Johnson, 1990	N
Yeung and Sanfey, 2004	N	Brooks and Zank, 2005	Y
Masaki et al., 2006	N	Abdellaoui et al. 2007 *	Y
Yechiam and Ert, 2007	N	Birnbaum and Bahra, 2007	N
Erev et al., 2008	N	Abdellaoui et al. 2008 *	Y
Silberberg et al. ,2008	N	Ert and Erev, 2008	N
Kamarajan et al., 2009	N	Rabin and Weizsäcker 2009 *	Y
Koritzky and Yechiam, 2010	N	Ert and Erev, 2010	N
Ert and Yechiam, 2010	N	Koritzky and Yechiam, 2010	N
Glöckner and Hochman, 2011	N	Yechiam and Ert, 2011	N
Hochman and Yechiam, 2011	N	Battalio et al., 1990	
Yechiam and Telpaz, in press	N	Thaler and Johnson, 1990	

+ - For conciseness we did not include the references in this Table. They can be found in Yechiam and Hochman (in press).

* = Hypothetical large amounts (exceeding $100).

4. *Implications to Maximization*

The "successful loser" effect (Bereby-Meyer & Erev, 1998; see also Denes-Raj & Epstein, 1994) is the finding that when choice alternatives differ in their expected value, losses lead to greater maximization. This effect of losses appears to emerge even in a situation where gains and losses are presented simultaneously or in close time ranges. While previously, this effect has been explained due to loss aversion we have demonstrated that losses enhance performance even in situations where making the appropriate choice leads to more losses – consistently with the attentional model.

For example, in Yechiam and Hochman (2012) we administered the following choice problem using the decisions from experience paradigm:

Gain condition

50% to win 1, 50% to win 200 (EV = 100.5) P(H) = 0.56

Win 35 + N

Loss condition

50% to lose 1, 50% to win 200 (EV = 99.5) P(H) = 0.66

Win 35 + N

Where N is a noise factor randomly sampled from [-5,-4,-3,-2,-1,0,1,2,3,4,5]. In this choice task, the advantageous alternative (H) is the one that produces losses. Specifically, it produces a minor loss of 1 in the Loss condition compared to a gain of 1 in the Gain condition. According to the loss aversion model, people should perform worse in the Loss condition (i.e., select H less) due to the increased weighting of losses compared to gains. This is also predicted by the expected utility theory assumption of dominance. In contrast, according to the attentional model, losses should increase the sensitivity to the different task payoffs, leading to more choices from H in the Loss condition. The results showed that across 100 trials there were significantly more choices from the advantageous alternative in the Loss condition – even though it was only the advantageous alternative that produced losses. This pattern can only be explained if one assumes that the effect of losses is not specific to the loss component but rather that it extends to the gain component as well, as postulated by the attentional model (an alternative explanation is a contrast effect but losses similarly affect performance in the absence of contrast effects).

5. *Implications to Response Time.*

Under various accounts reaction time is considered an indicator of the amount of mental effort exerted in decision tasks (e.g., Payne, Bettman, & Johnson, 1993). Several studies have found an increase in response times in the loss domain compared to the gain domain (Porcelli & Delgado, 2009; Xue et al., 2009; Yechiam & Telpaz, 2011; in press), and more generally in the face of negative versus positive stimuli (Derryberry, 1991; Leppänen, Tenhunen, & Hietanen, 2003). In contrast, no such difference in response time was found when gains and losses were produced intermittently by the same choice alternative (Preuschoff, Bossaerts, & Quartz, 2006), even if an increased fERN following losses was observed (Masaki et al., 2006; Fujiwara et al, 2009).

While this complex relation between reaction times and gains and losses cannot be reconciled by the loss aversion model, it does support the attention-based model. Namely, if we assume that reaction time represents an extended attentional component rather than the extent of the acute orienting response (Porges, 1992), this can explain why losses lead to greater response time relative to gains in a separate condition. However, when losses

are intermittently presented with gains, this attentional effect is carried over to other outcomes, thus eliminating the asymmetry.

6. *Implications to Individual Differences*

These were detailed in the previous section. Participants were found to be more consistent across tasks or across sessions in decision situations involving losses.

7. *Evolutionary Implications*

The most common explanation for the attention-grabbing effect of losses involves the fact that they signal potential danger to the organism (Rozin & Royzman, 2001). The idea is that a small penalty, such as the sight of a snake or a spider, serves as a predictor of an imminent larger penalty. This explanation suggests an asymmetry in the basic ecological significance of losses. A complementary explanation which does not assume this asymmetry implicates the fact that natural defense mechanisms often signal the existence of resources. For example, plants that have edible leaves tend to protect themselves with thorns and spines to a greater extent than plants with leaves having no nutritional value (Esau, 1965). Similarly, in a given species of deer animals with greater body mass and fat levels tend to grow larger antlers (Scribner, Smith, & Johns, 1989). In human culture as well high potential costs are very often associated with high potential gains in barter situations, in situations involving the exertion of effort, and in security systems. Consequentially, in some settings losses/threats may signal greater resources and potential opportunities, and not only substantial dangers. In these contexts, it might be evolutionary adaptive to attend to situations involving losses in order to identify cases where such opportunities could be exploited. This suggests that keeping alert and focused in situations involving losses may be an adaptive strategy, even without assuming a basic asymmetry in the survival value of losses and gains. Consistent with this notion, we have demonstrated that losses lead to increased arousal, performance, and behavioral consistency, even in the absence of loss aversion.

c.3.4 Small Decisions and Human Factors

The experimental studies reviewed above focus on small decisions: The stakes in the typical experimental task were small, and the participants did not invest very much time and/or effort in each choice. Nevertheless, we believe that the behavioral regularities documented in this research can be of high practical value. Our belief is based on three sets of observations. First, many important economic phenomena are the direct product of small decisions. For example, small decisions by drivers (e.g., the decisions between the gas and the break pedal) affect traffic accidents, traffic jams, and pollution. Similarly, small clicking decisions by internet users determine the future of newspapers, and of the music industry.

Second, in many settings high stakes decision problems are shaped by small decisions. For example, consider the high stake decision among different job offers. In many cases this big decision problem is affected by earlier small decisions. The job offers available to a specific college graduate are likely to depend on small decisions that she has made as a child and as a student. Small decisions that lead to high grades, and good connections tend to improve the job offers.

A third set of observations come from studies that directly examine the human factor implications of the learning phenomena presented above. Some of these studies are reviewed below we have discussed.

Gentle Enforcement of Safety Rules

Erev & Rodensky (2004; Erev et al., 2010c, 2010d; and see related idea in Zohar, 1980) note that the research reviewed above has four implications for the design of safe working environments. First, the results suggest that rule enforcement is necessary even when safe behavior (e.g., the use of safety equipment) is the rational course of action. The explanation of the relevant risks might not be enough. When workers make decisions from experience they are likely to underweight the low-probability-high-hazard event and behave as if they believe "it won’t happen to me."

A second implication concern the effectiveness of rule enforcement systems in which a small proportion of violations are severely punished (see Becker, 1968). The current review implies that systems of this type are likely to be effective in the context of decisions from description, but less effective or ineffective in the context of decisions from experience. When decisions are made from experience, low probability punishments are likely to be underweighted.

A third implication is optimistic. It implies that the fact that workers take unnecessary risks and behave as if they ignore safety rules does not imply that they will object to attempts to enforce these rules. Indeed, the observation that low probability events are over-weighted in decisions from description implies that when workers are explicitly asked to consider the safety issue they will agree that they want to behave safely, and will

be happy to see that the management designs a rule enforcement system to help them achieve this goal.

Finally, the arguments presented above suggest that behavior is much more sensitive to the probability than to the magnitude of the punishment. Thus, a gentle Continuous Punishment ("gentle COP") policy that implies low punishments with high probability can be very effective (as long the fine is larger than the benefit from violations of the rule).

Erev and Rodensky (2004, and see Erev, 2007) applied this "gentle COP" method in twelve Israeli factories. The basic idea was the design of a mechanism by which supervisors will be encouraged to approach each worker who violates the safety rule and remind him that this behavior might result in injury, and will be recorded (if repeated). The official role of these "violations records" was to allow the management to positively reinforce workers who observe the safety rule by giving these workers a higher probability of winning a lottery. Baseline data were collected about two months prior to intervention. The data included objective measures of the workers' safety behaviors. The intervention started with a formal presentation of the new policy to all the workers. Figure 4 presents the percentage of workers that obey three safety rules before and throughout the intervention in a representative department (in a factory that manufactures chemical products) over a period of 4 years. The baseline data were collected a month before the beginning of the intervention. The data for the rest of the observations were collected in the following months.

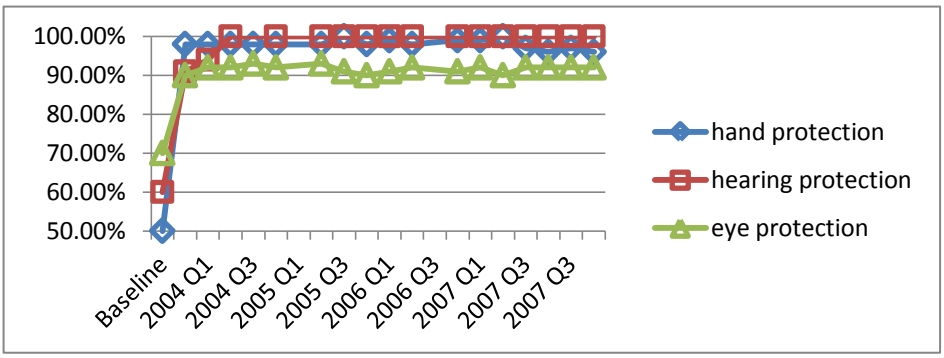


Figure 4: Summary of the effect of gentle COP in a representative factory

As demonstrated in Figure 4, the intervention had a large and immediate effect. A similar pattern was observed in all twelve factories. The rate of safe behavior increased to 90% immediately after the beginning of the intervention. More interesting is the observation that the effect of the intervention did not diminish with time. The rate of safe behavior increased or stayed high during the two years since the beginning of the intervention. Given the success of the intervention, and its relatively low cost, the factories have decided to maintain the experimental policy after the experiment. Follow-up research show a similar effect of gentle rule enforcement in encouraging medical personnel to use protection gloves (see Erev et al., 2010d), and in reducing cheating in university exams (Erev et al., 2010c).

Encoding and Displaying ATR Designations in SAR Images

This study was supported by a grant from the USAF Air Force Research Laboratory and carried out by Dr. Pe'erly Setter, Prof. Joel Norman, Maya Lipkin-Goldberg, and Dr. Hadas Marciano. The report appeared as Report No. AFRL-HE-WP-TR-2006-0157 in 2006.

The study both compared two methods of providing analysts with ATR (Automatic Target Recognition) confidence ratings, and examined whether providing these ratings yielded superior performance to ATR designations without added confidence information. Twelve analysts participated. They were presented with SAR (Synthetic Aperture Radar) images each of which contained one of three types of ATR designations. Two of the designation types included ATR confidence ratings and a third did not. The two ATR designations types that included confidence levels specified the confidence of the ATR system (three levels: less than .70, about .80, and more than .90) either by surrounding the SAR item with three different shapes or by placing a number next to the item. The third designation type did not give confidence information, but simply surrounded those SAR items designated by the ATR as targets with an ellipse. All the designations were in partially transparent red. Each SAR image contained between 10 and 18 items, 5 to 12 of these being targets (T62, BMP2, or, BTR60) and the others distractors (ZIL 131 or D7). The analysts were also given a post-experimental questionnaire to assess their subjective opinions of the three designations. Hit Rates (HR) and False Alarm Rates (FAR) and the signal detection statistic d' were calculated and analyzed[1]. These measures of performance did not yield any major differences between the three designation types, with the exception of slightly (but borderline significant) fewer FARs for the ellipses. The post-experimental questionnaire indicated that the subjective feelings of the analysts just barely favored presenting ATR confidence designations, and that of the two modes of presenting the confidence information they preferred the shapes over the numbers.

As very minor differences were found between the three designation types, the question was raised whether the ATR confidence ratings were, perhaps, not heeded by the participating analysts. To check this all instances where targets were designated with an ATR confidence level were combined (numbers and shapes) and HRs and FARs were calculated for the three confidence levels. It was seen that both HRs and FARs decreased with decreasing confidence levels, as had been shown in our earlier study (Setter, Norman, & Marciano, 2004), indicating that the analysts were indeed aware of the ATR confidence designations. Finally, it was argued that while the study appeared to indicate that ATR confidence designations do not benefit analysts' performance, there are good reasons to assume that in a "real life" situation they will.

[1] Note that throughout this report, HRs, FARs, and d's refer to the performance of the participants in the study and not to the performance of the ATR system.

An Examination of SAR Image Interpretation Aids: Magnification and an Information Window

This study was supported by a grant from the USAF Air Force Research Laboratory and carried out by Dr. Pe'erly Setter, Dr. Hadas Marciano, Maya Lipkin-Goldberg, and Prof. Joel Norman. The report appeared as Report No. AFRL-RH-WP-TR-2010-0009 in 2008.

Synthetic Aperture Radar (SAR) is an important means of acquiring information from afar. Flown by plane or satellite it simulates a huge radar antenna and yields many advantages, but it also raises certain problems. One of these occurs when analysts attempt to interpret the SAR images. In order to provide the analyst with an image that presents a larger general picture, the scale is decreased and the targets appear quite small. To overcome this difficulty it is necessary to magnify parts of the image to allow the examination of suspected targets. This magnification can be implemented in several ways. Research on such computerized magnifications has yielded inconsistent results as to which method of magnification is superior. One method of magnification presents two separate images in windows next to each other. One window displays the entire image, while the second window displays relevant details. Parameters that vary are the exact size and placement of the windows. An alternative method utilizes a digital simulation of a magnifying glass that appears over and within the borders of the original image. The area of magnification is controlled by the computer mouse and covers the area of interest of the analyst. Automatic Target Recognition (ATR) utilizes computer algorithms to try and recognize targets in images obtained from a variety of sensors. One of the possible advantages of ATR is that it might lighten the load of the analysts who are inundated by an excess of images that are supplied by today's technologies.

The ideal goal of ATR systems would be to designate all the targets in an image (maximal hits) without producing false alarms. In such a case the ATR could replace the human analysts. However, present day ATR systems are far from perfect and the analysts have to check and determine which ATR designations are correct and which targets were not designated by the ATR.

The participants in both studies reported below were expert analysts with a military background. The first study included four blocks of images, each block consisting of one of the combinations of the two independent variables: moving magnifier/side-window magnifier; information window available/not available. The analysts were allowed to use the magnification aids and information window whenever they wished. Each block consisted of 18 images. Each image consisted of a SAR image of an area with 10 to 18 vehicles in it. Some of these vehicles were designated as targets by the ATR with a red ellipse. The reliability of the ATR system was approximately 80%, and the recognition rate of the ATR was also 80%. The analysts were instructed to examine all the vehicles in the image, whether designated by the ATR or not, and to mark all the vehicles s/he recognized as targets. There were three "targets", T62, BMP2, and BTR60, and two "distractors", D7 and ZIL131. The analysts marked each suspected target with a red "X"

by pressing the left button of the mouse. After the analyst finished marking all the suspected targets s/he moved on to the next image. At the end of the experiment the analysts were given feedback as to how many points they had accumulated after which they filled out a post experimental questionnaire on the computer.

The analysis of results of the first part of the study, the large experiment, indicated that there were no significant differences in performance among the various conditions. In other words, hit rates and false alarm rates were the same for the four combinations of the two variables, type of magnification and availability of information window. On the other hand, the analysis of the post experimental questionnaire indicated that the majority of the analysts preferred working with the moving magnifier as compared to the side-window magnifier. They expressed the feeling that the moving magnifier is helpful in focusing one's attention on the vehicle, that it is more intuitive and convenient, and that it best serves their needs. Most of the analysts noted that they only used the information window when they felt unsure about the suspected target. It seemed that they did not see the information window as an important and helpful aid and did not use it very often. While the statistical analysis did not yield any differences in performance as a function of the information window, there was a trend indicating that the information window slowed down their performance. The analysts also provided ideas for improving the effectiveness of the information window.

In the second part of the study, the eye-movement monitoring part, nine analysts performed a shortened version of the big experiment while their eye-movements were monitored. Many studies have indicated that a great deal can be learned about visual processes by studying eye-movements. In this experiment the analysts were presented with two exemplars of the four combinations of the two variables that served in the large experiment.

The analysis of the eye-movement data indicated that the analysts examined each vehicle for longer periods of time when the moving magnifier was used than the side-window magnifier was used. This was evidently due to the analysts diverting their attention to the side-window. However, the number of fixations was the same under both conditions. These findings indicate that the moving magnifier is the more comfortable as it helps in focusing ones attention on the source of information during image interpretation. We found that the analysts were affected by the ATR and examined the designated vehicles more extensively than those not designated. In other words, the analysts devoted more attention to vehicles that the ATR system designated as suspect. This indicates that the analysts utilized the ATR system in order to reach their decisions.

A further finding was that little use was made of the information window; the analysts did not gain much benefit from it, and its usage declined with practice. If the information window was used it appears to have slowed down the analysts. As for the different types of information in the window, it was found that the analysts focused mainly on the upper part of the window that included an optical picture of the vehicle, and less with the other parts of the window, that included a SAR image and sketches of the vehicle. The analysts

raised the possibility of adding other information should be examined, such as SAR views from several angles. Their varied suggestions for adding information need to be examined to see if they are indeed helpful.

The eye-movement study also provided video strips showing exactly how the eyes scanned each image. The analysis of these strips indicated that the analysts did not all use the same scanning patterns, with some being systematic and others rather random in their approach to the images. A surprising and somewhat troubling finding in the analyses of the strips was the fact that not all the vehicles in the images were examined. About 6% of the vehicles were not examined. What is more some of vehicles that were not marked as targets in the first run were examined a second time.

In other words, it would seem that the analysts were not able to keep track of which vehicles they had inspected and which not. This problem can be alleviated by either teaching the analysts to use a systematic scanning method which would not allow missing items in the image or by giving them the possibility of marking vehicles that appear to them to be distractors with a mark of a different color than that of the marked targets by pressing, say, the right button on the mouse.

To sum up the eye-movement study:

- The moving magnifier is superior to the side-window magnifier.
- The information window, as conceived in the present study, does not yield any benefit and appears to slow down the analysts.
- Means must be developed to prevent the analysts from skipping items in the image or examining them twice.
- The analysts made suggestions both concerning the magnification and the information window and these should be examined.

Automatic Enforcement Methods: Overt vs. Covert Speed Cameras and the Optimal Conditions for their Use

This study is supported by a grant from the Research Fund on Insurance Matters of the Association of the Israel Insurance Association to Prof. Joel Norman, Dr. Pe'erly Setter, and Dr. Hadas Marciano. The first year of two has lapsed and a Hebrew Technical Report covering that period was submitted in March 2012

(see: http://www.igudbit.org.il/_Uploads/156ReportYear1peerli.pdf). An English paper is currently in preparation.

This study consists of three stages: comparing the efficacy of overt (visible) and covert (hidden) speed cameras in yielding adherence to the legal speed limits, comparing the effectiveness of different types of feedback regarding illegal speeding (e.g., immediate vs. delayed), and comparing different types of combinations of overt and covert cameras. The first stage was recently completed and it will be briefly reported here. The second stage is currently being run.

Thirty experienced drivers participated in the first part of the experiment, 15 with overt speed cameras and 15 with convert cameras. The 24 km route was simulated in a STISIM

driving simulator, with speed limits at either 90 km/h or 50 km/hr and 10 speed cameras along the route (either overt or covert). Each driver participated in three repetitions of the route. The drivers were paid for participating in the study. The pay consisted of a fixed sum, but they could also earn more money by finishing the route as fast as possible, but they were also fined for being caught speeding by the cameras. This simulated real-life conditions where drivers want to get to their destination as quickly as possible, but without being caught speeding.

The results indicated that the drivers with the overt cameras drove considerably faster than those with the covert cameras; the average speed for the overt camera condition was 92 km/h while that for the covert was 67 km/h. What is more, it was found that the average speed of the overt group increased over sessions, while that of the covert group decreased. An analysis of the driving behavior of the participants indicated that the drivers in the overt camera group developed what has been called "kangaroo driving", where the drivers slow down near the overt camera and then speed up after passing it. The overt camera drivers refined this behavior from session to session and that was the cause of the increased speed over sessions.

The researchers summarized their results as indicating that overt cameras are not effective in reducing driving speed, but also noted that due to the proliferation of sophisticated equipment (e.g., smart-phones with special apps) covert cameras are really no longer covert.

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c.4 Skill Acquisition and Training: Prof. Gopher, Prof. Erev, Prof. Yechiam, and Prof. Norman

c.4.1 Executive Control and Skill Acquisition

Training and development of skills with a focus on executive control processes and coping with high demand tasks has been central to our research program at the Minerva center since its inception. It has been led by Prof. Daniel Gopher with continuing collaboration and contribution of Prof. Ido Erev and Prof. Eldad Yechiam. Skill and expertise level are the most powerful differentiator between individuals in the performance of any given task. The conceptual framework and research approach that have been developed and employed in this work are briefly summarized below.

Skill is conceptualized as a well organized knowledge base in long term memory for the performance of a targeted task, which has been developed with experience and guided training (e.g. Anderson, 1981, 1982; Chase & Ericsson, 1981, Meyer & Kieras, 1997, Gopher, 2006, 2012a). The nature, form and format of encoded, stored and retrieved information may vary widely. It may be semantic, motor, modality specific or abstract. It may be episodic, declarative or procedural. In all cases its main purpose and value is that the experience and knowledge of the past can help one to cope with present and future reoccurring and new demands. This is the most general and functional meaning of the term "Skill". Skill is hence best tested by its retention and transfer to more efficient coping with recurring or new events. Task performance levels by themselves may not be a sufficient indication of skill, as they can be the product of imitation, copying or following instructions. Learning requires active interaction and control and is maximized when it results from intentional efforts (Schmidt & Bjork, 1992; Gopher, 2006, 2007).

Because skills are acquired and called upon to the performance of tasks, the term "task" should also be briefly discussed and clarified. A task can be characterized along many dimensions and specific features. Some of the common descriptive features may include: stimulus type, presentation mode, transformation and computation requirements, response type, performance instructions and reward structure. These are all separate elements that can be combined in numerous ways which may include all or part of them, to create variety of tasks and serve different goals. A task is hence viewed as a specific combination of these elements in the service of goal-directed behavior (Gopher 2006).

Webster’s unabridged dictionary (McKechnie, 1959) proposes three definitions for the term "task":

1 A piece of work assigned to or demanded of a person.

2 Any undertaking or a piece of work.

3 An undertaking involving labor or difficulty.

Note the emphasis on the "undertaking" or the "coping" with a demand. Tasks are conceived to be the fundamental units of goal-directed behavior. They encompass the structural and dynamic constraints on performance in the service of intentions or

instructions. Tasks are a joint product of top-down constraints and the properties of the environment. Information-processing modes, response types, memory representations, performance competency, strategies and attention policies, are all defined, bounded and developed within their respective "task shells" (Gopher 2006). The term "task shell" was introduced by Gopher to denote the integrated joint product of all structural and dynamic properties that comprise a task. Task shells are argued to have a self standing theoretical and empirical status, which is akin to the Gestalt fundamental notion of the whole being more than the sum of its composing parts (Kellman, 2000; Koffka, 1935).

Similarly, it is argued that task shells have a marked influence on the work of their elements: stimuli, responses, representations, transformations, etc. Shells are important for the understanding of interaction, facilitation and interference effects on performance, within and between tasks. Shells also delineate the boundaries of an acquired skill, the value of practice, and the cost of transfer. The formation of a task shell is the building block of the conduct of purposive behavior. It is formed and acquired by executive control processes and monitored by metacognition. It is further observed that cognitive psychology in general and the domain of skill acquisition and training in particular have overlooked the importance of incorporating the construct of a task shell its influence and derivatives, in theoretical frameworks and in studying its formation and influence on behavior (Gopher 2006).

From this perspective skill, as an organized knowledge base, can be conceptualized to comprise three basic components (dimensions), **elementary capabilities** (sensory, motor, semantic, computational etc.; e.g. Logan 1988, Schneider & Schiffrin, 1977); **control and executive control competencies** (e.g. Anderson 1981, 1982 Meyer & Kireas, 1997, Gopher 1993, 2006, 2007), Metacognitive knowledge (e.g. Bjork 1999, Koriat, A. Ma'ayan, H. Nussinson R. et al. 2006). By analogy, overall task performance can be compared to the quality of a music piece played by an orchestra. The musical competencies of the players on their instruments are the elementary units; the conductor represents the control and executive control processes; metacognitive monitoring is provided by the professional music critic.

Consistent with this general approach, our research program followed up 6 main research topics (It is also important to note is that basic research and experimental studies in each topic have been accompanied by application work). The six topics are:

1. **What is the nature and format of a Skill as an integral entity and a representation of its dimensions and levels?** The development, determinants and formats of task shells, which incorporate combine and integrate the different components and levels of task related competencies (Conceptual framework and experimental studies described in Gopher 2006, 2007, **Major applications** Health care tasks (Gopher & Donchin, 2011. 1n press; Skills task analysis; Gavish, Krupenia & Gopher, 2012, Gopher 2012).

2. **What is the contribution and distinct role of executive control skills in the performance of high demand tasks?** The emphasis change as a training protocol and a methodological approach for manipulation, exploration and training of executive control skills (Gopher 1993, Erev & Gopher 1999, Yechiam E., Erev, I., Yehene, V. , Gopher, D.l 2004, Gopher 2006, 2007) **Major applications** pilot training, Basket ball and Ice Hockey; http://www.intelligym.com/, multimodal virtual reality training platforms, Bergamasco, Bardy, & Gopher 2012).
3. **What is the contribution to task performance of training protocols targeting exclusively one dimension/aspect of skill?** (e.g. executive control, elementary units, metacognition) **Major applications** Sports, Skills. (http://www.intelligym.com/)
4. **What is the confluence on skill acquisition of rich bottom up enaction and top down executive control training protocols? (**Development and evaluation of six training platforms in the Skills project, Bergamasco, Bardy, & Gopher 2012)
5. **Development of training protocols and training platforms** (modes of emphasis change and introduced variability, accelerators and transfer studies; Gopher 2012a,b, Yechiam, E., Erev, I., Gopher, D. (2001). **applications**: Sports, Skills, aging).
6. **Executive control and aging** (Blumen, H.M, Gopher, D., Steinerman, J.R, Stern, Y. (2010), Stern Y. Blumen H. M. Rich, L.W., Richards, A. Herzberg. Gopher, D. (2011)& Gopher (2011), task switching (Mackay, Stern & Gopher in press).

Last 7 years main application areas: Health care and Medical systems, Skill training in multimodal virtual reality environments, cognitive trainers of basketball and Ice Hockey.
Past application domains: Aviation and flight training, Safety at work.

The following section presents brief summaries of the main research and application work associated with the above topics:

Emphasis Change

Emphasis change is a training protocol under which subjects are required, during training, to change systematically their emphasis, effort, attention allocation policy (these terms are used interchangeably) on major subcomponents of the performed tasks. Emphasis levels are varied between few-minute practice trials or among pre-specified short durations of task performance (Gopher, 2007). There are four major variants of the emphasis change protocol:

1. Variable priorities—Manipulation of attention allocation policies in concurrent task performance (Gopher, 1993; Gopher & North, 1977; Kramer, Larish, & Strayer, 1995)

2. Emphasis change—Change of emphasis on components of a complex task through instructions and augmented feedback indicators (Fabiani, Buckley, Gratton, Coles, Donchin, & Logie, 1989; Gopher, Weil, Bareket, 1994; Gopher, Weil, Siegel, 1989; Shebilske, Goettl, Corrington, Day, 1999; Shebilske, Jordan, Goettl, Day, 1999; Shebilske, Reigan, Arthur, & Jordan, 1992).

3. Introduction of a secondary task—Change of primary task performance strategies by adding a secondary task (Seagull & Gopher, 1997; Yechiam, Erev, Yehene, & Gopher, 2004)
4. Task switching—Training under changed computations or task-switching requirements (Carlson & Shin, 1996 Kramer, A. Larish J., Weber T,. Bardell L; Gopher et al.1999, 2000; Kramer, Hahn, & Gopher, 1999).

Main Findings

The following presents a global 4-point summary of the most important outcomes of this work:

1. Emphasis change proved to be a robust training protocol. In all studies, for all tasks variants and subject populations, variable priority and emphasis change protocols led to substantially higher levels of task performance at the end of training, as compared with equal priority or no priority training protocols.
2. Emphasis change training have led to better transfer and adaptation to changed conditions, new tasks and operational environments.
3. In all of the studies, emphasis change and variable training were shown to have slower progress at early stages of training, as compared with no change or uniform training protocols, but subjects excel at advanced stages of training and in subsequent transfer tasks (e.g. Carlson & Shin, 1996; Yechiam et al. 2001).
4. When compared with part-task training protocols, emphasis change was shown to be poorer or equal at the end of training on the same task, but superior in transfer to different conditions and new tasks (e.g. Fabiani et al., 1989; Gopher et al., 1994).

Applications

Emphasis change training protocols have been, thus far, applied and found useful in the performance of five complex and highly demanding daily tasks:

1. **Piloting high performance airplanes**. A 10-hour training program on the modified Space Fortress game, under the emphasis change protocol, was found to increase by 30% the flight performance scores of cadets at the Israel airforce flight training school (Gopher et al. 1994).
2. **Flying with a helmet mounted display (HMD)**. HMD flight performance following training equaled flight levels under normal viewing conditions (Seagull & Gopher, 1997).
3. **Acquisitions of touch typing skills**. Employing the secondary task variant of the emphasis change protocol, Yechiam et al. 2001 were able to obtain much faster acquisition, higher typing rates, and better retention of touch-typing skills.
4. **Teaching old adults to cope with high attention management demands**. The variable priority protocol was found to be especially powerful in improving the coping ability of old adults with high demand tasks (Kramer et al. 1995; Kramer 1999).

5. **Training basketball players at the individual and team levels**. The principles and the knowledge acquired in the study of the emphasis change protocol were used by Ace, an Israeli based startup, to develop a cognitive trainer for basketball players. The trainer was beta tested during the 2004 -2009 seasons in several teams of the US college league. It was found to substantially improve the game playing of individuals and the overall achievements of their team. Teams trained with this trainers were the NCAA national champions 3 successive years (http://www.intelligym.com/)
6. **Cognitive training Ice Hockey** at the individual and team level. The principles and the knowledge acquired in the study of the emphasis change protocol were used by Ace to develop a cognitive trainer for Ice Hockey. The two US. Young national teams were trained on this trainers, improved considerably their game and win ratio. They won 13 gold medals in 18 world championship. Marked progress has also been demonstrated in the play of other teams around the US. (http://www.intelligym.com/0
7. **Training of Juggling skills in a virtual reality juggling platform**. Emphasis change protocols have significantly improved the spatial temporal control capabilities and juggling skills of trainees in the virtual juggling system, in which virtual balls were juggled by controlling virtual hands in a simulated virtual world. These skills were transferred to juggling with real balls, in which subjects trained in the virtual system were equal or better than subject trained throughout with real balls (Lagarde, Gopher et al. 2012).

Note that the 7 applications demonstrate performance advantage both within and between tasks. In the HMD, touch-typing, juggling and old adults' applications, emphasis change training helped trainees in the acquisition of competence on the task, and improved their performance in subsequent performance with the same task. In the flight, basketball and Ice Hockey and juggling, earlier training with this protocol on and specially developed computer games or virtual reality trainer, improved the performance of trainees on a different task, high demand operational task.

Task Shell and Controlled Processes

The "task shell" construct has already been presented and discussed in previous sections. To recapitulate, the term "task shell" was introduced to denote the integrated joint product of all structural and dynamic properties that comprise a task and is argued to have a self standing theoretical and empirical status. A task is conceptualized as joint product of top-down constraints and the properties of the environment. Information-processing modes, response types, memory representations, performance competency, strategies and attention policies, are all defined, bounded and developed within their respective "task shells" (Gopher 2006).

Two groups of experimental studies conducted in our laboratory demonstrated the strong and enduring influence of task shells on task performance in the laboratory and in real life. One group has shown the dominant influence of indirect emerging consequences

of external task features on creation of task shells. In the acquisition of typing skills on a chord data entry keyboard different rules of mapping letters to motor entry chords dominated and overruled within and between hands input-output correspondence (Gopher 2006, Raij, D. Gopher, D. & Kimchi, R., 1987. When learning to fly with a single helmet mounted display, manipulation of viewing conditions influenced basic eye-head coordination skills in visual scanning not only under helmet, but also in normal viewing conditions (Seagull & Gopher 1997). A second group of studies have shown the influence of task switching efforts and emphasis change training on the creation of a task shells which are led by top down, direct intentional efforts and voluntary Gopher D., Armony L., Greenshpan Y. 2000). More recently the influence of both emerging properties and top down strategies on the development of task shells have been explicated in the development of multimodal virtual reality training platforms for skills in sport, medicine and industrial work (Bergamasco, Bardy & Gopher, 2012). Performers may not be cognizant of the emergence of a task shell, its properties, constraints and far-reaching influences on short and long-term performances. Nonetheless, it represents performers' goal directed adaptive strategy, given task constraints and reward structure. It should be noted that task shells are integrative global constructs that do not occur immediately. They gradually develop with experience and training and are most clearly revealed when performers achieve competence in task performance. As such, the study of task shells is closely linked to the study of training and skill acquisition. Task shells evolve around leading dimensions: Dominant task features (e.g. mapping principles), environmental constraints (e.g. viewing conditions), control strategies (e.g. Flexibility in shifting efforts). Once established the global properties of the shell bind together its composing elements and influence their work in ways that cannot be predicted from a separate study of the elements.

Skills - Multimodal Interfaces for Capturing and Transfer of Skills

The skills project has been a five years (2006 to 2011) research project funded by the European Commission under its Sixth Framework Program for Research and Technological Development. The SKILLS project aimed at evaluating and exploiting robotics and virtual environments technologies for the training of specific skills, and it addressed skill acquisition according to a novel approach, setting aside the mainstream assumptions of common computer assisted training simulators. The SKILLS approach was to generate new training scenarios in which the user can afford new experiences in the performance of the devised task. The SKILLS Consortium includes universities and research centers with expertise in cognitive science, psychology, interaction design, virtual environments, augmented realities, and robotics, together with industries representative of the targeted application domains for novel multimodal training technologies. The research in SKILLS addressed the design of new multimodal systems able to handle human skills. Fundamental aspects of skill analysis, including cognitive science and interaction design, were taken into consideration to identify guidelines for

driving the analysis of the motion of skilled persons and to obtain a digital representation of human skill, as well as methodologies and techniques for capturing and rendering skills for training through digital technologies.

To be able to acquire, store, and transfer specific skills, such as those of a craftsman, a surgeon, or an expert juggler into the digital domain can generate new ways of interacting with the computer and new ways of communicating knowledge through it. The process of acquiring and storing skill allows for the generation of digital archives of performed acts which may be lost when the skilled person loses his or her capabilities due to illness or declining years. The concept of learning accelerators has been introduced to underline the importance of the process that customizes and exploits a subset of the multimodal data flows characterizing the interaction of the user with virtual environments to design a specific experience capable of improving and accelerating the acquisition of a specific skill.

Developing Training in Multimodal Environment

Training platforms are engineering systems developed to enable the acquisition of targeted skills and direct their development under guided instruction and training. In the Skills project there were six tasks for which multimodal virtual training platforms have been developed. To recapitulate these were Competitive Rowing (ROW), Juggling (JUG), Maxillo Facial Surgery (MFS), Upper Limb Rehabilitation (ULR), Industrial Maintenance and Assembly and Programming by Demonstration (PBD).

The construction and testing of the platforms have been guided by three key constructs which served to direct the selection of task components, their engineering instantiation and the studies to evaluate their training value. These are: **Relevance, facilitation** and **transferability**. **Relevance** refers to system ability to capture and provide relevant experience for the development of competency and skill on a targeted task. **Facilitation** refers to the inclusion of facilitation and guidance to assist and accelerate the acquisition of the designated skills. **Transferability** emphasizes the transfer of training and skill levels from VR training platform to task performance in the real world. Note that these concepts are markedly different from the concepts of "Presence" and "Immersion" which are measured and presently used as criteria for successful development of virtual worlds. As such, the development of multimodal virtual environments for training establish itself as a separate and clearly distinguished research effort in the study of virtual reality environments, their nature, foundations and prospective applications.

A unified framework of sensory-motor and cognitive sub-skills which has been developed in the project (Table 1), is the second conceptual framework which has led and should be kept in mind while reading the different segments of this report, This framework guided the development of training platforms. Although training platforms were developed for tasks in sport, medicine, rehabilitation and industrial work, in each case the training platform is not a complete representation of the task but a part task

representation anchored in the unified framework and its composites. That is, focus on representative sensory-motor and cognitive skill components embedded it the performance of task for which a training platform is developed

Table 1 - The sensory-motor and cognitive sub skills included in the unified conceptual framework of the Skills project.

Sensory-Motor sub-skills	**Cognitive sub-skills**
Bimanual coordination*	Control flexibility and attention
Hand-eye coordination *	management
Interpersonal coordination	Coping strategies and alternative response
Perception-by-touch	schemas
Prospective control	Memory organization, structure and
Proximal-distal coupling	development of knowledge schemas
Respiratory/movement coupling	Perceptual Observational
Fine force control	Procedural skills

Consistent with the 3 general constructs and the skills based unified framework, "Relevance" has been judged by the justification of the selected focus of training for each task (Skills, sub-skills, training protocols, etc), as well as the benefits of training experience to performance in the test conditions. "Facilitation" has been examined by the added value of accelerators and training protocols to performance and coping with task demands, as compared with unaided control conditions. Levels and benefits of "Transfer of training" are reflected in reference to two important criteria: 1) Viability of virtual reality training time as compared to time on the real life task; 2) Added and special benefits of virtual reality training over real life task experience. It should be recognized that virtual training environments are created as an alternative to actual task performance and on the job training. Hence, the first test of the created alternative environment is its comparative value to actual task experience. The question is whether the virtual environment provides a real alternative to actual task experience and training, or whether it may prolong, impair or even interfere with performance of the real task. The successful development of a comparable alternative training environment is an important achievement by itself. It is of special significance when training should be done remotely (e.g. IMA), the real system is very expensive or scarce (e.g. PBD, IMA), or when on the job training involves hazards and risks (e.g. Maxillo Facial Surgery training on live patients). In all of these cases it is sufficient to demonstrate that the virtual reality environment creates a viable replacement for training in the actual environment.

A second transfer perspective that should not be neglected is the ability and freedom of the virtual reality technology to create, control and design situations and training opportunities which are not possible in real life or not concur with normal physics. The question is can this freedom be used to create virtual experience and accelerators that will

provide opportunities for training benefits in the virtual environment over and beyond training in the real environment. This question has important theoretical and applied implications. It should be manifested by advantage of virtual reality training over real task training in task performance and coping with task demands. All training platforms presented in this report, examined and supported aspects of this notion of transfer. Taken together, the six tasks and nine virtual reality training platforms which have been developed in the Skills project are case studies in which the discussed principles have been systematically and successfully applied. All of them obtained supportive results of the evaluation and transfer of training studies, employing multimodal virtual reality platforms. Of special significance are the development and study of haptic interfaces, as well as the morals on the combined employment of haptic, visual and auditory information for the development of training schedules and skill acquisition.

Training Executive Control in Young and Old Adults

Evaluating and combating the influences of age and medical conditions on functional cognition at old age has become a central topic of interest in contemporary aging research. Of special focus has been the study of decline in executive control capabilities and the development of intervention modes that may preserve these capabilities and slow their decline. Drawing on the approach and methods developed in our laboratory to the study and training of executive control we have been established a collaborative effort with the Taub center for the study of aging and Alzheimer at Columbia University Medical school to investigate the hypothesis that complex and dynamic tasks, instantiated in a computer game like environment, may be a good training and testing paradigm to explicate aspects and dimensions of attention management and executive control capabilities. When compared in young and old adults they may enable examination of the differential nature and pace of the decline across the life span, as well as the linkage between learning and training to notions of cognitive reserve and the profile of individual differences in cognitive capabilities.

We have been studying and comparing training, skill acquisition and transfer of young and old adults on two very different games like environments, Space Fortress and the Breakfast Task (Craik, Bialystok, E. (2006)

, both programmed to present subjects with complex, dynamic and challenging demands calling for attention management and adoption of executive control strategies. However, Space Fortress has a strong emphasis on motor control (Blumen , Gopher Stern, 2010, Stern, Blumen & Gopher 2011), while the Breakfast Task is more cognitive and does not include such a requirement. In addition, we have studied and found interesting differences between young and old adults in their ability to switch between tasks and adopt new task set and performance strategies. Interactions among aspects of executive control by age revealed that conditions of greatest demand for older adults were high response execution complexity (selection demands) and low switch frequency during task switching (unexpected required reconfiguration) (Mackay, Stern & Gopher, in press) This

continued line of investigation may enhance our understanding of the basic dimensions and the trainability of executive control skills across the life span, as well as the prospects of alternative modes of intervention at old age.

c.4.2 Comparing Performance with Two Methods of Text Input with a Handheld Keypad: Four-Way vs. Multi-Press

This study was carried out by Leonid Papkov and Prof. Joel Norman for JetWays Technlogies in 2003.

This study compared two methods of text entry speed using handheld keypads; the conventional Multi-press (SMS) method and a novel Four-way method developed by JetWay Technologies. This new method utilizes specialized keys that can be pressed in one of four directions, allowing a one-press character entry.

Ten students participated in the experiment for pay, including bonuses for fast and accurate performance. After an initial test and training session each participant took part in nine experimental sessions; five participants used the Four-way method and five used the Multi-press method. Overall, each participant entered a total of 450 4-7-word sentences (mean of 30.5 characters per sentence).

Both speed and accuracy of performance were analyzed, but as accuracy was very high throughout, speed served as the primary measure of performance. The four-way method yielded higher speeds throughout, even at the beginning of the experiment. This superiority increased with practice, indicating that for expert users the advantage of the Four-way method would be even greater than that found in the last sessions. The results showed linear improvement with practice for both methods indicating that the participants were far from reaching asymptotic performance.

It was suggested that the Four-way method yields superior results because it does not require multiple presses for a single character, and no time-out pauses between entering successive characters using the same key. The speeds attained in the present study using the Four-way method were also faster than those reported in a study of another single-press method, Fastap, but such comparisons are only suggestive.

All in all, the results of the present study clearly point to the superiority of the Four-way method over the Multi-press method. What is more, they indicate that this difference is likely to become even larger with further practice. Comparing the results of this study with other similar studies also hints at the possible superiority of the Four-way method over other newly developed devices for handheld text entry.

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d. Publication and Conferences

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Koriat, A., & Nussinson, R. (2009). Attributing study effort to data-driven and goal-driven effects: Implications for metacognitive judgments. Journal of Experimental Psychology: Learning, Momory and Cognition, 35, 1338-1343.

Hoffmann-Biencourt, A., Lockl, K., Schneider, W., Ackerman, R., & Koriat, A. (2010). Self-paced study time as a cue for recall predictions across school age. British Journal of Developmental Psychology, 28, 767-784.

Koriat, A., & Ackerman, R. (2010). Choice latency as a cue for children's subjective confidence in the correctness of their answers. *Developmental Science, 13*, 441-453.

Koriat, A., & Ackerman, R. (2010). Metacognition and mindreading: Judgements of learning for self and other during self-paced study. Consciousness and Cognition, *19*, 251-264.

Hoffmann-Biencourt, A., Lockl, K., Schneider, W., Ackerman, R., & Koriat, A. (2010). Self-paced study time as a cue for recall predictions across school age. *British Journal of Developmental Psychology*, *28*, 767–784.

Koriat, A., Pansky, A., & Goldsmith, M. (2010). An output-bound perspective on false memories: the case of the Deese-Roediger-McDermott (DRM) paradigm. To appear in: A. Benjamin (Ed.), Successful remembering and successful forgetting: A Festschrift in Honor of Robert A. Bjork (pp. 297-328). London, UK: Psychology Press.

Koriat, A. (2011). Subjective confidence in perceptual judgments: A test of the self-consistency model. *Journal of Experimental Psychology: General, 140*, 117–139.

Koriat, A., & Adiv, S. (2011). The construction of attitudinal judgments: Evidence from attitude certainty and response latency. *Social Cognition, 29*, 577-611.

Ackerman, R., & Koriat, A. (2011). Response latency as a predictor of the accuracy of children's reports. *Journal of Experimental Psychology: Applied, 17*, 406-417.

Conferences

- Internationales Wissenschaftsforum der Universität Heidelberg (IWH). January 2003, Heidelberg, Germany.
  Monitoring and control processes during the study of new materials.

- 44th Annual Meeting of the Psychonomic Society. November 2003, Vancouver, Canada.
  Oobjective and subjective forgetting functions: the effects of retention interval on predicted and actual memory performance (With Prof. Robert A. Bjork, and Dr. Limor Sheffer)

- International DIP Workshop on Social Metacognition. July 2004, Heidelberg, Germany. *The Metacognitive regulation of accuracy and informativeness in memory reporting.* (With Prof. Morris Goldsmith, and Dr. Ainat Pansky).

- The Cognitive Section of the British Psychological Society. September 2004, Leeds, UK. *The intricate relationships between metacognitive monitoring and metacognitive control. Keynote speaker.*

- 6th Tsukuba International Conference on Memory-Memory and Emotion. March 2005, Tsukuba, Japan.
  Are we frightened because we run away? Some evidence from metacognitive feeling.

- Third Advanced Seminar: Metacognition, Control Processes and the Brain. March 2005, Sansepolcro, Italy.
  Monitoring and control processes during reading.

- Interdisciplinary Colloquium on Memory. April 2005, The Institute for Advanced Studies, the Hebrew University, Jerusalem, Israel.
  Metaphors of memory: Development in the research of the psychology of the human memory.

- Oswald-Kuelpe Award. November 2005, Wuerzburg, Germany.
  Reflections on the relation between consciousness and behavior.

- 46th Annual Meeting of the Psychonomic Society. November 2005, Toronto, Canada.
  Metacognitive processes underlying the inflation of conditional predictions.

- International Association of Metacognition. November 2005, Toronto, Canada.
  Memory and metamemory: *In honor of Thomas O. Nelson*.

- The 45th Congress of the German Society of Psychology (DGPS). Invited keynote speaker. September 2006, Nuremberg, Germany.
  Are we frightened because we run away? Evidence from metacognitive feelings and their relation to behavior.

- EUROCORES Programme: Consciousness in a Natural and Cultural Context (CNCC). November 2006. Copenhagen, Denmark.
  Metacognition: Implications for consciousness and control.

- EUROCORES Programme: Consciousness in a Natural and Cultural Context (CNCC). Fallibilities, Illusion and Metacognition. July 2007, Paris, France.
  The role of heuristics and attribution in affecting metaconigitive judgments and their accuracy. (With Prof. F. Strack)

- International Association of Metacognition, Psychonomic Society Meeting, November 15-18 September 2007. Long Beach, California.
  Subjective confidence: Some puzzling observations and an attempted resolution.

- May 2008, University of Tel Aviv, Israel.
  The intricate relationships between metacognitive monitoring and control processes during learning.

- 16th Annual Meeting of the European Society for Philosophy and Psychology (ESPP). June 2008, Utrecht, The Netherlands. Invited Symposium.
  The cause-and-effect relations between monitoring and control in metacognition.

- The 20th Anniversary International Conference on Systems Research, Informatics and Cybernetics. July 2008, Baden-Baden, Germany. Invited keynote *speaker* (Declined).

- The Asia Pacific meeting of the Economic Science Association (APESA09). March 2009, University of Haifa, Israel.
  The role of heuristics and attributions in affecting metacognitive judgments and their accuracy.

- Measuring the Impossible. May 2009, Wageningen, The Netherland.
  The assessment of eyewitness memory: a multi-componential, correspondence-oriented approach.

- Measuring the Impossible. January 2010, Brussels, Belgium.
  How to lie without trying.

- Encounter in Honour of Volfgang Prinz. September 2010, University of Haifa, Israel.
  Knowing by doing: The link between action and perception in metacognition.

- International workshop on epistemic norms from a naturalistic viewpoint: Interdisciplinary perspectives. October 2010, Paris, France.
  Subjective convictions and social consensus: Evidence from research on social attitudes and social beliefs.

- Metacognition: Where Next? November 2010, Hull, UK. Keynote speaker.
  What is so special about metacognitive feelings? The relationship to action.

- The Annual Meeting of the Psychonomic Society, November 2010, Illinois, U.S.A.
  The consensuality principle for confidence judgments

- Expert Meeting on Deception Detection, May 2011, Ghent, Belgium. *Expert advice***.**

- The 27th Annual Meeting of the International Society for Psychophysics. October, 2011, Israel. Keynote Speaker.
  How we know that we know: The process underlying subjective confidence.

- Invitation: Keynote Address, the Meeting of the Southern Society for Philosophy and Psychology, Savannah, March 2012 (declined).

- Invitation: Keynote Address, the 54th Meeting of Experimental Psychologists (TeaP). April 2012, Mannheim, Germany, (declined).

- Science and Values: Epistemic Goals, Economic Aspirations, Social Values, April 2012, University of Haifa, Israel. (With Shiri Adiv).
  Beliefs, attitudes and values: The question of subjective convictions.

Talks

- The 46th Annual Meeting of the Psychonomic Society. November 2005. Toronto, Canada.
  *Metacognitive processes underlying the inflation of conditional predictions (*With Prof. K. Fiedler, and Prof. R.A. Bjork).

- Boğaziçi University. April 2006, Turkey.
  Two modes of knowing about knowing and their intricate implications for judgments and behavior.

- Assessment of Eyewitness Memory, Initial project meeting & seminar. January-February 2007. Rotterdam, Holland.
  The assessment of eyewitness memory: A multi-componential, correspondence-oriented approach. Assessing potential memory performance (With Prof. M. Goldsmith, and Dr. A. Pansky).

- The 15th ESCoP Conference. August-September 2007. Marseilles, France.
  An output-bound perspective on false memories: the case of the Deese-Roediger McDermott (DRM) paradigm. (With Dr. A. Pansky, and Prof. M. Goldsmith).

d.1.2 Prof. Morris Goldsmith

Publications

Goldsmith, M., Koriat, A., & Weinberger-Eliezer, A. (2002). Strategic regulation of grain size in memory reporting. Journal of Experimental Psychology: General, 131(1), 73-95.

Koriat, A., Goldsmith, M., & Pansky A. (2003). Memory distortions and forgetting. In L. Nadel (Ed.), Encyclopedia of cognitive science (pp. 1076-1081). Nature Publishing Group (Macmillan).

Goldsmith, M., & Yeari, M. (2003). Modulation of object-based attention by spatial focus under endogenous and exogenous orienting. Journal of Experimental Psychology: Human Perception and Performance, 29(5), 897-918.

Goldsmith, M., Koriat, A., & Pansky, A. (2005). Strategic regulation of grain size in memory reporting over time. Journal of Memory and Language, 52, 505-525.

Pansky, A., Koriat, A., & Goldsmith, M. (2005). Eyewitness recall and testimony. In N. Brewer & K. Williams (Eds.), Psychology and law: An empirical perspective (pp. 93-150). New York: Guilford.

Koren, D., Poyurovsky, M., Seidman, L. J., Goldsmith, M., Wenger, S., & Klein, E. (2005). The neuropsychological basis of competence to consent in first-episode schizophrenia: A pilot metacognitive study. Biological Psychiatry, 57(6), 609-616.

Koren, D., Seidman, L. J., Goldsmith, M., & Harvey, P. D. (2006). Real world cognitive- and metacognitive-dysfunction in schizophrenia: A new approach for measuring (and remediating) more "right stuff." Schizophrenia Bulletin ,32 ,310-326.

Goldsmith, M. & Koriat, A. (2008). The strategic regulation of memory accuracy and informativeness. In A. Benjamin and B. Ross (Eds.), Psychology of learning and motivation, Vol. 48: Memory use as skilled cognition (1-60). San Diego, CA: Elsevier.

Koriat, A. Goldsmith, M., & Halamish, V. (2008). Controlled processes in voluntary remembering. In H. L. Roediger, III (Ed.), Cognitive psychology of memory. Vol. 2 of Learning and memory: A comprehensive reference, 4 vols. (J. Byrne, Editor). Oxford, UK: Elsevier.

Ackerman, R., & Goldsmith, M. (2008). Control over grain size in memory reporting - with and without satisficing knowledge. Journal of Experimental Psychology: Learning, Memory, and Cognition , 34(5), 1224-1245.

Pansky, A., Goldsmith, M., Koriat, A., & Pearlman-Avnion, S. (2009). Memory accuracy in old age: Cognitive, metacognitive, and neurocognitive determinants. European Journal of Cognitive Psychology (special issue on Aging, Cognition, and Neuroscience), 21(2/3), 303-329.

Koriat, A. & Goldsmith, M. (2010). Monitoring and control processes in the strategic regulation of memory accuracy (originally published in Psychological Review, 103, 490-517. Reprinted in Conway, M. & Moulin, M. (Eds.), Human Memory. SAGE Publication.

Yeari, M. & Goldsmith, M. (2010). Is object-based attention mandatory? Strategic control over mode of attention. Journal of Experimental Psychology: Human Perception and Performance, 36, 565-579.

Mulder, R.V. De, Noortwijk, C. van, Goldsmith M., Pansky, A., Koriat, A., Kadouri-Labin S. (2010), CORMAS: A Computerized Tool for the Analysis of Eyewitness Memory Correspondence. European Journal of Law and Technology, 1(3), 1-18.

Yeari, M., & Goldsmith, M. (2011). Organizational and spatial dynamics of attentional focusing in hierarchically structured objects. Journal of Experimental Psychology: Human Perception and Performance, 37, 758-780.

Ackerman, R., & Goldsmith, M. (2011). Metacognitive regulation of text learning: On screen versus on paper. Journal of Experimental Psychology: Applied, 17, 18-32.

Goldsmith, M. (2011). Quantity-accuracy profiles or type-2 signal detection measures? Similar methods toward a common goal. In P.A. Higham and J.P. Leboe (Eds.) Constructions of remembering and metacognition: Essays in honor of Bruce Whittlesea (pp. 128-136). Basingstoke: Palgrave-MacMillan.

Koriat, A., Pansky, A., & Goldsmith, M. (2011). An output-bound perspective on false memories: the case of the Deese-Roediger-McDermott (DRM) paradigm. In A. Benjamin (Ed.), Successful remembering and successful forgetting (pp. 301 -332). Psychology Press.

Goldsmith, M., Pansky, A., Koriat, A., Mulder, R.V. De, Noortwijk, C. van, Memon, A., & Markowitsch, H. (2011). The assessment of eyewitness memory: A multi-componential correspondence-oriented approach. In P. Kleve & K. van Noortwijk (Eds.), Something bigger than yourself: Essays in honor of Richard De Mulder (pp. 57-75). Rotterdam: Erasmus University.

Halamish, V., Goldsmith, M., & Jacoby, L. L. (2012). Source constrained recall: Strategic control of production quality. Journal of Experimental Psychology: Human Learning and Memory, 38, 1-15

Goldsmith, M., & Yeari, M. (in press). Central cue discriminability modulates object-based attention by changing spatial attention. Experimental Psychology.

Conferences

- International Symposium on Man versus Machine: The Experiment. October 2002, Haifa, Israel.
  Why my 3-year-old son is (far) more intelligent than Deep Junior [world computer chess champion]

- International DIP Workshop on Social Metacognition. July 2004, Heidelberg, Germany.
  The Metacognitive regulation of accuracy and informativeness in memory reporting (With Prof. Asher Koriat and Dr. Ainat Pansky).

- The Israel Society for Cognitive Psychology. October 2004, Bar-Ilan University, Israel. **Modulation of object-based attention by spatial focusing: The mediating role of perceptual organization* (with M. Yeari, C. Fyodorov).

**Poster: Strategic control over mode of attentional selection: Space-based vs. object-based* (with M. Yeari)

- 46th Annual Meeting of the Psychonomic Society. November 2005, Toronto, Canada.
  Paper: The strategic regulation of memory reporting: Monitoring and control of informativenss (With Prof. Asher Koriat, Dr. Rakefet Ackerman, and Dr. Ainat Pansky).

- 47th Annual Meeting of the Psychonomic Society. November 2006, Houston, U.S.A.
  Poster titled: Strategic control over object-based attention. (Dr. Menahem Yeari and Prof. Morris Goldsmith).

Paper: Modulation of object-based attention by spatial focusing: The role of perceptual organization. (Prof. Morris Goldsmith, Dr. Menahem Yeari, Chana Fyodorov, and Ben Friedman).

- 14th Annual Conference on Object Perception, Attention, and Memory (OPAM). November 2006, Houston, U.S.A.
  Talk titled: Is object-based attention mandatory? (Dr. Menahem Yeari and Prof. Morris Goldsmith).

- Affect, Motivation, and Decision-Making International Conference. December, 2006, Ein Boqeq, The Dead Sea, Israel.
  Poster: Control over grain size in question answering with unsatisficing knowledge. (With Dr. Rakefet Ackerman; winner of Best Poster Award and Best Student Paper Award).

- Meeting of the Society for Applied Research in Memory and Cognition (SARMAC). July, 2007, Lewiston, Maine, U.S.A.
  Paper: Resolving the accuracy-informativenss conflict in question answering: A new grain-control model (With Dr. Rakefet Ackerman).

- 15th Meeting of the European Society for Cognitive Psychology (ESCOP). August 2007, Marseille, France.
  Poster titled: Object-based and space-based hierarchical focusing of visual attention. (Dr. Menahem Yeari and Prof. Morris Goldsmith).

- 3rd Conference of Chais Research Center for the Integration of Technology in Education**:** Learning in the Technological Era. February 2008, Raanana, Israel.
  Paper: Learning Directly from Screen? Oh-no, I Must Print It! Metacognitive Analysis of Digitally Presented Text Learning (with Rakefet Ackerman)

- 16th Annual Conference on Object Perception, Attention, and Memory (OPAM). November 2008, Chicago, U.S.A.
  Poster: Spatial and organizational aspects of hierarchical attentional focusing (Prof. Morris Goldsmith and Dr. Menahem Yeari).

  Paper: Learning directly from screen? Oh-no, I must print it! Metacognitive analysis of digitally presented text learning (With Dr. Rakefet Ackerman)

- 25th Anniversary British Psychological Society Cognitive Section Annual Conference. September 2008, Southampton, U.K.
  Invited keynote address (Broadbent lecture): To 'tell the whole truth and nothing but the truth': The strategic regulation of memory accuracy and informativenss.

- 49th Annual Meeting of the Psychonomic Society. November 2008, Chicago, U.S.A.
  Poster: Source constrained recall: Strategic control of retrieval quality (With Dr. Vered Halamish and Prof. Larry L. Jacoby).

- 50th Annual Meeting of the Psychonomic Society. November 2009, Boston, U.S.A.
  Paper: Metacognitively Guided Retrieval and Report (META-RAR): Quality control processes in recall. (With Prof. Larry L. Jacoby, Dr. Vered Halamish, and Christopher Wallheim).

- 5th Bi-annual Meeting of the International Association for Metacognition. November 2009, Boston, U.S.A.
  Paper: Metacognitive analysis of learning regulation efficacy: Text learning on screen versus on paper. (with Dr. Rakefet Ackerman)

- 51st Annual Meeting of the Psychonomic Society. November 2010, St. Louis, U.S.A.
  Paper: Direct retrieval or generate-recognize mode: Strategic choice of retrieval strategy (with Dr. Vered Halamish & Prof. Larry L. Jacoby)

Paper: Organizational and spatial dynamics of attentional navigation within and between hierarchically structured object. (with Dr. Menahem Yeari)

- 5th International Conference on Memory (ICOM5). July 2011, York, England.
  Invited discussant for symposium on: *Achieving memory accuracy through memory control.*

d.1.3 Prof. Ruth Kimchi

Publications

Meinecke, C., & Kimchi, R., & Grandegger, C. (2002). Detection asymmetries: Effects of spatial density, spatial regularity, and retinal eccentricity. *Perception & Psychophysics, 64,* 829-843.

Kimchi, R., & Hadad, B. (2002). Influence of past experience on perceptual grouping. *Psychological Science, 13,* 41-47.

Behrmann, M., & Kimchi, R. (2003). What does visual agnosia tell us about perceptual organization and its relationship to object perception? *Journal of Experimental Psychology: Human Perception and Performance, 29,* 19-42.

Kimchi, R. (2003). Relative dominance of holistic and component properties in perceptual organization of visual objects. In M. Peterson, & G. Rhodes (Eds.), *Perception of faces, objects, and scenes: Analytic and holistic processes.* Oxford University Press.

Kimchi, R. (2003). Visual perceptual organization: A microgenetic analysis. In R. Kimchi, M. Behrmann, & C. R. Olson (Eds.), *Perceptual organization in vision: Behavioral and neurological perspectives* (pp. 117-153). Hillsdale, NJ: Erlbaum.

Behrmann, M., & Kimchi, R. (2003). Visual perceptual organization: Lessons from lesions. In R. Kimchi, M. Behrmann, & C. R. Olson (Eds.), *Perceptual organization in vision: Behavioral and neurobiological perspectives* (pp. 337-375). Hillsdale, NJ: Erlbaum.

Kimchi, R., Behrmann, M., & Olson, C. (Eds.) (2003). *Perceptual organization in vision: Behavioral and neural perspectives*. Mahwah, NJ: Erlbaum.

Navon, D., & Kimchi, R. (2004). The Beck effect is back, now in color: A demonstration. *Psychonomic Bulletin & Review, 11,* 98-103.

Kimchi, R., & Razpurker-Apfeld, I. (2004). Perceptual grouping and attention: Not all groupings are equal. *Psychonomic Bulletin & Review, 11,* 687-696.

Kimchi, R., & Hadad, B., Behrmann, M., & Palmer, S. (2005). Microgenesis and ontogenesis of perceptual organization: Evidence from global and local processing of hierarchical patterns. *Psychological Science, 16,* 282-290.

Behrmann, M., Avidan, G., Marotta, J. J., & Kimchi, R. (2005). Detailed exploration of face-related processing in congenital prosopagnosia: 1. Behavioral findings. *Journal of Cognitive Neuroscience, 17:7,* 1130-1149.

Behrmann M., Avidan, G., Lee, G., Kimchi, R., Luna, B., Humphreys, K., and Minshew, N. (2006). Configural processing in autism and its relationship to face processing. *Neuropsychologia, 44,* 1, 110-129.

Hadad, B. & Kimchi, R. (2006). Developmental trends in utilizing closure for grouping of shape: Effects of spatial proximity and collinearity. *Perception & Psychophysics, 68(8),* 1264-1273.

Razpurker-Apfeld, I., & Kimchi, R. (2007). Time course of perceptual grouping: The role of segregation and shape formation. *Perception & Psychophysics*, *69*, 732-743.

Kimchi, R., Yeshurun Y., & Cohen-Savransky, A. (2007). Automatic, stimulus-driven attentional capture by objecthood. *Psychonomic Bulletin & Review, 14(1),* 166-172.

Scherf, K. S., Luna, B., Kimchi, R., Minshew, N., & Behrmann, M. (2008). Missing the big picture: Impaired development of global shape processing in autism. *Autism Research, 1*, 114-129.

Hadad, B., & Kimchi, R. (2008). Time course of grouping of shape by perceptual closure: Effects of spatial proximity and collinearity. *Perception & Psychophysics, 70,* 818-827.

Kimchi, R., & Peterson, M. A. (2008). Figure-ground segmentation can occur without attention. *Psychological Science, 19(7),* 660-668.

Scherf, K. S., Behrmann, M., Kimchi, R., & Luna, B. (2009). Emergence of global shape processing continues through adolescence. *Child Development, 80,* 162-177.

Kimchi, R., Amishav, R., & Sulitzeanu-Kenan, A. (2009). Gender differences in global-local perception? Evidence from orientation and shape judgments. *Acta Psychologica, 130,* 64-71.

Yeshurun, Y., Kimchi, R., Sha'shoua, G., & Carmel, T. (2009). Perceptual objects capture attention. *Vision Research, 49,* 1329-1335.

Kimchi, R. (2009). Perceptual organization and visual attention. *Progress in Brain Research, 176,* 15-33.

Behrmann, M., Shomstein, S., & Kimchi, R. (2010). Conscious awareness of methodological choices: A reply to Milberg and McGlinchey. *Attention, Perception & Psychophysics, 72*(3), 622-627.

Shomstein, S., Kimchi, R., Hammer, M., & Behrmann, M. (2010). Perceptual grouping operates independently of attentional selection. *Attention, Perception & Psychophysics, 72*(3), 607-618.

Amishav, R., & Kimchi, R. (2010). Perceptual integrality of componential and configural information in face processing. *Psychonomic Bulletin & Review, 17*(5), 743-748.

Kimchi, R., & Amishav, R. (2010). Faces as perceptual wholes: The interplay between component and configural properties in face processing. *Visual Cognition, 18*(7), 1034-1062.

Pirkner, Y., & Kimchi, R. (2011). Surface features do not guide object continuity even when spatiotemporal information is ambiguous. In D. Algom, D. Zakay, E. Chajut, S. Shaki, Y. Mama, & V. Shakuf (Eds.). *Fechner Day 2011* (pp. 299-304). Raanana, Israel: International Society for Psychophysics.

Kimchi, R. (in press). Ontogenesis and microgenesis of visual perceptual organization. In J. A. Burack, J. T. Enns, & N. A. Fox (Eds.), *Cognitive Neuroscience, Development, and Psychopathology*. New York: Oxford University Press.

Peterson, M. A., & Kimchi, R. (in press). Perceptual organization in vision. In D. Reisberg (Ed.), *Oxford Handbook of Cognitive Psychology*. Oxford University Press.

Wagemans, J., Feldman, J., Gepshtein, S., Kimchi, R., Pomerantz, J. R., van der Helm, P. A., van Leeuwen, C. (2012, July 30). A century of Gestalt psychology in visual perception: II. Conceptual and theoretical foundations. *Psychological Bulletin.* Advance online publication. doi: 10.1037/a002933

Kimchi, R., Behrmann, M., Avidan, G., & Amishav, R. (in press). Perceptual separability of featural and configural information in congenital prosopagnosia. *Cognitive Neuropsychology*.

Conferences

- Razpurker-Apfeld, I. & Kimchi, R. (2002, July). Grouping and attention. Paper presented at the Israeli Conference on Cognitive Psychology, Judgment and Decision Making, Jerusalem, Israel.

- Kimchi, R., & Hadad, B. (2002, July). Influence of past experience on perceptual grouping. Poster presented at the Israeli Conference on Cognitive Psychology, Judgment and Decision Making, Jerusalem, Israel.

- Amishav, R., & Kimchi, R. (2002, July). The processing of visually presented words: The magical numbers three, four and five. Paper presented at the Israeli Conference on Cognitive Psychology, Judgment and Decision Making, Jerusalem, Israel.

- Kimchi, R. Perceptual grouping: Time course and attentional demands. (2002). *Cognitive and Neuropsychological Forum*, *Ben-Gurion University*, Israel. Invited talk.

- Kimchi, R. Perceptual organization in vision. (December, 2002). *Max Wertheimer Lecture Series*, *Johann Wolfgang Goethe-University Frankfurt*, Frankfurt, Germany.

- Kimchi, R., & Razpurker-Apfeld, I. (2003, May). Perceptual grouping and attention. Poster presented at the 3rd annual meeting of the Vision Sciences Society, Sarasota, FL, USA.

- Hadad, B., & Kimchi, R. (2003, September). Global and local processing of hierarchical patterns: A developmental study. Poster presented at the 13th Conference of the European Society for Cognitive Psychology, Granada, Spain.

- Amishav, R., & Kimchi, R. (2003, September). Semantic processing of visually presented words: The magical numbers four, and five. Poster presented at the 13th Conference of the European Society for Cognitive Psychology, Granada, Spain.

- Razpurker-Apfeld, I., & Kimchi, R. (2003, September). Attentional and temporal aspects of perceptual grouping. Paper presented at the 13th Conference the European Society for Cognitive Psychology, Granada, Spain.

- Kimchi, R., Hadad, B. (2003, November). Perceptual organization of hierarchical stimuli: A developmental study. Paper presented at the 44th Annual Meeting of the

Psychonomic Society, Vancouver, Canada.

- Kimchi, R. Issues in the perceptual organization of visual objects. (2004). Cognitive Seminar, *Hebrew University*, Jerusalem, Israel. Invited talk.

- Kimchi, R. Visual intelligence. (2004). *Institute of Advanced Judicial Studies*, Jerusalem. Invited talk.

- Kimchi, R., & Cohen-Savransky, A. (2004, April). The effect of perceptual organization on spontaneous allocation of visual attention. Poster presented at the 4th annual meeting of the Vision Sciences Society, Sarasota, FL, USA.

- Kimchi, R. (2004, October). Perceptual grouping and attention: Introduction to symposium. Paper presented at the meeting of the Israeli Society for Cognitive Psychology, Ramat-Gan, Israel.

- Kimchi, R., & Razpurker-Apfeld, I. (2004, October). Perceptual grouping and attention: Not all groupings are equal. Paper presented at the meeting of the Israeli Society for Cognitive Psychology, Ramat-Gan, Israel.

- Hadad, B., & Kimchi, R. (2004, October). Microgenesis and ontogenesis of perceptual organization of line configurations. Poster presented at the meeting of the Israeli Society for Cognitive Psychology, Ramat-Gan, Israel.

- Thomas, C., Behrmann, M., Kimchi, R., & Minshew, N. (2005, April). Global and local visual processing in autism: Insights from heterogeneous hierarchical letter stimuli. Poster presented at the meeting of the Society for Cognitive Neuroscience, New York, NY, USA.

- Behrmann, M., Thomas, C., Kimchi, R., & Minshew, N. (2005, May). Visual perceptual organization in adults with autism. Poster presented at the 5th annual meeting of the Vision Sciences Society, Sarasota, FL, USA.

- Kimchi, R., Yeshurun, Y., & Cohen-Savransky, A. (2005, November). Stimulus-driven attentional capture by objecthood. Paper presented at the 46th Annual Meeting of the Psychonomic Society, Toronto, Canada.

- Shomstein, S., Behrmann, M., Hammer, M., & Kimchi, R. (2006, May). Neglected Stimuli Influence Perception. Poster presented at the 6th Annual Meeting of the Vision Sciences Society, Sarasota FL, USA.

- Kimchi, R., & Hadad, B. (2006, November). Developmental trends in utilizing perceptual closure for grouping of shape. Paper presented at the 47th Annual Meeting of the Psychonomic Society, Houston TX, USA.

- Shomstein, S., Kimchi, R., Hammer, M., & Behrmann, M. (2006, November). The fate of neglected stimuli. Paper presented at the 47th Annual Meeting of the Psychonomic Society, Houston TX, USA.

- Kimchi, R. (2006, November). What does it mean that 'the whole is different from the sum of its parts'? Discussant, the 1st Meeting of the Configural Processing Consortium, Rice University Houston, USA.

- Kimchi, R. Object perception: Ontogenesis and microgenesis. (December, 2006). *International Workshop on Cognitive Neuroscience, Development and Psychopathology*, Institute for Advanced Studies, Jerusalem, Israel. Invited talk

- Kimchi, R., & Peterson, M. (2007, November). Figure-ground segregation can occur under inattention. Paper presented at the 48th Annual Meeting of the Psychonomic Society, Long Beach CA, USA.

- Kimchi, R. (2007, November). What does it mean that 'the whole is different from the sum of its parts': Explorations with face discrimination. Paper presented at the 2nd Meeting of the Configural Processing Consortium, Long Beach CA, USA.

- Kimchi, R., & Peterson, M. (2008, May). Figure-ground segmentation can occur without attention. Paper presented at the 8th Annual Meeting of the Vision Sciences Society, Naples FL, USA.

- Yeshurun, Y., Kimchi, R., Sha'shua, G., & Carmel, T. (2008, May). Perceptual objects capture attention. Poster presented at the 8th Annual Meeting of the Vision Sciences Society, Naples FL, USA.

- Hadad, B., & Kimchi, R. (2008, May). Grouping of shape by perceptual closure: Effects of spatial proximity and collinearity. Poster presented at the 8th Annual Meeting of the Vision Sciences Society, Naples FL, USA.

- Amishav, R., & Kimchi, R. (2008, November). Perceptual interactions between facial properties. Paper presented at the16th Annual Conference on Object Perception, Attention, and Memory, Chicago IL, USA.

- Amishav, R., & Kimchi, R. (2008, November). Perceptual interaction between component and configural properties in face perception. Poster presented at the 49th Annual Meeting of the Psychonomic Society, Chicago IL, USA.

- Kimchi, R. (2008, November). Discussant, the 3rd Meeting of the Configural Processing Consortium, Notre Dame South Bend, Indiana, USA.

- Mojica, A. J., Salvagio, E., Kimchi, R., & Peterson, M. (2009, May). On the relationship between attention and figure-ground perception. Poster presented at the 9th Annual Meeting of the Vision Sciences Society, Naples FL, USA.

- Kimchi, R., Yeshurun, Y., & Sha'shua, G. (2009, November). Perceptual organization influences automatic deployment of attention. Paper presented at the 50th Annual Meeting of the Psychonomic Society, Boston, Mass, USA.

- Kimchi, R. (2009, November). Discussant, the 4th Meeting of the Configural Processing Consortium, Tufts University, Boston, Mass, USA.

- Kimchi, R. Visual attention and perceptual organization. (April, 2010). *International Workshop on Selection and Control Mechanisms in Perception and Action*, Institute for Advanced Studies, Jerusalem, Israel. Invited talk.

- Kimchi, R., & Amishav, R. (2010, May). Perceptual integrality of componential and configural information in faces. Poster presented at the 10th Annual Meeting of the Vision Sciences Society, Naples FL, USA.

- Kimchi, R. Faces as perceptual wholes: The interplay between component and configural properties in face processing. (November, 2010). *5th meeting of the Configural Processing Consortium*, St. Louis, MO, USA. Invited address.

- Baruch, O., Kimchi, R., & Goldsmith, M. (2011, May). Attention is directed to distinguishing features during object recognition. Poster presented at the 11th Annual Meeting of the Vision Sciences Society, Naples FL, USA.

- Salvagio, E., Mojica, A. J., Kimchi, R., & Peterson, M. (2011, May). Reevaluating whether attention is drawn to figures. Poster presented at the 11th Annual Meeting of the Vision Sciences Society, Naples FL, USA.

- Pirkner, Y., & Kimchi, R. (2011, October). Surface features do not guide object continuity even when spatiotemporal information is ambiguous. Poster presented at the 27th Annual Meeting of the International Society for Psychophysics, Raanana, Israel.

- Kimchi, R. Object recognition and attention. (October, 2011). *Rovereto Attention Workshop: Attention and Objects*, Rovereto (TN), Italy. Invited talk.

- Kimchi, R. The interplay between component and configural properties in face perception. (October, 2011). *The SNAC talk series*, University of Haifa. Invited talk.

d.1.4 Prof. Joel Norman

Publications

Norman, J. (2002). Two visual systems and two theories of perception: An attempt to reconcile the constructivist and ecological approaches. Behavioral and Brain Sciences, 25,73-144.

Norman, J. (2002). Perceptual constancy: Direct vs. constructivist theories. Encyclopedia of the social and behavioral sciences. Oxford: Elsevier.

Setter, P., Norman, J., & Marciano, H. (2002). *Target detection in stereoscopic FLIR images*. Institute of Information Processing and Decision Making, IIPDM Technical Report (in Hebrew).

Setter, P., Sheffer D., & Norman, J. (2003). *A criterion for evaluating FLIR images.* Institute of Information Processing and Decision Making, IIPDM Technical Report (in Hebrew).

Sheffer D., Voskoboinik A., Setter P, & Norman J. Use of the Informational Difference as a Target Conspicuity Measure, Targets and Backgrounds IX: Characterization and Representation, AeroSense 2003, Proc. SPIE, Vol. 5075, pp. 150-161.

Setter, P., & Norman, J. (2004). *Stereoscopic vision for large distances*. Institute of Information Processing and Decision Making, IIPDM Technical Report (in Hebrew).

Setter, P., & Norman, J. (2005). *The effects of color in image interpretation tasks*. Institute of Information Processing and Decision Making, IIPDM Technical. Report (in Hebrew).

Setter, P., Norman, J., & Marciano, H. (2005). *The effects of time limitations on target identification.* Institute of Information Processing and Decision Making, IIPDM Technical Report (in Hebrew).

Setter, P., & Norman, J. (2006). *Improving X-Ray screening processes using stereoscopic displays.* Institute of Information Processing and Decision Making, IIPDM Technical Report (in Hebrew).

Setter, P., & Norman, J. (2006). *A study of human stereoscopic eye-movements to provide data for stereo computer vision models*. Report, Caesarea-Rothschild Foundation, University of Haifa.

Setter, P., Norman, J., Lipkin-Goldberg, M., & Marciano, H. (2006). *Encoding and Displaying ATR Designations in SAR Images*. Research Report, Air Force Research Laboratory, Human Effectiveness Directorate, Wright-Paterson AFB, OH., AFRL-HE-WP-TR-2006-0157 (ADA465163)

Setter, P., Marciano, H., Norman, J., & Hovev, M. (2007). The effects of the reliability of an automatic target recognition system on image analyst performance. Proceeding of the European Conference on Cognitive Ergonomics 2007 (ECCE 2007), London, England.

Setter, P., Marciano, H., Norman, J., & Hovev, M. (2007). The effects of time limitations on target identification. Proceeding of the European Conference on Cognitive Ergonomics 2007 (ECCE 2007), London, England.

Setter, P., Marciano, H., Lipkin-Goldberg, M., & Norman, J. (2008). *An examination of SAR interpretation aids: Magnification and an information window.* Research Report, Air Force Research Laboratory, Human Effectiveness Directorate, Wright-Paterson AFB, OH.

Setter, P., Ra'anan, N., & Norman, J. (2008). *Developing a method for alleviating visual fatigue reulsting form viewing stereoscopic displays*. Ergonomics and Human Factors Unit Report. (in Hebrew)

Mor, N., Norman, J, & Setter, P. (2009). *Visual fatigue and video display Terminals.* Research Report, Air Force Research Laboratory, Human Effectiveness Directorate, Wright-Paterson AFB, OH.

Setter, P., Marciano, H., Hel-Or, H., & Norman, J. (2009). Examination of the efficiency of different types of enlargement on target tracking. Ergonomics and Human Factors Unit Report. (in Hebrew)

Marciano, H., Setter, P., Norman, J., and Shimony, A. (2011). Examination of the efficiency of a two layer display for image understanding. Ergonomics and Human Factors Unit Report. (in Hebrew)

Marciano, H., Setter, P., Yeshurun, Y. Norman, J. & Toledo, T. (2011). The effect of billboards on driving as a function of type of billboard and its size. Report to the Road Safety Authority. (in Hebrew).

Conferences

- The European Conference on Cognitive Ergonomics. August 2007, London.
  Poster: The effects of the reliability of an automatic target recognition system on image analyst performance. (With Hadas Marciano, Dr. Pe'erly Setter, and Michal Hovev).

- The European Conference on Cognitive Ergonomics. August 2007, London.
  Poster: The effects of time limitations on target identification. (With Hadas Marciano, Dr. Pe'erly Setter, and Michal Hovev).

d.1.5 Dr. Yaffa Yeshurun (2005-2011)

Publications

Kimchi, R., Yeshurun, Y., & Cohen- Savransky, A. (2007). Automatic, stimulus-driven attentional capture by objecthood. Psychonomic Bulletin & Review, 14(1), 166-172.

Yeshurun, Y., & Carrasco, M. (2008). The effects of transient attention on spatial resolution and the size of the attentional cue. Perception & Psychophysics, 70(1), 104-113.

Yeshurun, Y., Montagna, B., & Carrasco, M. (2008). On the flexibility of sustained attention and its effects on a texture segmentation task. Vision Research, 48(1), 80-95.

Avraham, T., Yeshurun, Y.,& Lindenbaum, M. (2008). Predicting visual-search performance by quantifying stimuli similarities. Journal of Vision, 8(4):9, 1–22.

Yeshurun, Y., & Marom, G. (2008). Transient spatial attention and the perceived duration of brief visual events. Visual Cognition, 16(6), 826-848.

Yeshurun, Y., Carrasco, M., & Maloney, L. T. (2008). Bias and sensitivity in two-interval forced choice procedures. Vision Research, 48, 1837-1851.

Carrasco, M. & Yeshurun, Y. (2009). Covert Attention Effects on Spatial Resolution. In N. Srinivasan (Ed.) Progress in Brain Research. Vol 176, ATTENTION, The Netherlands: Elsevier, pp. 65-86

Yeshurun, Y., Kimchi, R., Sha'shoua, G., & Carmel, T. (2009). Perceptual objects capture attention. Vision Research, 49, 1329-1335.

Yeshurun, Y., & Rashal, E. (2010). Precueing attention to the target location diminishes crowding and reduces the critical distance. Journal of Vision, 10(10):16,1-12.

Marciano, H., & Yeshurun, Y. (2011). The effects of perceptual load in central and peripheral regions of the visual field. Visual Cognition, 19, 367-391.

Yeshurun, Y. & Hein, E. (2011) Transient attention degrades perceived apparent motion. Perception, 40, 905 – 918.

Conferences (2005-2011)

- Vision Science Society (VSS). May 2005, Sarasota, FL, USA.
  ** Motion perception is differentially effected by the transient and sustained components of spatial attention*.
  ** On the flexibility of covert attention and its effects on a texture segmentation task.*
- Brain & Cognition Workshop. January 2006, Taipei, Taiwan.
  The effects of transient attention on segregation and integration of spatial and temporal.
- Vision Science Society (VSS). May 2006, Sarasota, FL, USA.
  Transient attention and selective adaptation to high and low spatial frequencies.

- 2nd International Workshop on Visual Attention. March 2007, Buenos Aires, Argentina.
  Stimulus-driven attentional capture by objecthood information.
- Vision Science Society (VSS). May 2007, Sarasota, FL, USA.
  ** Evaluating the ability of visual search models suggested for computer-vision to predict human performance*.
  ** Differential effects of endogenous and exogenous covert attention on texture segmentation.*
- Vision Science Society (VSS). May 2008, Naples, FL, USA.
  Perceptual objects capture attention.
- Vision Science Society (VSS). May 2009, Naples, FL, USA.
  ** Differential effects of transient attention on adaptation to different spatial frequencies.*

  ** The effects of transient attention and target contrast on crowding at different eccentricities.*
- European Conference on Visual Perception (ECVP). August 2009, Regensburg, Germany.
  Modeling neurophysiological and psychophysical effects of attention via dynamic modulation of receptive fields.
- Selection and Control Mechanisms in Perception and Action, , April 2010,Jerusalem, Israel.
  **Transient attention and the interplay between the temporal and spatial domains of perception*
  **Do object-based effects merely reduce spatial costs?*

  **The Attentional Attraction Field: Modeling spatial and temporal effects of spatial attention Perceptual load in central and peripheral regions and its effects on performance.*
- Vision Science Society (VSS), May, 2010, Naples, FL, USA.

  **Temporal crowding with normal observers and its interplay with spatial crowding.*

  **The Attentional Attraction Field: Modeling spatial and temporal effects of spatial. attention*
- Asia-Pacific Conference on Vision (APCV), July 2010, Taipei, Taiwan.

  Transient attention and perceptual tradeoffs.
- Vision Science Society (VSS), May 2011, Naples, FL, USA.

  Modeling Combined Proximity-Similarity Effects in Visual Search.
- 3rd International Workshop on Visual Attention, October 2011, Allahabad, India.

  Transient attention and perceptual tradeoffs

d.1.6 Prof. Ido Erev

Publications

Skills or other major grant supported studies with an asterisk

*Erev, I., Roth, A.E., Slonim, S.L., & Barron G. (2002), "Predictive value and the usefulness of game theoretic models". *International Journal of Forecasting,* 18(3), 359-368.

Haruvy, E. & Erev, I. (2002), On the Application and Interpretation of Learning Models. In Zwick R. and Rapoport A. (Eds.), *Experimental Business Research*. Kluwer Academic Publishers.

*Perry, O., Haruvy, E. & Erev, I. (2002), "Frequent Delayed Probabilistic Punishment in Law Enforcement". *Economics of Governance*, 3, 71-85.

*Yechiam, E., Haruvy, E., Erev, I., (2002), "Reinforcement learning and the prevention of data catastrophes". *Journal of Managerial Psychology*, 17, 599-611.

*Yechiam, E., Barron, G., Erev, I., & Erez, M. (2003), "Cause related marketing: The equalizer". *Journal of Consumer behavior, 2, 320-332.*

*Meyer, J., Gilat, S. & Erev, I. (2003), "Consensus games in categorization decisions". *Journal of Mathematical Psychology, 47, 417-428.*

*Barron, G. & Erev, I. (2003), "Small feedback based decisions and their limited correspondence to description based decisions". *Journal of Behavioral Decision Making*, 16, 215-233. (Based on this paper Barron won the 2003 de-Finetti prize, awarded by the European Association for Decision Making, for the best paper written (or co-authored) by a graduate student.)

*Yechiam, E., Erev, I., Yehene, V., & Gopher, D. (2003), "On the transition from touch-typing training to everyday use: The value of continued strategic encouragement". *Human Factors,* 45 (4): 671-684

*Erev, I., Barron, G., & Remington, R. (2004), "Right of way in the sky: Two problems in aircraft self-separation and the auction-based solution". *Human Factors*. 46(2). 277-287

*Hertwig, R. Barron, G., Weber, E. and Erev, I. (2004), "Decisions from experience and the weighting of rare events". *Psychological Science,* 15 (8): 534-539.

* Yechiam, E. Erev, I., & Parush, A. (2004), "Easy-first training programs". *Journal of Experimental Psychology: Applied,* 10 (2): 89-96

*Barkan, R., Erev, I., Singer, E. and Zach, M. (2004), "Tips allocation rule, visibility and quality of service in cafés". *Tourism Economics*, 10(4) 449-461

Bamberger, P., Erev, I., Kimmel, M., & Oref-Chen T. (2005), "The effects of peer assessment on individual performance and contribution to group processes: The impact of anonymity." *Group and Organism Management.* 30 (4): 344-377.

*Erev, I., & Livne-Tarandach, R. (2005). Experiment-based exams and the difference between the behavioral and the natural sciences. In Zwick R. and Rapoport A. (Eds.), *Experimental Business Research, Vol 3*. Dordrecht, The Netherlands: Springer.

Hanaki, N., Sethi, R., Erev, I. & Peterhansl, A. (2005), "Learning strategies". *Journal of Economic Behavior and Organizations.* 56 (4): 523-542

*Yechiam, E., Barron, G. & Erev, I. (2005), "Description, experience and the effect of rare terrorist attacks". *Journal of Conflict Resolutions.* 49 (3), 430-439

*Erev, I. and Barron, G. (2005), "On adaptation, maximization and reinforcement learning among cognitive strategies". *Psychological Review. 112(4), 912-931.*

Erev, I. & Haruvy, E. (2005). Generality, Repetition, and the Role of Descriptive Learning Models. *Journal of Mathematical Psychology, 49 (5): 357-371*

*Hertwig, R. Barron, G., Weber, E. and Erev, I. (2006), Risky Prospects: When Valued Through A Window of Sampled Experiences. In K. Fiedler, & P. Juslin (Eds.), *Information sampling and adaptive cognition* (pp. 72-91). Cambridge, England: Cambridge University Press.

* Munichor, N., Erev, I., & Lotem, A. (2006). "Risk attitude and small time saving decisions". *Journal of Experimental Psychology: Applied,* 7 (4), 277-285.

*Grosskopf, B., Erev, I. & Yechiam, E. (2006), "Forgone with the wind". *International Journal of Game Theory. 34, 285-302*

*Yechiam, E. Erev, I., & Barron, G. (2006), "Insurance, safety, and the contradicting effects of experience and presentation". *Safety Science,* 44 (6), 515-522.

Erev, I. (2007). On the weighting of rare events and the economics of small decisions. In: S. H. Oda (Ed.), *Advances in Experimental Economics, Lecture Notes in Economics and Mathematical Systems, Vol. 590.* Dordrecht, The Netherlands: Springer.

*Erev, I., Roth, A.E., Slonim, R.L., & Barron, G. (2007), "Learning and equilibrium as useful approximations: Accuracy of prediction on randomly selected constant sum games". *Economic Theory,* 33 (1), 29-51.

*Ert, E., & Erev, I. (2007). "Replicated alternatives and the role of confusion, chasing, and regret in decisions from experience". *Journal of Behavioral Decision Making,* 20 (3), 305-322.

Erev, I., & Roth, A.E., (2007). "Multi-agent learning and the descriptive value of simple models." *Artificial Intelligence Journal,* 171, 7, 423-428.

* Parush, A., Ahuvia, S. & Erev, I. (2007). Degradation in spatial knowledge Acquisition when using automatic navigation systems. In S. Winter, M. Duckham, L. Kulik & B. Kuipers (eds). (2007). S*patial Information Theory. 8th International Conference, COSIT 2007.* (pp. 238–254). Berlin: Springer-Verlag.

Zohar, D. & Erev, I. (2007), "On the Difficulty of Promoting Workers' Safety Behavior: Overcoming the Underweighting of Routine Risks". *International Journal of Risk Assessment and Management,* 7 (2), 122-136.

Grodzinski, U., Erev I., Lotem A. (2008). Can hungry nestling be trained to reduce their begging? *Behavioral Ecology,* 19, 116-125.

Ben-Elia E., Erev, I., & Shiftan Y. (2008). "The combined effect of information and experience on drivers' route-choice behavior." Transportation,* 35, 2, 165-177.

*Erev, I., Glozman, I., & Hertwig, R. (2008). "What impacts the impact of rare events". *Journal of Risk and Uncertainty, 36 (2),* 153-177.

*Erev, I., Ert, E., and Yechiam, E. (2008). Loss aversion, diminishing sensitivity, and the effect of experience on repeated decisions. *Journal of Behavioral Decision Making*. 21(5): 575-597.

* Erev, I., Shinovich, D., Schurr, A., & Hertwig, R. (2008). "On the effect of base rates in perception studies, and base rate neglect in judgment studies". In: H. Plessner, C Betsch and T. Betsch (Eds.). *Intuition in Judgment and Decision Making.* (pp. 135-148). LEA.

*Ert, E., & Erev, I. (2008) "The Rejection of Attractive Gambles and the Heuristic Interpretation of Loss Aversion." *Journal of Economic psychology,* 29, 715–723.

*Shafir, S., Reich, T. Tsur, E., Erev, I. & Lotem, A. (2008). "Perceptual accuracy and conflicting effects of certainty on risk-taking behaviour." *Nature,* 453, 12 June, 917-921.

*Luria, G., Zohar, D. & Erev, I. (2008). "The effect of Visibility on Supervisors' Commitment to Safety." *Journal of Safety Research,* 39, 273–280.

*Biele, G., Erev I., & Ert, E. (2009). "Learning, risk attitude and hot stoves in restless bandit problems." *Journal of Mathematical Psychology.* 53, 3,155-167.

Hertwig, R., & Erev, I. (2009), "The description–experience gap in risky choice." *Trends in Cognitive Sciences,* 13, 517-523.

*Erev, I. Ert, E. Roth, A. E., Haruvy, E., Herzog, S., Hau, R. Hertwig, R. Stewart, T., West, R. and Lebiere, C. (2010) "A choice prediction competition, for choices from experience and from description." *Journal of Behavioral Decision Making, 23,* 15-47.

Erev, I. & Haruvy, E. (2010), "Two-stage lotteries and the value of unresolved uncertainty". *Marketing Letters.*

*Erev, I., Ingram P., Raz, O. and Shany, D. (2010), "Continuous punishment and the potential of gentle rule enforcement". *Behavioural Processes*.

*Erev, I., Rodensky, D., Levi, M., Hershler, M., Adami, H., Donchin, Y. (2010). The value of gentle enforcement on safe medical procedures. *Quality and Safety in Health Care.*

* Ben Zion, U., Erev, I., Haruvy, E., & Shavit, T. (2010). Adaptive behavior leads to under-diversification. *Journal of Economic psychology,* 31, 985–995.

Erev, I., Ert, E., Roth, A.E. (2010). A choice prediction competition for market entry games: An introduction. *Games, 1,* 117-136.

Ert, E., Erev, I., Roth, A.E. (2011). "A choice prediction competition for A Choice Prediction Competition for Social Preferences in Simple Distribution Games: An Introduction." *Games*.

Erev, I., Haruvy, E. (in press). Learning and the economics of small decisions. Invited chapter submitted to Kagel, J.H. and Roth, A.E. (Eds.), *The Handbook of ExperimentalEconomics*.PrincetonUniversityPress.
http://www.utdallas.edu/~eeh017200/papers/LearningChapter.pdf

Erev, I. and Grainer, B. (in press). On Psychology, Economics, and the Prediction of Human Behavior. Invited chapter submitted to Guillaume F. and Schotter A. (Eds.) The handbook on Methods of Modern Experimental Economics. Oxford University Press.

Conferences

- Erev, I., Roth, A.E., Barron, G. & Slonim, B., "On the predictive value of simple models". Economic Science Association (a plenary address presented by Roth) Boston, MA June 2002;

- Erev, I. "On maximization and adaptation: Experimental results, simple model and applications". Presented at the Psychology and Economics workshop, New York University, Feb 2001; Psychology and Economics, University of Michigan, Feb 2001; Economic Theory, University of Chicago Feb, 2001; Cognitive Psychology, University of Maryland, March, 2001; Workshop on learning and bounded rationality in markets, Firenze, June, 2001; Economic Theory, University of Texas, Sept, 2001; Economic Theory, University of North Carolina, Oct, 2001; Marketing Camp, Insead, April, 2004; Decision Science workshop, Univ. of Arizona, April 2005;Max Planck Institute, Berlin, November, 2005.

- Erev, I. & Hertwig, R. "Decisions, judgment, and the weighting of rare events". Presented at the workshop on Information sampling, Heidelberg, Germany May 2002. Also presented at the ESA meeting, Pittsburgh, PA, June 2003; SPUDM, Zurich, August, 2003; The second Asian conference in Business Research, Hong Kong, December 2003.

- Erev, I., Ingram P., Raz, O. & Shany, D. "On the possibility of gentle rule enforcement." Presented (a plenary address) at the meeting of the North American Association for Computational Social and Organizational Science, Pittsburgh, PA, June, 2003. Also presented at the Murat Sertel memorial Conference Economic Theory, Istanbul Turkey, May 2004; Organizational Behavior Seminar, Tel Aviv University, April 2005; Organizational Theory Seminar, University of Haifa, May 2005.

- Erev, I. & Shimonovich, D., & Shurr, A., & Hertwig, R. "On the Effect of Base Rates in Perception Studies and Base Rate Neglect in Judgment Studies". Presented at the workshop on Intuition and Decision Making, Heidelberg, Germany February 2004).

- Erev, I. "On the economics and the psychology of small decisions." Presented (a plenary address) at the meeting of Israeli cognitive psychology association, Ramat Gan, October, 2004. Also presented (as a plenary address) in the Experimental Economic Science conference, Kyoto, Japan, December 2004; Decision Science seminar, Insead, November 2005.

- Erev, I. & Haruvy, E. "Generality, Repetition, and the Role of Descriptive Learning Models" Presented at the Mathematical Psychology sminar Univ of Indiana, March 2005; Decision Science workshop, Univ. of Arizona, March 2005;

- Erev, I. Schurr, A., & Hertwig, R. "The psychological impact of rare events". Presented at the Affect, Motivation and Decision Making International Conference. Ein Boqeq, Israel, December 2006. Also presented at the workshop on Metrology and Social Science, Exeter, UK, June 2007.

- Erev, I. & Haruvy, E. "Learning and the Economics of Small decisions". Presented at the workshop on Experimental Economics, Stony Brook, NY, July 2007. Also presented in an invited session in the meeting of the Experimental Psychology Society, London, UK, January 2008., and in seminars in: Florida State University (Experimental Economic, September 2007), University of Texas at Dallas (October 2007, Experimental economics), Texas A&M University (October 2007, Experimental economics), Carnegie Mallon University (October 2007, Social and Decision Science), Harvard University (Behavioral economics), New York University (January, 2008), University of Pennsylvania (March 2008, Behavioral Science), Columbia University (March 2008, Management). University of Konstanz (September, 2008), Hebrew University (December 2008), Tel Aviv University (Januray, 2009), Ben Gurion Univ. (January, 2009), University of Pampeo Fabra (July, 2009), Workshop on regret and decision making, Jerusalem, Israel (May, 2009), The Meeting of the Society for Quantitative Analysis of Behavior, Phoenix Arizona (May 2009), Summer school in experimental Economics Jena (July, 2010), Workshop on financial decisions, Pisa, (October, 2010), Marseille (February, 2011). Workshop on Decision making, Allahabad, India (December, 2011).

- Erev, I. On the potential applications of the study of decisions from experience. Paper presented at the One-Day Workshop ‘Unravelling decisions from experience’, sponsored by the European Association for Decision Making (EADM) and the Centre for Economic Learning and Social Evolution (ELSE), London, UK (January 2008)

- Erev, I. & Greiner, B. Psychology, economics, and the prediction of human behavior. Paper presented at the workshop on the Methods of Modern Experimental Economics, New York, April 2008. Also presented at the public workshop on the Methods of Modern Experimental Economics, New York, October 2009. Meeting on Economic and Philosophy, Kyoto, Japan (March, 2010). Workshop on Psychology and Economics, Konstanz (December, 2010)

- Erev, I. A choice prediction competition, for choices from experience and from description. Round table discussion in the International Conference of the Asian Economic Science Association, Haifa, Israel, May 2009.

- Erev I. & Ert, E. Weighting experiences. Sapir conference on Individual Decision-Making: A Behavioral Approach, Tel Aviv, Israel, June 2009. Also presented in the Decision, Theory and Applications meeting, Paris June 2009.

- Erev I. Loss aversion, overconfidence and betting. The Decision, Theory and Applications meeting, Paris June 2011.

d.1.7 Prof. Eldad Yechiam (2005-2011)

Publications

Skills or other major grant supported studies with an asterisk.

Yechiam, E., Barron, G., and Erev. I. (2005). The role of personal experience in contributing to different patterns of response to rare terrorist attacks. *Journal of Conflict Resolution*, *49*, 430-439.
Yechiam, E. (2006). Why are macros not used? A brief review and an approach for improving training. *Computers and Education*, *46*, 206-220.

Yechiam, E., and Busemeyer, J.R. (2006). The effect of foregone payoffs on underweighting small probability events. *Journal of Behavioral Decision Making*, *19*, 1-16.

* Lovallo, W.R., Yechiam, E., Sorocco, K.H., Vincent, A.S., and Collins, F.L. (2006). Working memory and decision-making in familial risk for alcoholism: studies from the Oklahoma Family Health Patterns Project. *Alcoholism: Clinical and Experimental Research*, *30 (5)*, 763-773.

Yechiam, E., Erev, I., and Barron, G. (2006). The effect of experience on using a safety device. *Safety Science*, *44 (5)*, 515-522.

* Lane, S., Yechiam, E., and Busemeyer, J.R. (2006). Application of a computational decision model to examine acute drug effects on human risk taking. *Experimental & Clinical Psychopharmacology*, *14 (2)*, 254-264.

Grosskopf, B., Erev, I., and Yechiam, E. (2006). Foregone with the wind: Indirect payoff information and its implications for choice. *International Journal of Game Theory*, *34 (2)*, 285-302.

* Kester, H., Sevy, S., Yechiam, E., Burdick, K.E, Cervellione, K.L, and Kumra, S. (2006). Decision-making impairments in adolescents with early-onset schizophrenia. *Schizophrenia Research*, *85 (1-3)*, 113-123.

* Johnson, S.A., Yechiam E., Murphy, R.M., Queller, S., and Stout, J.C. (2006). Motivational processes and autonomic responsivity in Asperger's disorder: Evidence from the Iowa gambling task. *Journal of the International Neuropsychological Society*, *12 (5)*, 668-676.

* Yechiam, E., Goodnight, J., Bates, J.E., Busemeyer, J.R., Dodge, K.A., Pettit, G.S., and Newman, J.P. (2006). A formal cognitive model of the Go/No-Go discrimination task: Evaluation and implications. *Psychological Assessment*, *18 (3)*, 239-249.

* Sevy, S., Hassoun, Y., Bechara, A., Yechiam, E., Napolitano, B., Burdick, K., Delman, H., and Malhotra, A. (2006). Emotion-based decision-making in healthy subjects: Short-term effects of reducing dopamine levels. *Psychopharmacology*, *188(2)*, 228-235.

* Yechiam, E., and Budescu, D.V. (2006). The sensitivity of probability assessments to time units and performer characteristics. *Risk Analysis*, *3 (3)*, 177-193.

Yechiam, E., and Ert, E. (2007). Evaluating the reliance on past choices in adaptive learning models. *Journal of Mathematical Psychology, 51 (2),* 75-84.

Yechiam, E., Veinott, E.S., Busemeyer, J.R., and Stout, J.C. (2007). Cognitive models for evaluating basic decision processes in clinical populations. In R. Neufeld (Ed.), *Advances in clinical cognitive science: Formal modeling and assessment of processes and symptoms* (page 81-111). Washington, D.C.: American Psychological Association Publications.

* Sevy, S., Burdick, K., Visweraiah, H., Abdelmassih, S., Lukin, M, Yechiam, E., and Bechara, A. (2007). Iowa Gambling Task in schizophrenia: A review and new data in patients with schizophrenia and co-occurring cannabis use disorders. *Schizophrenia Research, 92 (1-3),* 74-84.

* Yechiam, E., Kanz, J., Bechara, A., Stout, J.C., Busemeyer, J.R., Altmaier, E.M., and Paulsen, J. (2008). Neurocognitive deficits related to poor decision-making in people behind bars. *Psychonomic Bulletin and Review, 15,* 44-51.

Yechiam, E., and Gopher, D. (2008). Deliberate suppression of vision as a training tool for multimodal skills. In SKILLS consortium, *Beyond movement: The history and future of gesture analysis* (page 80-103). Alinea publishing house.

Lev, D., Hershkovitz, E., and Yechiam, E. (2008). Decision making and personality in traffic offenders: A study of Israeli drivers. *Accident Analysis and Prevention, 40,* 223-230.

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Conferences (2005-2011)

- Affect, Motivation, and Decision Making Conference. December 2006, Ein Boqeq, The Dead Sea, Israel.
  Acute drug effects on motivational and cognitive processes involved in repeated choice
- Conference on Subjective Probability, Utility, and Decision Making (SPUDM 21). August 2007, Warsaw, Poland.
  Poor theory of mind is associated with erratic choice behavior but not with IQ: Findings in Aspergers and healthy subjects.
- 1st International Workshop on MultiModal Interfaces for the Transfer of Human Skills: "Beyond Movement". December 2007, Sant'anna School of Advanced Studies, Pisa, Italy.
  Deliberate suppression of vision as a training tool for multimodal skills.
- The 29th International Congress of Psychology. July 2008, Berlin, Germany.
  Using cognitive models for understanding individual differences in decision making and neuropsychological disorders.
- Workshop on Unraveling Decisions from Experience. January 2008, University College of London, UK.
  On the potential of using experience-based tasks for studying individual differences.
- The Annual Conference of the Phoenix Program for Road Safety. July 2008, Bar-Ilan University, Ramat Gan, Israel.
  The decision making style of risky drivers.
- The Scientific Conference on the SKILLS Integrated Project. December 2008, Augsburg, Germany.
  Suppression of visual guidance in remote training accelerates learning.
- International Workshop on Regret, Emotions, and Decision Making. March 2009, Hebrew University, Jerusalem, and Ben-Gurion University, Be'er Sheva, Israel.
  The trap of risks with rare losses is made deeper by regret: Implications to social learning and drug abuse.
- Fifth Asia Pacific Meeting of the Economic Science Association. March, 2009, Haifa, Israel.

The challenge of Neuroeconomic applications: Predicting the individual's decisions across situations.

- International Conference on Learning, Reward-Seeking Behaviors and Addiction. May 2009, Hebrew University, Jerusalem, Israel.
  Dynamics of involvement in small probability risks: Population model and studies of drug abusers.
- The joint 42nd Annual Meeting of the Society for Mathematical Psychology and the 40th annual conference of the European Mathematical Psychology Group. July 2009, Amsterdam, Netherlands.
  Applications of the Loss Signals Risk hypothesis.
- Conference on Subjective Probability, Utility, and Decision Making (SPUDM 22), August 2009, Rovereto, Italy.
  Losses induce consistency in human choice behavior.
- Annual Conferences of the Cognitive Science Society. Portland, Oregon, August 2010. Won the Cognitive Science Society Computational Modeling Prize in applied cognition (together with Eyal Ert). *Risk attitude in decision making: A clash of three approaches.*
- The 43rd Annual Meeting of the Society for Mathematical Psychology, Portland, Oregon, August 2010. *The effect of losses on maximization: Loss aversion versus a global-effect model*.
- EADM Workshop on Intuition: Methods and Recent Findings. Bonn, Germany (May, 2010). *Using physiological measures to track intuitions: The example of losses.*
- International Conference on Behavioral Decision Making, Interdisciplinary Center, Herzliya, Israel, May 2011. 1) *Disentangling the behavioral and brain responses to Losses*. 2) *The problem in the assessment of risk taking: Different risks, different building blocks, different measures*.
- Plenary symposium lecture in Conference on Subjective Probability, Utility, and Decision Making (SPUDM 23), Kingston, UK, August 2011
  The effects of losses on attention provide sufficient conditions for their impact on maximization and individual difference.

d.1.8 Prof. Daniel Gopher

Publications

Books

Donchin Y. & Gopher D (2011) Around the Patient Bed: Human Factors and Safety in Health Care. Carta Jerusalem, Israel. An English version is to be published in 2013 by Taylor and Francis CRC, Florida US.

Bergemasco M. Bardy B. Gopher D.(Eds.). (in press, 2012). Skill Training in Multimodal Virtual Environments. Taylor and Francis CRC press.

Journals and book chapters

Nave, R. Iani, C., Herer. P., Gopher, D., Lavie, P. (2002) Residual effects of day time administration of melatonin: Dependency on nap length. *Behavioral Brain Research* 131, pp 87-95

Yechiam, E., Erev, I., Yehene, V. , Gopher, D. (2004). Melioration and the Transition from Touch-Typing Training to Everyday Use. *Human Factors,* 45, pp 671-684.

Iani, C., Gopher, D., Lavie, P. (2004). Peripheral vosoconstriction reflects exerted mental effort. *Psychophysiology*, 41, pp 789-798.

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Gopher D., Donchin, Y. (2011) The embedded risks and challenges of modern health care and the urgent call for proative Human Factors. Pascale de Carayon (Ed.) Handbook of Human Factors and Ergonomics in Health Care and Patient Safety. Taylor and Francis, CRC, Roca Baton, FL, USA, pp 27-42

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Gopher D. (in press) Development of training platforms in multimodal virtual reality environment. In: Bergemasco M. Bardy B. Gopher D.(Eds). Skill Training in Multimodal Virtual Environments. Taylor and Francis CRC press.

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Julien LagardeJ., Gopher D., Avizano C. A., Erev, V., Lippi, V., Zelic G., (In press) Training to juggle with a light weight juggler (LWJ). In: Bergemasco M. Bardy B. Gopher D.(Eds) Skill Training in Multimodal Virtual Environments. Taylor and Francis CRC press.

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Korman M., Cohen A., Weiss K., Reiner M., Gopher D. (in press). Effects of Practice and Sensory Modality on Stiffness Perception. Presence.

Confrences

Conferences Proceedings (refereed papers)

- Iani C., Gopher D., Grunwald A., Lavie P., (2002). Peripheral artirial tone response to levels of continuous and discrete load in an agricultural flying task Proceedings of the 46th annual meeting of the Human Factors and Ergonomics Society. Baltimore, USA.
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- R. Sela, Y. Auerbach, Z. Straucher, M. Rogachov, O. Klimer, D. Gopher, R. Bar-Deroma, R. Carmi, A. Kuten, S.Pollack, (2005). A Cognitive User Centered Redesign of a Radiotherapy Chart. Proceedings of the 49th annual meeting of the Human Factorsand Ergonomics Society. Orlando, FL. USA

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- Gopher, D. (2009). Assessing the training potential of the Virtual Reality Training Platforms of Skills International Conference on Multimodal Interfaces for Skills Transfer, Bilbao Spain.

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Conference presentations (Abstract in the proceeding)

- Gopher D., Barnea D., (2002). Switching between tasks: What constitutes a task unit. The 42th Annual Meeting of the Psychonomic Society. Kansas City, Kansas, USA.

- Yechiam, E. Gopher, D. (2003). A strategy based model to the interpretation of visual dominance in perceptual-motor tasks, The 43th Annual Meeting of the Psychonomic Society. Vancouver, Canada.

- Gopher D. Invited Keynote (2004). Control Processes in the formation of task units. The 28th International Congress of Psychology, Bejing, China.

- Kahana A., Gopher D., Grunwald A., Iani C., Lavie P. Invited (2004). Workload Distribution in the Glass Cockpit. The 28th International Congress of Psychology, Bejing, China.

- Gopher D. Invited, (2005) Emphasis change as a training protocol for high demand tasks. Applied Attention, a festschrift meeting in the honor of C. Wickens. Urbana, Illinois.

- Gopher D. (2005) Training of high demand tasks. ASCI 2005, Cognitive Interdisciplinary Conference, Briancon, France.

- Gopher D., Chuntonov O., Yehene V., (2005). Inhibitive and Adaptive Control Processes in task switching. The 45th Annual Meeting of the Psychonomic Society. Toronto, Canada
- Gopher, D., Chuntunov O., (2007). Individual Differences in Executive Control Functions. The 48 Annual Meeting of the Psychonomic Society. Long Beach, U.S.A.

- Yechiam E., Gopher D., (2007). Deliberate suppression of vision as a training tool for multimodal skills. Beyond Movement, Pisa, Italy.

- Gopher D. (2008). The factorial structure of the differences between individuals in their ability to focus on a task and switch between tasks. XXIX International Congress of Psychology, Berlin, Germany.

- Gopher D., Bluman, H., Stern, Y. (2009). Training cognitive control in old adults. XVI meeting of the European Society for Cognitive Psychology, Krakow, Poland.

- Gopher, D. (2010, Keynote address). Multimodal virtual reality training of perceptual motor skills. The D-CIS 3ed Human Factors Conference. Delft, The Netherlands.

Keynote and Plenary presentations

- The 28th International Congress of Psychology, 2004, (Keynote address) Control Processes in the formation of task units, (2004), Bejing, China.

- XXIX International Congress of Psychology, 2008, (Invited Symposuim) The factorial structure of the differences between individuals in their ability to focus on a task and switch between tasks. (2008), Berlin, Germany.

- International Conference on Multimodal Interfaces for Skills Transfer. 2009 (plenary lecture). Assessing the training potential of the Virtual Reality Training Platforms of Skills, Bilbao Spain, 2009.

- Third International Conference on Applied Human Factors and Ergonomics (Invited symposium) Skills training in multimodal virtual environments. (2010). Miami Florida, USA.

- Skills International Conference, 2011, (Plenary lecture)_Training of Perceptual Motor Skills in Multimodal Virtual Environments. (2011) Montpellier France.

e. Israeli-German Cooperation

e.1 Joint Projects

e.1.1 Metacognition: A Window to the Conscious and Unconscious Determinants of Behavior.

Federal ministry of education and research (German-Israel Project Cooperative program - DIP) (2002-2007).

This project constitutes a collaborative effort by a group of cognitive and social psychologists from Israel and Germany. Metacognition serves in this project as a common ground for understanding the intricate interplay between conscious and unconscious processes as they affect judgment and behavior. Research and discussions by the collaborating partners was aimed toward the development of a comprehensive conceptual framework that allows to tie together a variety of scattered empirical findings. To our knowledge, this is the first organized attempt of researchers to bring insights from both Cognitive and Social Psychology to bear on this complex problem.

Researchers:

Israel – Minerva Center, Haifa
Prof. Asher Koriat
Prof. Morris Goldsmith
Dr. Ainat Pansky
Dr. Ravit Nussinson

Germany (5 research teams):
Prof. Dr. Herbert Bless, University of Mannheim, Mannheim, Germany.
Prof. Dr. Klaus Fiedler, University of Heidelberg, Heidelberg, Germany.
Prof. Dr. Dagmar Stahlberg, University of Mannheim, Mannheim, Germany.
Prof. Dr. Fritz Strack, Psychology Department, University of Würzburg, Würzburg, Germany.
Prof. Dr. Michaela Wänke, Universität Basel, Basel, Switzerland .
Prof. Dr. Edgar Erdfelder, University of Mannheim, Mannheim, Germany.

We were invited to present the project at the Symposium *"10 Years of DIP"*, Jerusalem, October 2007. The project was presented by Prof. Asher Koriat and Prof. Michaela Wänke.

For project's mapping - see Appendix section h.3.

e.1.2 The Function-Disadvantage Effect in German: A Window to the Extraction of Sentence Structure during Reading

DFG Grant to Max-Planck Institute for Psychological Research, Munich. (2003 - 2005)

Researchers:
Prof. Asher Koriat, Minerva Center, Israel.
Dr. Jochen Müsseler, Max-Planck Institute for Psychological Research, Munich, Germany.
Dr. Monika Nisllein, Psychology Department, University of Munich, Germany.

The main findings of this project were published in:

Müsseler, J., Nisslein, M., & Koriat, A. (2005). German capitalization of nouns and the detection of letters in continuous text. *Canadian Journal of Experimental Psychology, 59*(3), 143-158.

e.1.3 The Intricate Relationship between Metacognitive Monitoring and Metacognitive Control during Learning: A Developmental Perspective

German-Israeli Foundation (GIF) (2007-2011)

Researchers:
Prof. Asher Koriat. Minerva Center, Haifa.
Dr. Rakefet Akerman. Minerva Center, Haifa.
Prof. Dr. Wolfgang Schneider, University of Würzburg, Würzburg, Germany.
Dr. Kathrin Lockl, Otto-Friedrich-University of Bamberg, Bamberg, Germany.

This project involved a collaboration between cognitive psychologists from the Minerva Center (Koriat and Ackerman) and developmental psychologists from Germany (Schneider and Lockl). It grew out of previous work on adult metacognition that had been carried out at the Minerva Center. That work posed a challenge regarding the development of metacognitive processes, and raised new questions not investigated before. That work indicates that although monitoring often guides control operations, it is sometimes based itself on the feedback from control operations. Furthermore, monitoring often relies on cues and heuristics that operate unconsciously to shape metacognitive feelings. In this project we imported insight from this work to study metacognitive processes during learning in children. Altogether 9 experiments were planned, which attempted to trace the development of the intricate interplay between monitoring and control processes.

The project on the whole not only has yielded valuable findings but also has helped in promoting a conceptual framework for the analysis of metacognitive processes in school children. This framework poses challenges to the study of metacognitive development which traditionally emphasized explicit expressions of monitoring judgments, and brings

to the fore new issues regarding the development of subtle interplay between monitoring and control processes.

Several publications emerged from this project:

Koriat, A., Ackerman, R., Lockl, K., & Schneider, W. (2009). The easily learned, easily-remembered heuristic in children. *Cognitive Development*, *24*, 169-182.

Koriat, A., Ackerman, R., Lockl, K., & Schneider, W. (2009). The memorizing-effort heuristic in judgments of learning: A developmental perspective. *Journal of Experimental Child Psychology*, *102*, 265–279.

Koriat, A., & Ackerman, R. (2010). Choice latency as a cue for children's subjective confidence in the correctness of their answers. *Developmental Science, 13,* 441-453.

Koriat, A., & Ackerman, R. (2010). Metacognition and mindreading: Judgments of learning for self and other during self-paced study. *Consciousness and Cognition*, *19*, 251-264.

Hoffmann-Biencourt, A., Lockl, K., Schneider, W., Ackerman, R., & Koriat, A. (2010). Self-paced study time as a cue for recall predictions across school age. *British Journal of Developmental Psychology*, *28*, 767–784

Ackerman, R., & Koriat, A. (2011) Response latency as a predictor of the accuracy of children's reports. *Journal of Experimental Psychology: Applied*, *17*, 406–417.

Koriat, A., Ackerman, R., Adiv, S., Lockl, K., & Schneider, W. (submitted 2012, *Journal of Experimental Psychology: General*). The effects of goal-driven and data-driven regulation on metacognitive monitoring during learning.

e.1.4 The Assessment of Eyewitness Memory: A Multi-Componential, Correspondence-Oriented Approach.

European Union 6th Framework Program (FP6), New and Emerging Science and Technology (NEST) (2007-2010).

Prof. Asher Koriat, Prof. Morris Goldsmith, and Dr. Ainat Pansky – Minerva Center, were the Coordinators of this EU-supported project. The project received a grant in the sum of 1.7 million Euro. Among the participants were Prof. Hans Markowitsch (U. Bilelefeld, Germany), and Dr. Med. Aglaja Stirn (Director of the Clinic for Psychosomatic Medicine of the Johann Wolfgang Goethe-University, and a Research Fellow at the Max-Planck-Institute for Brain Research, Frankfurt, Germany).

The aim of the project was to develop diagnostic tools for the accuracy of witnesses memory reports. Eyewitness testimony forms an important part of the justice system. Even when eyewitnesses mean to tell the truth, however, they can be surprisingly unreliable. EyewitMem aimed to reduce injustice by bringing a more scientific approach to evaluating eyewitness testimony. The participants in the project combined expertise in

memory, forensic psychology, neuroscience, and artificial intelligence to gain insights into the mechanisms and determinants of memory accuracy, and to develop instruments that can serve as diagnostic tools in evaluating the accuracy of memory reports.

Prof. Hans Markowitsch and Dr. Aglaja Stirn were responsible for the fMRI part of the study in which an effort was made to identify correlates of true and false memory reports using manipulations designed to induce false recall and recognition.

Several publications came out of this project:

Markowitsch, H.J., & Kalbe, E. (2007). Neuroimaging and crime. In S. Å. Christianson (Ed.), *Offender's memory of violent crime*. Chichester, UK: John Wiley & Sons.

Brand, M. & Markowitsch, H. J. (2008). The role of the prefrontal cortex in episodic memory. In E. Dere, A. Easton & J. P. Huston (Eds.), *Handbook of behavioral neuroscience: Episodic memory research*, Vol. 18 (pp. 317 - 342). Amsterdam: Elsevier.

Goldsmith, M. (2008). Did this really happen? The monitoring and control of human memory. In R.V. De Mulder (Ed.), *Mitigating risk in the context of safety and security: How relevant is a rational approach?* (pp. 87-106). Rotterdam: Erasmus University.

Koriat. A. (2008a). Subjective confidence in one's answers: The consensuality principle. *Journal of Experimental Psychology: Learning, Memory & Cognition*, 34(4), 945-959.

Koriat, A. (2008b). When confidence in a choice is independent of which choice is made. *Psychological Bulletin and Review*, 15(5), 997-1001.

Markowitsch, H.J. (2008). Gedächtnis und Brain Imaging. *Fortschritte der Neurologie Psychiatrie*, 76 (Suppl. 1), S1-S6.

Memon, A., Mastroberardino, S. & Fraser, J. (2008). Munsterberg's Legacy: What does eyewitness research tell us about the reliability of eyewitness testimony? *Applied Cognitive Psychology*, 22, 841-851.

Mulder, R.V. De, Noortwijk, C. van, Kleve, P. (2008). New School Case Law Knowledge Management, *International Journal of Private Law*, 1(3/4), 304-318.

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Markowitsch, H. J. & Staniloiu, A. (2009). Measuring truth with psychological and neuroscientific methods. *MINET Conference Proceedings: Measurement, Sensation, and Cognition*, 92-94.

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Neuropsychology (pp 793-809). Oxford (UK): Oxford University Press.

Memon, A., Fraser, J., Colwell, K., Odinot, G., & Mastroberardino, S. (2010). Distinguishing truthful from invented accounts using reality monitoring criteria, *Legal & Criminological Psychology*, 15, 177-194.

Memon, A., Zaragoza, M., Clifford, B. & Kidd, L. (2010). Inoculation or antidote? The effects of Cognitive Interview timing on false memory for forcibly fabricated events. *Law & Human Behavior*, 34, 105-117.

Mulder, R.V. De, Noortwijk, C. van, Combrink-Kuiters, L., Jurimetrics. (2010). please! In Paliwala, A. (Ed.), *A History of Legal Informatics* (pp. 147-178).

Mulder, R. V. De, Noortwijk, C. Van, Goldsmith, M., Pansky, A., Koriat, A., & Kadouri-Labin, S. (2010). CORMAS: A computerized tool for the analysis of eyewitness memory correspondence. *European Journal of Law and Technology*, 1(3), 1-18.

Otgaar, H., Candel, I. Memon, A. & Almerigogna, J. (2010). Differentiating between children's true and false memories using reality monitoring criteria, *Psychology, Crime & Law*, 16(7), 555-566.

Goldsmith, M. (2011). Quantity-accuracy profiles or type-2 signal detection measures? Similar methods toward a common goal. In P.A. Higham and J.P. Leboe (Eds.) *Constructions of remembering and metacognition: Essays in honor of Bruce Whittlesea* (pp. 128-136). Basingstoke: Palgrave-MacMillan.

Koriat, A., Pansky, A., & Goldsmith, M. (2011). An output-bound perspective on false memories: the case of the Deese-Roediger-McDermott (DRM) paradigm. In A. Benjamin (Ed.), *Successful remembering and successful forgetting* (pp. 302-332). New York: Psychology Press.

Pansky, A., & Nemets, E. (2012). Enhancing the quantity and accuracy of eyewitness memory via initial memory testing. *Journal of Applied Research in Memory and Cognition , 1*, 2-11.

e.1.5 Advisory Boards member

Prof. Asher Koriat served on the Advisory Boards of the Max-Planck Institute for Psychological Research, Munich, and the Max-Planck Institute for Cognitive and Brain Sciences, Leipzig, for a total period of 13 years (until 2010).

e.1.6 Asymmetries in Visual Search and Texture Segregation

Prof. Ruth Kimchi collaborated with ***Prof. Cristins Meinecke*** (now at Friedrich-Alexander-University, Erlangen) on asymmetries in visual search and texture segregation. A collaborative paper was published in 2002.

e.1.7 Commentary

Prof. Ralph Hertwig (now Max-Planck, Berlin) was invited to write a commentary (Tapping into the Wisdom of the Crowd--with Confidence, Science, 2012, 303-304) on an article by ***Prof. Asher Koriat*** (When are two heads better than one and why? Science, 2012, 360-362, supported by Minerva).

e.1.8 Attentional Effects on Motion Perception

Dr. Yaffa Yeshurun is collaborating with ***Dr. Elisabeth Hein*** from the University of Tübingen, Germany, on a project dealing with attentional effects on motion perception. A collaborative paper was published: Yeshurun, Y. & Hein, E. (2011) Transient attention degrades perceived apparent motion. Perception, 40, 905 – 918.

e.1.9 Multimodal Interfaces for Capturing and Transfer of Skill- SKILLS

An Integrated Project of the European Community 6th Framework Program (2006-2011).

Researchers:

Prof. Daniel Gopher and Prof. Eldad Yechiam – Minerva Center, Technion, are principle investigators in a research and development consortium, collaborating with 15 partners from nine European countries, including three research groups from Germany:

(1) Deutsches Zentrum Raumfahrt E.V. (DLR), Munich, led by Dr. Carsten Preusche, Thomas Hulin and Dr. Patrick van der Smagt, on the development of a VR training platform for minimal invasive surgery.

(2) Fraunhofer Institut für Graphische Datenverarbeitung (IGD), Virtual and Augmented Reality laboratory, Darmstadt, led by Dr.Uli Bockholt, Dr. Didier Stricker and Sabine Webel, on the development of VR training platforms for industrial maintenance and assembly and for minimal investive surgery.

(3) KUKA Roboter GmbH, Augsburg, led by Dr. Ralf Koeppe, Dr. Ulrike Phleps, Dr. Uwe Zimmermann and Volker Schmirgel, on the development of VR training platform for the programming by demonstration robot.

As part of the SKILLS EU Project, ***Prof. Eldad Yechiam*** was the scientific leader of a demonstrator called "Programming by Demonstration". The project focused on the effect of tactile involvement by touching and feeling forces of a large robot on the ability to learn physical rules using this robot (see joint publications by Hulin et al. below).

Most recently, a joint book ("Skill Training in Multimodal Virtual Environments", CRC Press) has been written with the German partners from Skills. The book is co-edited by ***Prof. Daniel Gopher*** and features several chapters that were written jointly by the German partners and Technion investigators. These chapters include a paper by Gavish,

Webel etc. in the topic of training maintenance and assembly skills, and a chapter by Hulin, Yechiam et al. on the effect of tactile involvement on rule learning, which reflect specific collaborations in the project applications.

e.1.10 Decisions from Experience

Prof. Ido Erev and ***Prof. Ralph Hertwig*** (who moved from the Max Planck Institute for Human Development in Berlin to the University of Basel) are working on a large project on decisions from experience. This project has led to many publications (see below in the joint publications section), and many additional interesting observations that are under current investigation. The outcomes of this project were presented in many meetings including:

Erev, I., & Hertwig, R. *Decisions, judgment, and the weighting of rare events*. Presented at the workshop on Information sampling, Heidelberg, Germany May 2002. Also presented at the ESA meeting, Pittsburgh, PA, June 2003; SPUDM, Zurich, August, 2003; The second Asian conference in Business Research, Hong Kong, December 2003.

Erev, I., Shimonovich, D., Shurr, A., & Hertwig, R. *On the effect of base rates in perception studies and base rate neglect in judgment studies*. Presented at the workshop on Intuition and Decision Making, Heidelberg, Germany (February 2004).

Erev, I., Schurr, A., & Hertwig, R. *The psychological impact of rare events*. Presented at the Affect, Motivation and Decision Making International Conference. Ein Boqeq, Israel, December 2006. Also presented at the workshop on Metrology and Social Science, Exeter, UK, June 2007.

e.1.11 Invited talks of German Scholars

Prof. Ido Erev was co-organizer of a conference titled "Learning, Decision-Making and Evolutinary theory: Can we bridge the gap?" (along with Alex Kacelnik, Sharoni Shafir, and Arnon Lotem) that took place in Kfar Blum, Israel, November 7-11, 2010, and was partially funded by the Israel Science foundation. The conference had two invited talks from German scholars: ***Prof. Ralph Hertwig*** (currently at MPI Berlin) and ***Dr. Henrike Hultsch*** (Freie Universitat Berlin).

e.1.12 Learning in Social Interactions

Prof. Ido Erev and his ***PhD student Kinneret Teoderescu*** have participated in the 2010 summer school in experimental economics at the Max Plank institute in Jena. Prof. Erev taught a course on learning, and Kinneret attended the school. This activity has started several research cooperations. One of them led to the following publication:
Wasilios Hariskos, Johannes Leder and Kinneret Teodorescu (2011) Market Entry Prediction Competition 2010. Games, 2, 200-208.

e.1.13 Evolution and Decisions

Prof. Ido Erev has participated in the Ernst Strüngmann Forum (June 19-24, 2011, Frankfurt/Main) on Evolving the Mechanisms of Decision Making: Toward a Darwinian Decision Theory. The forum wrote a chapter that summarizes basic research on variations in decision making. This activity initiated cooperation between ***Prof. Erev*** and ***Dr. Niels Dingemanse*** **(**Department of Behavioural Ecology and Evolutionary Genetics, Max Planck Institute for Ornitholog at Seewiesen), ***Prof. Martin Kocher*** **(**Department of Economics**,** Ludwig-Maximilians-Universität München**)** and Ph.D student ***Max Wolf*** **(**Department of Biology and Ecology of Fishes**,** Leibniz-Inst. of Freshwater Eco.& Inland Fisheries, Berlin).

e.1.14 Beyond rationality

Prof. Ido Erev is starting a new project with ***Prof. Reinhard Selten*** (Dept. of Economics, Bonn University) and two of his students, ***Dr. Sabine Pittnauer*** and ***Dr. Martin Hohnisch*** that focus on the value of economic models that replace the rationality assumption with the assumption of general descriptive model.

In a related project Prof. Erev and ***Dr. Ben Grainer*** (Max Planck Institute of Economics, Strategic Interaction Group, Jena, Germany, and now in University of New South Wales, Australia). This project was presented in several workshops including the workshop on Psychology and Economics, University of Konstanz (December, 2010) and is summarized in the following paper:

Erev, I. and Grainer, B. (in press). On Psychology, Economics, and the Prediction of Human Behavior. Invited chapter submitted to Guillaume F. and Schotter A. (Eds.) The handbook on Methods of Modern Experimental Economics. Oxford University Press

e.1.15 Physiological Correlates of Decision Making Behavior

Dr. Andreas Glöckner (Max Planck Institute for Research on Collective Goods) collaborated *with* ***Prof. Eldad Yechiam*** and ***Guy Hochman*** (Technion, Prof. Yechiam's PhD. student) in a project studying the physiological correlates of decision making behavior. Specifically, the project has aimed to differentiate between brain processes implicated in emotions and cognitions associated with choice outcomes of different probabilities and magnitudes. The collaboration has produced a chapter, as well as a research paper of Glockner and Hochman, (see below in the joint publications section). Another ongoing research project of these three partners is entitled "*The Subjective Significance of Uncertain Behavior: A psychophysiological Approach "*.

e.2 Joint Publications and Publications which are Directly Connected to the Cooperation

Meinecke, C., & Kimchi, R., & Grandegger, C. (2002). Detection asymmetries: Effects of spatial density, spatial regularity, and retinal eccentricity. *Perception & Psychophysics, 64,* 829-843

Hertwig, R., Barron, G., Weber, E., & Erev, I. (2004). Decisions from experience and the weighting of rare events. *Psychological Science,* 15 (8): 534-539.

Hanaki, N., Sethi, R., Erev, I., & Peterhansl, A. (2005). Learning strategies. *Journal of Economic Behavior and Organizations,* 56 (4): 523-542.

Müsseler, J., Nisslein, M., & Koriat, A. (2005). German capitalization of nouns and the detection of letters in continuous text. *Canadian Journal of Experimental Psychology, 59*(3), 143-158.

Grosskopf, B., Erev, I., & Yechiam, E. (2006). Forgone with the wind. *International Journal of Game Theory*, 34, 285-302.

Hertwig, R., Barron, G., Weber, E., & Erev, I. (2006), Risky prospects: When valued through a window of sampled experiences. In K. Fiedler, & P. Juslin (Eds.), *Information sampling and adaptive cognition* (pp. 72-91). Cambridge, England: Cambridge University Press.

Koriat, A., Fiedler, K., & Bjork, R. A. (2006). Inflation of conditional predictions. *Journal of Experimental Psychology: General, 135,* 429-447.

Erev, I., Glozman, I., & Hertwig, R. (2008). What impacts the impact of rare events. *Journal of Risk and Uncertainty, 36 (2),* 153-177.

Erev, I., Shinovich, D., Schurr, A., & Hertwig, R. (2008). On the effect of base rates in perception studies, and base rate neglect in judgment studies. In: H. Plessner, C Betsch and T. Betsch (Eds.), *Intuition in Judgment and Decision Making.* LEA.

Koriat, A., Nussinson, R., Bless, H., & Shaked, N. (2008). Information-based and experience-based metacognitive judgments: Evidence from subjective confidence. In J. Dunlosky & R. A. Bjork (Eds.), *Handbook of memory and metamemory* (pp. 117-135). New York, NY: Psychology Press.

Seibt , B., Neumann, R., Nussinson, R., & Strack, F. (2008). Movement direction or change in distance? Self and object related approach-avoidance movements. *The Journal of Experimental Social Psychology, 44*(3), 713-720.

Yechiam, E., & Gopher, D. (2008). Deliberate suppression of vision as a training tool for multimodal skills. In SKILLS consortium, *Beyond movement: The history and future of gesture analysis* (pp. 80-103). Alinea publishing house.

Biele, G., Erev I., & Ert, E. (2009). Learning, risk attitude and hot stoves in restless bandit problems. *Journal of Mathematical Psychology*. 53, 3,155-167.

Hertwig, R., & Erev, I. (2009), Description–Experience Gap in Risky Choice. *Trends in Cognitive Sciences*, 13, 517-523.

Koriat, A., Ackerman, R., Lockl, K., & Schneider, W. (2009). The memorizing-effort heuristic in judgments of learning: A developmental perspective. *Journal of Experimental Child Psychology, 102,* 265–279.

Koriat, A., Ackerman, R., Lockl, K., & Schneider, W. (2009). The easily learned, easily-remembered heuristic in children. *Cognitive Development, 24,* 169-182.

Nussinson, R., Seibt, B., Häfner, M., & Strack, F. (2009). Come a bit closer: Approach motor actions lead to feeling similar and behaviorally assimilating to others. *Social Cognition*. In press.

Erev, I. Ert, E. Roth, A. E., Haruvy, E., Herzog, S., Hau, R. Hertwig, R. Stewart, T., West, R. and Lebiere, C. (2010). A choice prediction competition, for choices from experience and from description. *Journal of Behavioral Decision Making, 23,* 15-47.

Hochman, G., Glöckner, A., & Yechiam E. (2010). Physiological measures in identifying decision strategies. In A. Glockner and C. Witteman (Eds.), *Tracing intuitions*. Philadelphia: Psychology Press.

Hoffmann-Biencourt, A., Lockl, K., Schneider, W., Ackerman, R., & Koriat, A. (2010). Self-paced study time as a cue for recall predictions across school age. *British Journal of Developmental Psychology*, *28*, 767–784

Hulin, T.; Schmirgel, V.; Yechiam, E.; Zimmermann, U. E.; Preusche, C. & Pohler, G. (2010), Evaluating exemplary training accelerators for Programming-by-Demonstration, Procceedings of RO-MAN, 2010 IEEE', pp. 440 -445.

Koriat, A., & Ackerman, R. (2010). Choice latency as a cue for children's subjective confidence in the correctness of their answers. *Developmental Science, 13,* 441-453.

Koriat, A., & Ackerman, R. (2010). Metacognition and mindreading: Judgments of learning for self and other during self-paced study. *Consciousness and Cognition*, *19*, 251-264.

Ackerman, R., & Koriat, A. (2011) Response latency as a predictor of the accuracy of children's reports. *Journal of Experimental Psychology: Applied*, *17*, 406–417.

Glöckner, A., & Hochman, G. (2011). The interplay of experience-based affective and probabilistic cues in decision making: Arousal increases when experience and additional cues are inconsistent. *Experimental Psychology*, *58*, 132-141.

Yeshurun, Y. & Hein, E. (2011) Transient attention degrades perceived apparent motion. *Perception, 40,* 905 – 918.

Wasilios Hariskos, Johannes Leder and Kinneret Teodorescu (2011) Market Entry Prediction Competition 2010. Games, 2, 200-208.

Koriat, A., Ackerman, R., Adiv, S., Lockl, K., & Schneider, W. (submitted 2012, *Journal of Experimental Psychology: General*). The effects of goal-driven and data-driven regulation on metacognitive monitoring during learning.

Bergemasco M. Bardy B. Gopher D.(Eds.). (in press). *Skill Training in Multimodal Virtual Environments*. Taylor and Francis CRC press.

Erev, I. and Grainer, B. (in press). On Psychology, Economics, and the Prediction of Human Behavior. Invited chapter submitted to Guillaume F. and Schotter A. (Eds.) The handbook on Methods of Modern Experimental Economics. Oxford University Press

Hulin, T., Schmirgel,, V., Zimmerman, U.E., Yechiam, E., Telpaz, A., & Preusche, C. (In press). Training approaches for improving robot programming-by-demonstration skills. In M. Bergamasco, B. G. Bardy, & D. Gopher (Eds.), *Skills Training in Multimodal Virtual Environments*. Taylor & Francis.

e.3 Collaborators from Germany

- Prof. Carlos Alos-Ferrer, Department of Economics, University of Konstanz, Germany.
- Dr. Guido Biele, Max-Planck-Institute, Berlin, Germany.
- Prof. Dr. Herbert Bless, University of Mannheim, Germany.
- Dr. Ulrich Bochhult, Fraunhofer Institut für Graphische Datenverarbeitung (IGD), Virtual and Augmented Reality laboratory, Munich, , Germany.
- Dr. Niels Dingemanse, Department of Behavioural Ecology and Evolutionary Genetics, Max Planck Institute for Ornitholog at Seewiesen, München, Germany.
- Prof. Dr. Edgar Erdfelder, University of Mannheim, Germany.
- Prof. Dr. Klaus Fiedler, University of Heidelberg, Germany.
- Dr. Andreas Glöckner, Max Planck Institute for Collective Goods, Bonn, Germany.
- Dr. Ben Grainer (Max Planck Institute of Economics, Strategic Interaction Group, Jena, Germany), now in University of New South Wales, Australia.
- Prof. Hauke, R. Heekeren Freie Universiät Berlin, and Max Planck Institute for Human Development, Germany.
- Dr. Elisabeth Hein, Universität Tübingen, Tübingen , Germany.
- Anja Hoffmann-Biencourt, University of Wuerzburg, Germany.
- Dr. Martin Hohnisch, Department of Economics, Bonn University, Germany.
- Thomas Hulin, Deutsches Zentrum Raumfahrt E.V. (DLR), Munich, Germany.
- Dr. Masami Ishihara, Department of Psychology, Max Planck Institute for Human Cognitive and Brain Sciences Leipzig, Germany.
- Prof. Martin Kocher, Department of Economics, Ludwig-Maximilians-Universität München, München, Germany.
- Dr. Ralf Koeppe, KUKA Roboter GmbH, Augsburg, Germany.
- Dr. Kathrin Lockl, Otto-Friedrich-University of Bamberg, Bamberg, Germany.
- Prof. Dr. Cristina Meinecke, Friedrich-Alexander-University, Erlangen, Germany.
- Prof. Dr. Jochen Müsseler, Max-Planck Institute for Psychological Research, Munich, Germany. Now in Work and Cognitive Psychology Department, RWTH Aachen University, Germany.

- Dr. Andreas Nicklisch, Max Planck Institute for Collective Goods, Bonn, Germany.
- Prof. Dr. Monika Nisslein, Psychology Department, University of Munich.
  Max Planck Institute for Human Cognitive and Brain Sciences, Leipzig, Germany.
- Dr. Ulrike Phleps, KUKA Roboter GmbH, Augsburg, Germany.
- Dr. Sabine Pittnauer, Department of Economics, Bonn University, Germany.
- Dr. Carsten Preusche, Deutsche Zentrum Raumfahrt e.V. (DLR), Darmstadt, Germany.
- Volker Schmirgel, KUKA Roboter GmbH, Augsburg, Germany.
- Prof. Dr. Wolfgang Schneider, Psychology Department, University of Würzburg, Germany.
- Prof. Reinhard Selten, Department of Economics, Bonn University, Bonn, Germany.
- Prof. Dr. Dagmar Stahlberg, University of Mannheim, Germany.
- Dr. Med. Aglaja Stirn, Clinic for Psychosomatic Medicine of the Johann Wolfgang Goethe-University, and a Research Fellow at the Max-Planck-Institute for Brain Research, Frankfurt, Germany.
- Prof. Dr. Fritz Strack, Psychology Department, University of Würzburg, Germany.
- Dr. Didier Stricker, Fraunhofer Institut für Graphische Datenverarbeitung (IGD), Virtual and Augmented Reality laboratory, Munich, , Germany.
- Dr. Patrick van der Smagt, Deutsche Zentrum Raumfahrt e.V. (DLR), Darmstadt, Germany.
- Prof. Dr. Michaela Wänke - University of Erfurt (now University of Basel).
- Sabine Webel, Fraunhofer Institut für Graphische Datenverarbeitung (IGD), Virtual and Augmented Reality laboratory, Darmstadt, Germany.
- Max Wolf, Department of Biology and Ecology of Fishes, Leibniz-Inst. of Freshwater Eco. & Inland Fisheries, Berlin, Germany.
- Dr. Hubert Zimmer, Psychology Department, Saarland University, Saarbruecken, Germany.
- Dr. Uwe Zimmerman, KUKA Roboter GmbH, Augsburg, Germany.

e.4 Short Term Visits in the Center

- ***Prof. Klaus Fiedler*** and ***Prof. Michaela Wänke*** visited the Center, February 2004, attending the second "Metacognition: A Window to the Conscious and Unconscious Determinants of Behavior" ***DIP project meeting***. The meeting, attended by the Israeli collaborators, ***Prof. Morris Goldsmith*** and ***Dr. Ainat Pansky***. ***Prof. Fiedler*** also gave a formal talk within the framework of Joint University of Haifa – Technion Minerva Seminars. Title of talk: *"Pseudo-Contingencies – an Overlooked Cognitive Illusion"*.
- The second interdisciplinary ***DIP workshop*** (entitled "Metacognition: A window to the Conscious and Unconscious Determinants of Behavior") was held in Haifa, Israel, April 2006. The workshop was attended by the ***DIP researchers*** and graduate students, as well as distinguished social psychologists from around the world, who are leading experts in the areas of metacognition and conscious and unconscious processing. The guest attendants included: Prof. Ap Dijksterhuis, Prof. Ran Hassin, Prof. Nira Lieberman, and Prof. Piotr Winkielman.
- ***Dr. Guido Biele,*** Max-Planck-Institute, Berlin, Germany, has visited the Center in 2006 and also in 2007 (for a total period of five weeks over the two years), as a part of the collaboration with ***Prof. Ido Erev*** and ***Dr. Eyal Ert***. ***Dr. Biele*** also gave a formal talk within the framework of Joint University of Haifa – Technion Minerva Seminars. Title of talk: *"Human Learning in Partially Observable Markov Problems"*.
- ***Prof. Ralph Hertwig***, Max Planck Institute for Human development in Berlin, and University of Basel, Switzerland, has visited the Center in March, 2008, as a part of the collaboration with ***Prof. Erev***. ***Prof. Hertwig*** also gave a formal talk within the framework of Joint University of Haifa – Technion Minerva Seminars. Title of talk*: "Mental Powers: How Less Can Be More"*.
- ***Dr. Andreas Glöckner***, Max Planck Institute for Research on Collective Goods, Bonn, Germany, has visited the Center in May, 2008, as part of the collaboration with ***Prof. Eldad Yechiam*** and ***Guy Hochman*** (Prof. Yechiam's PhD. student). ***Dr. Glöckner*** also gave a formal talk within the framework of Joint University of Haifa – Technion Minerva Seminars. Title of talk**:** *"Investigating Intuition Automatic and Deliberate Processes in Quick Decisions*
- ***Volker Schmirgel, Dr. Uwe Zimmermann*** from the KUKA Roboter GmbH, Augsburg, ***Dr. Carsten Preusche, Thomas Hulin*** from the Deutsches Zentrum Raumfahrt E.V. (DLR), Munich, and ***Sabine Webel*** from the Fraunhofer Institut für Graphische Datenverarbeitung (IGD), Darmstadt, have visited the center in October, 2008, as part of the Haifa meeting of the SKILLS project, collaborating with ***Prof. Daniel Gopher*** and ***Prof. Eldad Yechiam***.

- ***Prof. Boris Velichkovsky***, Dresden University of Technology, Germany, has visited the Center in March, 2009, to discuss future collaboration with ***Prof. Joel Norman***. He also gave a formal talk within the framework of Joint University of Haifa – Technion Minerva Seminars. Title of talk: "*From Studying Cognitive Systems to Developing Cognitive Technologies*".

e.5 Short-Term Visits of the Center's Members in Germany

- ***Prof. Ruth Kimchi*** was invited to give the 2002 Max Wertheimer Lecture in Frankfurt, Germany, December, 2002.
- ***Prof. Asher Koriat*** and ***Prof. Morris Goldsmith*** attended the first "Metacognition: A Window to the Conscious and Unconscious Determinants of Behavior" ***DIP project general meeting***; held in Heidelberg, Germany, January 2003. The meeting was attended by the collaborating researchers from Israel and Germany, as well as graduate students of cognitive and social psychology from both Israel and Germany.
- ***Prof. Asher Koriat*** and ***Prof. Morris Goldsmith*** attended an interdisciplinary ***DIP workshop*** on social metacognition, held in Heidelberg, Germany, July 2004. The workshop was attended by the DIP researchers, as well as distinguished cognitive and social psychologists from around the world, who are leading experts in the areas of metacognition and conscious and unconscious processing. The guest attendants included: Prof. Robert Bjork, Prof. Elizabeth Bjork, Prof. Pablo Brinnol, Prof. David Dunning, Prof. Larry Jacoby, Prof. Marcia Johnson, Prof. Colleen Kelley, Prof. Arie Kruglanski, Prof. Steve Lindsay, Prof. Norbert Schwarz, Prof. Zakary Tormala, and Prof. Bruce Whittlesea.
- ***Prof. Erev*** has visited ***Dr. Guido Biele*** in the Max Planck institute in Berlin, for their collaborative work, November, 2005.
- ***Prof. Asher Koriat*** was invited to be a keynote speaker at The 20th Anniversary International Conference on Systems Research, Informatics and Cybernetics, July, 2008, Baden-Baden, Germany.
- ***Prof. Daniel Gopher*** visited ***Prof. Dietrich Manzey*** and the Human Factors program at TU Berlin, on July 2008, and conducted a joint faculty seminar on the topic of "Training and development of high demand skills".
- ***Prof. Daniel Gopher*** and ***Prof. Eldad Yechiam*** have attended four **SKILLS** meetings in Germany for review of work progress, design of future work, and training sessions: (1) December, 2006, in DLR – Oberpfaffenhofen. Munich. (2) July, 2008, in Fraunhofer-Gesellschaft zur Förderung der angewandten, Darmstat. (3) December, 2008, in Kuka Roboter, Augsburg. (4) October , 2010 in Fraunhofer-Gesellschaft zur Förderung der angewandten, Darmstat.

- ***Prof. Eldad Yechiam*** has visited ***Dr. Andreas Glöckner*** in Berlin while attending the International Conference of Psychology, in July, 2008.
- ***Prof. Daniel Gopher*** was invited to organize a session on "Individual Differences in Executive Control" and gave a lecture on "The factorial structure of the differences between individuals in their ability to focus on a task and switch between tasks", at the XXIX International Congress of Psychology**,** July 2008, Berlin, Germany.
- ***Prof. Erev*** has visited ***Prof. Carlos Alos-Ferrer*** of Konstanz University, in September 2008. This led to the planning of a joint research project.
- ***Guy Hochman*** (Prof. Eldad Yechiam's PhD. student) has visited ***Dr. Andreas Glöckner***'s lab in Germany for their collaborative work in October, 2008.
- ***Prof. Daniel Gopher***, ***Dr. Nirit Gavish*** and ***Dr. Stas Krupenia*** visited DLR in Munich to coordinate research work of **Skills** project, in December 2008.
- ***Prof. Asher Koriat*** has visited ***Prof. Wolfgang Schneider*** (Würzburg) and ***Dr. Kathrin Lockl*** (Bamberg) in September, 2009, to progress their collaborative GIF project ("The intricate relationships between metacognitive monitoring and metacognitive control during learning: A developmental perspectives").
- ***Eldad Yechiam*** was an invited speaker in the EADM Workshop on Intuition: Methods and Recent Findings, which took place in Bonn, Germany, on May, 2010. The workshop was coordinated by ***Dr. Andreas Glöckner***.
- ***Prof. Ido Erev*** was invited to teach a five-session course on "Learning and the Economics of Small Decisions" in the International Max Planck Research School on "Adapting Behavior in a Fundamentally Uncertain World" that was held in Jena, Germany, July and August 2010.
- ***Prof. Ido Erev*** has presented his joint project with ***Ben Grainer*** (Max Planck Institute of Economics, Strategic Interaction Group, Jena, Germany, and now in University of New South Wales, Australia) in a workshop on Psychology and Economics, University of Konstanz, December, 2010.
- ***Prof. Ido Erev*** has participated in the Ernst Strüngmann Forum on Evolving the Mechanisms of Decision Making: Toward a Darwinian Decision Theory, in Frankfurt/Main June 19-24, 2011.
- ***Dr. Yaffa Yeshurun*** was invited to give a talk at the CITEC Colloquium, Bielefeld University, Germany, June 2011: "Transient attention and the interplay between the temporal and spatial domains of perception".
- ***Prof. Asher Koriat*** was invited to give a Keynote Address at the 54th Meeting of Experimental Psychologists (TeaP), Mannheim, Germany, April, 2012. (Declined for family reasons).

e.6 Joint University of Haifa – Technion Minerva Seminars Hosting German Collaborators

- Dr. Andrea Kiesel, University of Würzburg, Germany.
  Parallel Activity of Task Sets - Evidence from Subliminal Priming in Task Switching
- Dr. Jochim Hansen, University of Basel, Switzerland.
  The Role of Expectation in the Ease of Retrieval Effect
- Prof. Dr. Klaus Fiedler, University of Heidelberg, Germany.
  Pseudo-Contingencies – an Overlooked Cognitive Illusion
- Prof. Dr. Hans J. Markowitsch, University of Bielefeld, Germany.
  Brain Imaging Correlates of Patirnts with Emotion-Related Memory Disorders
- Prof. Ralph Hertwig, Max Planck Institute for Human development in Berlin, and University of Basel, Switzerland.
  Mental Powers: How Less Can Be More
- Dr. Andreas Glöckner, Max Planck Institute for Research on Collective Goods, Bonn, Germany.
  Investigating Intuition Automatic and Deliberate Processes in Quick Decisions
- Dr. Andreas Nicklisch, Max Planck Institute for Research on Collective Goods, Bonn, Germany.
  Wage Differentials, Fairness, and Social Comparison: An Experimental Study of Interrelated Ultimatum Bargaining
- Prof. Boris Velichkovsky, Dresden University of Technology, Germany.
  From Studying Cognitive Systems to Developing Cognitive Technologies
- Dr. Masami Ishihara, Max Planck Institute for Human Cognitive and Brain Sciences Leipzig, Germany.
  Horizontal Spatial Representations of Number and Time
- Prof. Jochen Braun, Otto-von-Guericke University, Magdeburg, Germany.
  Why is Visual Perception Multi-Stable?
- Prof. Wolfgang Prinz
  Action Simulation: Exploring Representational Underpinnings of Unseen Action

e.7 Minerva Workshops Hosting German Collaborators

- **The 1st Minerva Workshop: Decisions from Experience**

* Prof. Ralph Hertwig
Bernoulli Goes Cognitive
Ph.D. Student Nira Munichor
Risk Attitude in Small Timesaving Decisions
Dr. Morris Goldsmith
On the (Potential for Stronger) Mutual Relations between Decision-Making and basic Cognitive Research- An open discussion

- **The 6th Minerva Workshop: on Small Decisions**

* Dr. Guido Biele
Human Learning in Partially Observable Markov Problems
Amos Schurr
Two Systems, Careful Analysis, and Base Rate Neglect
Dr. Ro'i Zultan
Peak or Rare
Dr. Shahar Ayal and Guy Hochman
The Priority Heuristic, Confidence and Reaction Time

- **The 10th Minerva Workshop**

* Martin Hohnisch, * Sabine Pittnauer, * Reinhard Selten and * L. Kramer (U. of Bonn)
Taste Characteristics and the Deployment of Selection Procedures
Yael Steinhart
Whether You Win or Whether You Lose: The Differential Risk Of Priming tThe Deliberative and Affective Systems in On-Line Auctions
Eitan Gerstner
Brands as Investments

- **The 15th Minerva Workshop: on Cognition and Organizational Behavior: In Honor of Daniel Gopher and Miriam Erez**

Day 2: Organizational Behavior in Honor of Miriam (Mia) Erez
Climate and Innovation (Chair: Cynthia Lee)
Ben Schneider
An Historical Overview of the Service Climate Research Paradigm
Dov Zohar
What is the Difference between Organizational Climate and Culture (and Why do People Mix the Two)?

*Michael Frese
Toward a Psychology of Entrepreneurship - An Action Regulation Theory Perspective
Motivation (Chair: Avi Kluger)
Ed Locke
The Effect on Performance of Having Simultaneous Learning and Performance Goals
Gary Latham
The Importance of Subconscious Goals for Influencing Organizational Behavior
Dov Eden
Means Efficacy: A Motivational Construct Whose Time Has Come
Cross-Culture and Emotions (Chair: Julia Bear)
Anat Rafaeli
Emotions at Work
Simcha Ronen
Ecocultural Predictors of Country-Culture clusters
Chris Earley
Cultural Intelligence and the Evolution of Cross-Cultural OB
Innovation Center - Iris Arbel
Panel of former students (short presentations): Eitan Naveh, Ester Unger-Aviram, Dana Vashdi, Ella Miron-Spektor, Alon Lisak (Chair: Cynthia Lee)
Mia Erez

e.8 Post Docs and Graduate Students

- ***Dr. Ravit Levi-Sadot*** (***Nussinson***) - received her PhD. under the supervision of ***Prof. Asher Koriat*** in 2001. During 2001- 2002 she held a Post Doc position at the University of Würzburg, Germany (under the supervision of ***Prof. Dr. Fritz Strack***). ***Dr. Nussinson*** is one of the participating researchers in BMBF – **DIP** Project (2002-2006). While in Germany she established new opportunities for cooperation between researchers from the Minerva Center and German institutes. ***Dr. Nussinson*** continues to cooperate with German researchers, current and former members of the Würzburg group (see joint publication section).
- ***Eva Smolka*** - finished her M.A. at the Center (under the supervision of Dr. Zohar Eviatar, 2002), and her Ph.D. at the Philipps-University of Marburg, Germany. She is working on a psycholinguistic project under Prof. Rösler (Psychology) and Prof. Wiese (Linguistics). The project combines the study of language representation and ERP studies. Specifically, Eva's thesis deals with *"Word Representations in the Mental Lexicon"*.

- ***Dr. Jochim Hansen***, then a PhD student supervised by Michaela Wänke, spent a two-week research internship (March, 2004) at the University of Haifa, supervised by ***Prof. Asher Koriat, Prof. Morris Goldsmith,*** and ***Dr. Ainat Pansky***. During his visit, ***Dr. Hansen*** met the researchers and graduate students at the Haifa lab, and presented a lecture to the Haifa group, titled: "*The Role of Expectation in the Ease of Retrieval Effect*".
- ***Dr. Eyal Ert*** (then a graduate student at the Technion) has participated in the 2004 summer school at the Max-Planck Institute for Human Development in Berlin. During the summer school he worked with ***Dr. Andreas Nicklisch*** (then a graduate student at the Max-Planck Institute on Collective Goods in Bonn) on the effect of uncertainty in trust games. ***Dr. Ert*** and ***Dr. Nicklisch*** won a Minerva fellowship that supported their joint research. ***Dr. Nicklisch*** has spent two weeks at the Minerva Center in the Technion during 2006, and has visited Israel again in 2007. ***Dr. Ert*** and ***Dr. Nicklisch*** completed one project (see joint publication section), and plan to continue their cooperation.
- ***Dr. Guido Biele*** (Max-Planck-Institute, Berlin) collaborates with ***Prof. Ido Erev*** and ***Dr. Eyal Ert***. This research project started when ***Prof. Erev*** visited the Max Planck institute in Berlin in 2005. Important parts of the project where conducted when ***Dr. Biele*** visited the Minerva center in Haifa in 2006 and 2007. A paper that describes the results of the first part of the project (See Biele et al., 2009) appeared in Journal of Mathematical Psychology (described at the Individual Research Reports section).
- ***Dr. Andreas Nicklisch*** (Max Planck Institute for Collective Goods, Bonn) visited Israel in December, 2006 to present a joint work with ***Dr. Eyal Ert*** in the Affect, Motivation, and Decision Making Conference in Ein Bokek. ***Dr. Nicklisch*** visited the Technion in November 2007 in order to work with ***Dr. Ert*** on their project and to give a formal talk, titled: "*Wage Differentials, Fairness, and Social Comparison: An Experimental Study of Interrelated Ultimatum Bargaining*".
- ***Dr. Massami* Ishihara** from the Max-Planck Institute of Cognitive and Brain Sciences has spent a week (May, 2009) at the Minerva Center at the University of Haifa. ***Dr. Ishihara***, collaborating with ***Prof. Koriat***, ran experiments with Hebrew speaking participants at the Center. ***Dr. Ishihara*** also gave a formal talk within the framework of Joint University of Haifa – Technion Minerva Seminars, titled: *"Horizontal Spatial Representations of Number and Time"*.

f. Future Activities and Research Plan

f.1 Future Work on Metacognition in Learning and Memory

f.1.1 The Subjective Confidence in One's Decisions

An attempt will be made to pursue Koriat's research published in *Psychological Review* (2012) and *Science* (2012) in several directions.

1. Generalization of the model to other domains. So far the self-consistency model of subjective confidence has been found to hold true for word matching, semantic memory, episodic memory, social beliefs, social attitudes, and perceptual judgments. We wish to extend investigation to the prediction of others' decisions. This extension has important implications. For example, the model implies that in the case of economic behavior, confidence in one's investment decision should predict the likelihood that others will make the same investment. The expected result should be a general escalation in which decision makers converge on the same investment decisions. In some cases this process alone may lead to a speculative bubble as suggested by initial simulations.
2. The study reported in *Science* did not involve actual group decisions. The plan is to use group decisions under different conditions, including the Delphi procedure. The hypothesis that will be examined, is that when individual decisions are basically wrong, group interaction should exacerbate the situation, yielding decisions that are even less accurate than the individual decisions. This should occur under certain conditions. However, under other conditions (that will be specified) inter-individual interactions should always be beneficial. Indeed, dyadic interactions have been found to alleviate faulty judgments under some conditions (Koriat, 2008a).
3. The work on confidence yielded a curious effect, named "choice-independent confidence" (CIC, Koriat, 208b): For forced-choice two-alternative general-information questions, confidence in the correctness of the answer differed reliably for different questions, regardless of which answer was chosen. That is, for some items people were relatively more confident than others regardless of their choice. Subsequent exploratory work suggested that the CIC effect is obtained for some domains but not for others. The results do not lend themselves to a simple interpretation, and more work is wanted.

Koriat, A. (2008a). Alleviating inflation of conditional predictions. Organizational Behavior and Human Decision Processes. 106, 61–76.

Koriat, A. (2008b). When confidence in a choice is independent of which choice is made *Psychonomic Bulletin and Review*, *15*, 997-1001.

Koriat, A. (2012). The self-consistency model of subjective confidence. *Psychological Review, 119*, 80-113.

Koriat, A. (2012). When are two heads better than one and why? *Science, 336*, 360-362.

f.1.2 The Metacognitive Regulation of Memory Accuracy and Informativeness

Prof. Goldsmith's research on metacognitive regulation of accuracy and informativeness in memory reporting will continue. In particular, the research is presently focused on the examination and isolation of front-end (control of retrieval) and back-end (monitoring the products of retrieval and control of reporting) components. Funding of this line of research by the U.S.-Israel Binational Science Foundation (BSF) has ended, and it is now supported entirely by the Minerva center (until additional funding can be secured). Prof. Goldsmith will continue his collaboration both with Prof. Larry Jacoby, and with Dr. Vered Halamish, who has returned from her post-doctoral studies with Prof. Robert Bjork at UCLA, and next year will be doing a second post-doc at the Open University of Israel. We are using our newly developed META-RAR methodology to examine the role of front-end and back-end processes in mediating a variety of memory effects and phenomena, such as the "testing" effect, source-monitoring mode, encoding-retrieval interactions, and more.

f.2 Visual Perception and Attention

f.2.1 Perceptual Organization, Visual Attention, and Visual Awareness

Prof. Kimchi and her associates plan to continue their investigation, focusing on the following:

- An ongoing project (with collaboration with Dr. Yaffa Yeshurun) focuses on the influence of perceptual organization on the automatic deployment of attention. Once we have demonstrated that perceptual "object" captures attention, we can now ask which organization factors (e.g., collinearity, closure, proximity, etc.) are necessary for a spontaneous attraction of attention to the "object". This research may provide us with a clue to the nature of "objecthood".
- Research concerning the role of attention in perceptual organization yields inconsistent results (Kimchi, 2009). We intend to further explore this issue (in collaboration with doctoral student Einat Rashal). In particular, we examine the hypothesis that attention is required to resolve a competition between potential competing organizations.
- Examination of the selective aspect of perceptual organization, the organizing function of attention, and their relation to visual awareness, in an attempt to develop an interactive framework for our understanding of the relations between these important functions of our perceptual system.
- Following the Gestalt tradition, much of the research on perceptual organization examines individual organization principles under conditions in which all else is equal. The perceptual system, however, integrates many organization cues, and often operates in a rich environment. We intend to examine organizational processes in the context of richer, more complex visual scenes.

f.2.2 Object recognition and Visual Attention

f.2.2.1 *Role of Attention in Object Recognition*

Prof. Ruth Kimchi, Prof. Morris Goldsmith and Dr. Orit Baruch will continue their collaborative project on the role of attention in object recognition.

f.2.2.2 *Control of Visual Attention to Objects and Space*

There are ongoing projects in each of the three main branches of Prof. Goldsmith's research: the role of spatial focus of attention in object-based attentional selection, strategic control of object-based attention, and attentional navigation of hierarchically structured displays.

f.2.3 Attentional Mechanisms

Dr. Yaffa Yeshurun's research plans for the coming years will follow several research paths that explore, from different angles, the role that attention plays in the processing of visual information. The main research path investigates the effects of transient attention on both the temporal and spatial aspects of perception in order to deepen our understanding of perceptual tradeoffs. Another research path involves evaluation of computational models of visual search; and the last path discussed here involves the development and testing of a computational model of attention that simulates attentional shifting of receptive fields. Future plans for these three paths are discussed below. Other research projects that are not detailed here (for the sake of brevity) include the exploration of the interplay between attention and perceptual organization, and a project that explores the effects of perceptual load on the efficiency of the attentional selectivity when measured under both highly controlled conditions and under conditions that resemble real life. The former project is conducted with Prof. Ruth Kimchi and the latter with Dr. Hadas Marciano, both from the Minerva Center, University of Haifa.

f.2.3.1 *The Effects of Transient Attention on the Temporal and Spatial Aspects of Perception*

This research path involves several directions of investigation:

Transient Attention and Selective Adaptation

I have previously suggested that several effects of transient attention on various temporal and spatial aspects of perception can be explained by an attentional mechanism that facilitates spatial segregation and temporal integration but impairs spatial integration and temporal segregation (e.g., Yeshurun & Hein, 2011; Yeshurun & Levy, 2003; Yeshurun & Marom, 2008). One possible physiological implementation of this mechanism suggests that transient attention favors parvocellular over magnocellular neural activity (e.g., Yeshurun & Sabo, 2012). Here, selective adaptation is employed as a tool for testing this hypothesis.

Attention and Adaptation to Spatial Frequency and Orientation: Because the processing of high spatial frequency is associated with parvo activity and the processing of low spatial frequency is associated with magno activity, if transient attention favors parvo over magno activity it should magnify adaptation effects with high frequency but minimize them with low frequency.

Attention and Motion Adaptation: It has been previously shown that the direction of the motion aftereffect (MAE) that results from adaptation to a plaid composed of both high and low spatial frequency gratings that are moving in opposite directions depends on whether the MAE is tested with a static or flickering stimulus. With a static stimulus that activates sustained channels (corresponding to parvo activity) the MAE is in the opposite direction

to that of the high frequency grating. But with a flickering stimulus, which activates transient channels (corresponding to magno activity), the MAE is in the opposite direction to that of the low frequency grating (Shioiri, Matsumiya & Tamura, 2008). Given the above hypothesis, transient attention should prolong MAE with a static stimulus but shorten it with a flickering stimulus.

Data collection with these two projects has already started, and will be finalized in the near future.

Spatial and Temporal Crowding and the Role of Transient Attention

We have previously demonstrated that transient spatial attention improves overall performance under conditions of spatial crowding, and most importantly reduce of the critical distance over which crowding takes place (Yeshurun & Rashal, 2010). Currently and in the future we focus on temporal crowding (i.e., when the target is surrounded by other stimuli in time rather than space) and possible interactions between spatial and temporal crowding. Because previous studies only looked at temporal crowding at the fovea, and only demonstrated a low level of temporal crowding, we started with testing whether higher levels of temporal crowding can be found with peripheral targets. We are also exploring visual displays that include both temporal and spatial crowding to evaluate the relationships between these two types of crowding. Once this is established we intend to add manipulation of spatial, and possibly temporal, attention to test whether corresponding attentional effects can be found with temporal crowding as was found for spatial crowding.

f.2.3.2 ***Computational Modeling of Visual Search***

This work is conducted in collaboration with Dr. Tamar Avraham and Prof. Michael Lindenbaum from the Technion.

In this work we develop and test computational models of visual search that takes into account various effects of grouping. We started with two models that predict the effects of elements similarity (e.g., distracter homogeneity and target-distracter similarity) on visual search, and demonstrated that these models can predict human performance better than several prominent models of visual search (Avraham, Yeshurun & Lindenbaum, 2008). Currently we focus on the development and testing of a third, extended model that can also account for the effect of spatial proximity. The first two models were based on the distribution of the pair-wise feature differences between display elements, and they therefore only took into account feature-wise differences. In the extended model the pair-wise feature differences are replaced by a distance measure that is a superposition of the feature-wise differences and the spatial distance. This enables the model to predict, for instance, that visual search is easier when the stimuli are spatially clustered by similarity

than when the same stimuli are randomly located. Accordingly, our current and future experiments include manipulations of both features similarity and spatial arrangement.

f.2.3.3 ***Attention as an Attractor of Receptive Fields***

This work is conducted in collaboration with Dr. Orit Baruch from the Minerva Center, University of Haifa.

In this project we develop and test a computational model that portrays the attentional mechanism as an attraction field: The allocation of attention to a location attracts (shifts) the centers of receptive fields towards this location. We performed several model simulations showing that this attentional attraction of receptive fields can serve as a simple unifying framework to explain a diverse range of attentional effects including gain enhancement, enhanced contrast sensitivity, enhanced spatial resolution, prolonged perceived duration, degraded temporal resolution, multiplicative and non-multiplicative modulations of neuronal response and suppressed response surrounding the focus of attention. Thus, this model links physiological measurements at the unit level with psychophysical observations of both the spatial and temporal domains of perception. Currently we work on further development of the model, like the addition of base activity and normalization processes, to ensure it will resemble more closely the already known characteristics of the visual system. We also intend to conduct several critical psychophysical tests of the model's predictions to support the model's assumptions and ensure that the model is indeed relevant for our understanding of visual attention.

f.2.4 Human Factors

Among the many topics we have been working on at the Ergonomics and Human Factors Unit, we will continue working on high-level displays, especially stereoscopic and autostereoscopic (no glasses needed) displays. In addition, we have fairly recently acquired a research driving simulator and we are planning a series of studies utilizing it that we hope will be funded by several big companies in the automotive industry. Four of these planned studies are briefly described below:

Designing Virtual Displays (Huds) for Optimal Driving Performance and Minimal Distraction of the Driver's Attention

Automotive Head-Up Displays (HUDs) present driving information on the windshield. Ostensibly these displays seemingly improve driving safety as the driver does not need to look down at the dash board while driving. However, HUDs also raise many HMI (Human-Machine Interface) problems that are liable to lead to accidents. These problems are sensory, perceptual, and cognitive in origin. We propose to develop HUD displays that will mitigate these problems. We will seek optimal placement locations and optimal

optical projection distances to attenuate the sensory and perceptual problems. Importantly, we will devise displays that do not encumber the human attentional mechanism. We will base this on the fairly recent notion of two visual systems – a fast automatic system that does not burden attention and a slower "cognitive" one that does – trying to supply the driver with information via the automatic system.

Introducing Driver Eye-Tracking to Better Channel the Driver's Attention

We propose to examine the possibility of introducing an eye-monitoring system into cars that will be able to caution the driver of an impending accident. Studies show that the pattern of eye-movements can serve as an indication of driver distraction and on the probability of occurrence of accidents and near accidents. Importantly, there exist algorithms that are capable of predicting accidents with relatively high reliability on the basis of monitoring eye-movements as the driver gazes at the outside world. What is more, monitoring eye-movements can indicate inappropriate driving behavior, such as the driver not looking at the mirrors with sufficient frequency. We will examine candidate algorithms to see how well they predict accidents, the optimal method of cautioning the driver, the best cautionary alarms for the different eye-movement patterns (e.g., the alarm for looking for a long time at objects not on the road should be different from the alarm for lack of alertness evidenced by not looking at the mirrors). In addition we will examine the efficiency of the various alarms, the driver's attitude towards them, and their effectiveness over time.

Developing Sophisticated Warning Signals that Do Not Distract the Driver

Recently we have witnessed a massive growth in the development of various in-car technologies intended to improve road safety. Typical examples are warning systems aimed at warning the driver of various kinds of hazards. These systems may dramatically change the nature of the driving task. On the one hand, they have the potential of reducing or even preventing collisions. On the other hand, they may also increase the driver's cognitive load, and possibly distract the driver's attention so as to compromise safety. In other words, these "intelligent" systems may theoretically improve road safety by compensating for human limitations, but their implementation may limit some of their potential benefits, or even worse, reduce road safety. We plan to develop superior warning systems that would not suffer from HMI deficiencies. We will experimentally test several alternative warning systems seeking to find the best design that would warn the driver about impending hazards without distracting her from the driving task.

Examining the Interaction between the Driver and Advanced In-Car Automatic Systems

Among the many new ITSs (Intelligent Transport Systems) currently being developed are Intelligent Speed Adaptation (ISA) systems. These include a wide variety of systems that serve to limit the speed of the vehicle. The most nonintrusive forms of ISA only

provide the driver with constant information about the speed limit without influencing the vehicle speed. The most intrusive ISA systems affect the vehicle control by restricting the vehicle's speed to that of the road's speed limit. These systems raise many HMI questions, such as the perils involved in an intrusive system that limits speed even in overtaking maneuvers. Other problems relate to the reliability of the system and its effects on the trust of the drivers in the system. What is more, it is hard to deploy these systems and their widespread adoption has not yet been implemented, mainly because drivers are unwilling to not control the car's speed. We plan to develop an ISA that will be optimally designed to limit speeds without the concomitant undesirable consequences. We will examine several alternative ISA systems seeking the system that combines effective speed control while not eliciting accompanying behavioral problems, such as distracting the driver, arousing animosity towards the system, and others.

f.3 Decision Making

f.3.1 Decisions from Experience

Prof. Ido Erev and his associates intend to continue the extension of the study of decisions from experience in three directions. One direction involves the clarification of learning in dynamic setting. Our recent research suggest that the basic properties of decisions from experience is static settings can be capture with contingent sampling models that approximate the optimal learning strategies in dynamic settings. That is, agents behave "as if" they assume that their outcome is a function of the state of nature, and this state is determined by an unobserved Markov chain. We plan to explore this hypothesis by studying learning in Markov environments.

A second direction involves learning among cognitive strategies. For example, in a recent research (Teoderescu & Erev, 2012) we examine the decision to explore. Our results suggest that the decision to explore reflect the basic properties of decision from experience. Thus, it is possible to predict the conditions that lead to over-exploration and to under-exploration.

In a third line of research we plan to explore the implications of the basic properties of decisions from experience on the design of laws and regulations that facilitate efficient social interactions.

f.3.2 Understanding the Effects of Losses through the Prism of Attention

In a recent series of papers we have highlighted an attentional model for the effect of losses on cognition and behavior (see review in Yechiam & Hochman, in press). This set of studies challenged the so call "tilted scales" model of losses where losses are given more weight than gains; and suggested that the effect of losses is modulated by attention. Under the attention-based model losses lead to greater investment of cognitive resources and time, but this produces general sensitivity to the task incentive structure, and not merely to its loss component. In the next set of studies in this project we aim to examine new predictions implied by the attentional model of losses, as well as to explain additional findings through attentional perspectives. The new predictions include: 1) Delayed effects of experiencing losses on search behavior and performance. For example, a re-analysis of a previous dataset of experience based tasks (Ert & Yechiam, 2011) reveals that following tasks with losses individuals show more choice switching than following tasks with gains, a phenomenon we refer to as "loss restlessness". This ‘after effect’ of losses may shed light on related regularities in the stock market, such as the leverage effect. 2) The effect of losses on performance is expected to be more pronounced when attentional resources are poor, because in this condition performance is more dependent on the magnitude of attentional resources assigned to the task.

We also plan to examine whether the contrast effect of losses (Slovic et al., 2002) could be driven by attentional effects of losses as well. The contrast effect is the finding that a small loss coupled with a large gain improves the attractiveness of this gain. It is posited that increased risk taking in this situation is due to the increased task attention, which leads to a realization that risk taking is not disadvantageous. A related effort will be to examine whether we can replicate effects of losses on behavior (e.g., a positive effect on performance, increased choice switching, and the contrast effect) without losses, using only attentional manipulations. This effort has some potential applications to disciplinary techniques. Parents sometimes over-use punishments, and acquiring alternative attention-inducing techniques may improve their ability to instruct children in a more positive atmosphere.

Referenes

Ert, E., & Yechiam, E. (2010). Consistent constructs in individuals' risk taking in decisions from experience. *Actza Psychologica*, *134*, 225-232.

Slovic, P., Finucane, M.L., Peters, E., & MacGregor, D.G. (2002). The affect heuristic. In T. Gilovich, D. Griffin, & D. Kahneman (Eds.), *Heuristics and biases: The psychology of intuitive judgment* (pp. 397-420). New York: Cambridge University Press.

Yechiam E., & Hochman, G. (in press). Losses as modulators of attention: Review and analysis of the unique effects of losses over gains. *Psychological Bulletin*.

f.3.3 The Moderating Role of Losses and other Environmental Cues on the Relation between Physiological Predisposition to Take Risk and Actual Risk Taking Behaviour

The construct of risk taking will be studied by assessing the relations between tonic arousal, EEG asymmetry, and risk taking behavior. Several theories of personality have proposed that high aroused individuals tend to exhibit risk aversion. Similarly, relations have been found between frontal EEG asymmetry and risk taking behavior. We posit that these brain-behavior associations are activated much more strongly in risks with losses, as losses increase arousal and trigger relevant traits associated with the sensitivity to risk. In an initial study we (Yechiam & Telpaz, 2011) have shown that the negative correlation between risk taking and arousal only surfaces for risk taking with losses; and thus "to take risk is to fact loss" at least when considering the relation between stable bodily signals (i.e., tonic arousal) and behavior.

Three studies are planned in order to test and extend this general hypothesis. In study 1 we will examine the relation between tonic arousal, frontal EEG asymmetry, and risk taking in laboratory risk taking tasks that either include or do not include losses. Recent studies of the frontal EEG asymmetry have shown that greater left frontal activity predicts higher behavioral activation sensitivity (e.g., Harmon-Jones & Allen, 1997;

Sutton & Davidson, 1997), and, in some studies, lower behavioral inhibition sensitivity (Sutton & Davidson, 1997). Similarly to arousal, it has been argued that behavioral activation/inhibition is highly associated with risk taking behavior. We posit that the implied relationship between frontal EEG asymmetry and risk taking will be moderated by losses. In Study 2 we will examine whether an association between physiological predisposition factors, such as arousal and frontal EEG asymmetry, and risk taking may also be enhanced (in the absence of losses) by environmental signals communicating the importance of the outcomes (e.g., by manipulating payoff size) and by attentional manipulations. Finally, in Study 3 (pending on external funding) we will investigate whether losses also moderate the relation between carrying the short version of the Serotonin transporter (5-HTTLPR) and risk taking behavior. This genetic compound was previously found to be associated with risk avoidant behavior (Kuhnen & Chiao, 2009). It is expected that the relation with actual risk taking behavior would be stronger with losses. Through these studies we hope to clarify the role of environmental signals in moderating the relation between tonic physiological predispositions to take risk and actual risk taking behavior

f.4 Skill Acquisition and Executive Control

The topics of Prof. Gopher's present and planned research with the Minerva center follow and elaborate on the work and knowledge that has been accumulated in the study of Executive control and skill acquisition. As before, efforts combine basic research and application work.

f.4.1 Training Executive Control in Young and Old Adults Employing Videogame Environments

This is a continuing collaborative research effort between Prof. Yaakov Stern at Columbia University and Prof. Daniel Gopher and their research teams.

Evaluating and combating the influences of age and medical conditions on functional cognition at old age has become a central topic of interest in contemporary aging research. Of special focus have been the study of decline in executive control capabilities and the development of intervention modes that may preserve these capabilities and slow their decline. A major claim of the present proposal is that complex and dynamic tasks, instantiated in a computer game like environment, may be a good training and testing paradigm to explicate aspects and dimensions of attention management and executive control capabilities. When compared in young and old adults they may enable examination of the differential nature and pace of the decline across the life span, as well as the linkage between learning and training to notions of cognitive reserve and the profile of individual differences in cognitive capabilities. We study and compare training, skill acquisition and transfer of young and old adults on two very different game like environments, Space Fortress and the Breakfast Task, both programmed to present subjects with complex, dynamic and challenging demands calling for attention management and adoption of executive control strategies. However, Space Fortress has a strong emphasis on motor control, while the Breakfast Task is more cognitive and does not include such a requirement.

We employ training and transfer research paradigms to study executive control and compare emphasis change and no emphasis training in young and old adults. Training and transfer are tested using two different computer games tasks both emphasize executive control, but differ in their basic ability structure. Employing game like environments in both training and transfer phases of the study is consistent with our general claim that computer games provide a richer and challenging research environment, which is also closer to daily life. As indicated, the aim is to identify two tasks imposing high executive control demands, but based on very different component skills. Such a difference will enable to better examine a possible distinction between the acquisition and transfer of the higher level executive control competencies, from

those associated with the basic ability composites of the performed task. Because in the Space Fortress game there is such a high demand of complex motor control, we were searching for a task in which motor capabilities are not a dominant factor in game performance. Employing one task in training and the other in transfer and switching them, may enable us to examine the generalization of acquired executive control skills, over and beyond the specific training environment in which they were acquired. Moreover, experimenting with the emphasis change protocol in two very different performance contexts may shed light on the interrelation between the executive control skill level and its operands. Although some work along this line has already been reported (e.g. Kramer, Larish & Strayer 1995. Gopher 1993), it was not done on tasks of the complexity and difficulty of the computer games proposed for the present work, and not over the length of training planned for the present studies.

The comparison between young and old adults performing the same tasks and undergoing the same training protocols is not less intriguing. Assuming that on the average basic ability levels are higher in young than in old adults, one important question is whether the relative contribution and potency of executive control training of the type represented by the EC protocol is similar in young as in old adults? Some indication that this may not be the case is hinted by the difference between the efficiency of EC training in all previous young adult studies as compared with the lower performance levels obtained in our preliminary study of Space Fortress in old adults. On the one hand it is possible that if threshold levels in basic abilities cannot be maintained, higher level executive skills cannot be trained or benefits less from training. On the other hand it is possible that improved executive abilities may at least partially compensate for basic ability deficits. This is one idea embedded in the Cognitive Reserve notion (Stern, 2008).

f.4.2 Technology Inspired Rehabilitation

This direction of research and development follows the conceptual framework knowledge and experience which were acquired in the Skills project. We specifically focus on motor and cognitive rehabilitation of impaired performance following a trauma, with the intention to employ technologies and machine learning models that were developed during the 5 years of the skill project for the study of functional impairment and development of new rehabilitation protocol. Collaborators to the Technion group are: Massimo Bergamasco and Antonio Prisoli from PERCRO, Pisa. Avi Karni and Tamar Weiss from Haifa U. and Ofer Keren director of the cognitive rehabilitation ward at the Sheva Rehabilitation Hospital

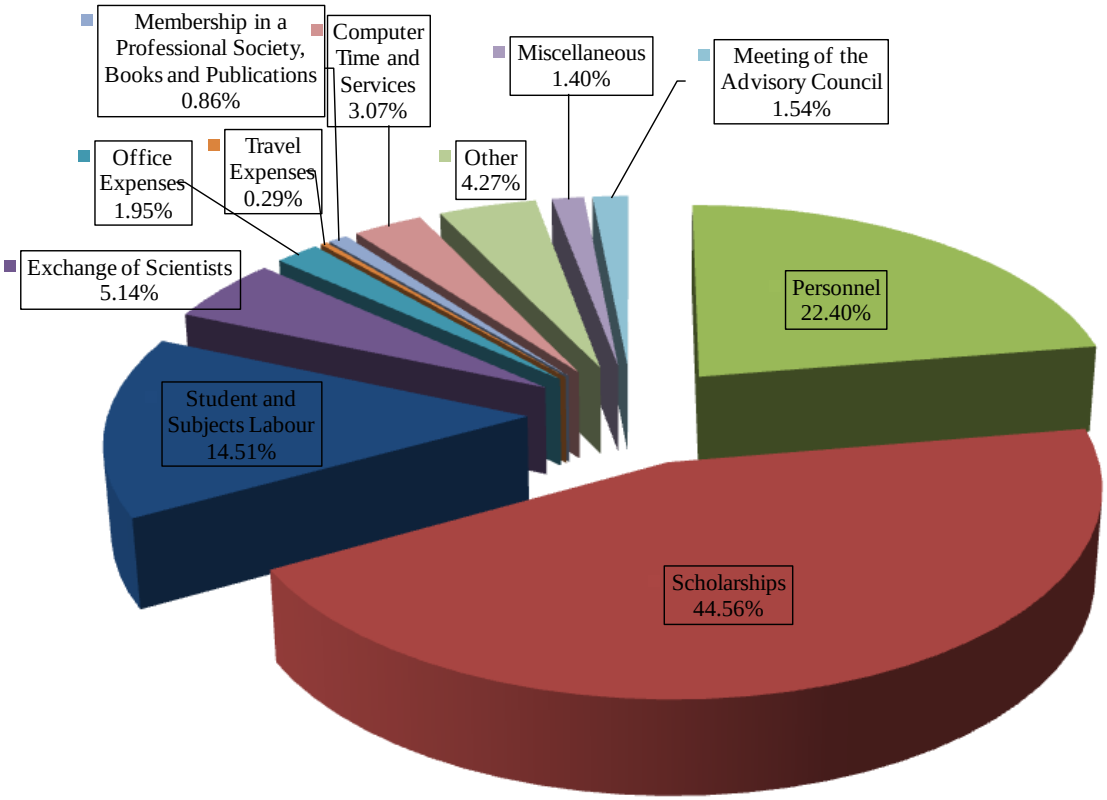
We propose to focus our work on technology-inspired methodologies of rehabilitation that highlight the importance of going from the conventional therapy notion of a static and "generic" optimal solution during motor-cognitive recovery, to a dynamic mapping of

ongoing physiological & pathophysiological abilities of individual patients that feeds (is coupled to) the optimization of the technological system parameters. We thus view rehabilitation as a set of dynamic processes in which at different time-points the same individual (and the "same" functional disabilities) may necessitate a different ‘corrective’ training procedures, or most effectively respond to a distinct set of rehabilitation-training inputs. Robotic systems must meet the motor and cognitive needs of individual patients and there is a need to establish a recurrent, ongoing interaction that is based on specific individual parameters that will allow DYNAMIC parametrization of rehabilitation procedures.

We propose the development of user-centered technologies and protocols that have the potential to support the objective, minimally obtrusive monitoring of the patient that will enhance his motor-cognitive abilities via adaptation, learning and control of client’s own environment through engagement with ecologically valid tasks. This is a multidisciplinary research effort for the use of robotic systems in rehabilitation, which draws upon cognitive and motor sciences, neuroscience, machine learning, and computer vision. By examining the cognitive processes involved in motor control and adaptation, optimal therapy should be considered in the context of a cognitive-motor schema wherein the patient may improve via "quanta". As the environmental context plays a very important role in motor adaptation and learning, we consider interactions with cognitive operations, such as motor planning, attention, motivation, as well as the environment (natural vs laboratory settings) and task nature, to be crucial factors that need to be incorporated into the next generation of robotic rehabilitation protocols.

g. Budget

g.1 Statistical Overview of the General Type of Expenditures (Averaged across 2002 – 2011)



g.2 Fiscal Reports

g.2.1 Fiscal Report: For the Period 1.10.2008 – 30.9.2009

NAME OF MINERVA CENTER: **Max Wertheimer Minerva Center for Cognitive Processes and Human Performance**

Total amount of endowment in:	€:	2,045,170
Invested in:	DM:	4,000,000
Interest received in % on endowment invested in	NIS:	551,735*
Nominal sum:	€:	100,137 **
Matching	€:	100,137 **
Total	€:	200,274 **

	University of Haifa		**Technion**		**University & Technion**	
	Original Proposal	**Actual Budget**	**Original Proposal**	**Actual Budget**	**Original Proposal**	**Actual Budget**
Salaries						
Personnel (*University*: 4 persons: Computer Programmer, Laboratory Coordinator, Research Coordinator; *Technion*: 3 Person)	40,000	38,533	8,000	8,000	48,000	46,533
Scholarships (*University:* 6; *Technion*: 9)	31,121	32,782	54,281	47,110	85,402	79,892
Student and Subjects labour (*University:* 8 persons; *Technion*: 1500 hrs)	30,000	19,749	12,000	12,000	42,000	31,749
Exchange of Scientists						
Visiting Israeli Scientists to Germany Visiting German Scientists to Israel, Workshops, Symposia and other international meetings	6,000	5,560	7,000	6,000	13,000	11,560

	University of Haifa		Technion		University & Technion	
	Original Proposal	**Actual Budget**	**Original Proposal**	**Actual Budget**	**Original Proposal**	**Actual Budget**
Operations Cost, Materials, Equipment						
Office Expenses	3,000	3,002	2,000	2,000	5,000	5,002
Travel Expenses	1,300	1,072	------	------	1,300	1,072
Membership in a professional society, Books and Publications	2,000	1,518	1,000	1,000	3,000	2,518
Computer time and services, Small appliances, Laboratory supplies, spare parts, Maintenance, installations	8,000	8,000	1,000	1,000	9,000	9,000
Other (Computer Insurance, Upgrade of computers and Peripheral Equipment, International communication)	8,000	8,016	1,000	1,000	9,000	9,016
Miscellaneous						
Joint Seminars, Production of Posters for Conferences, Refresher Courses	3,000	1,932	2,000	2,000	5,000	3,932
TOTAL EXPENDITURES:	**€ 132,421**	**€ 120,164**	**€ 88,281**	**€ 80,110**	**€ 220,702**	**€ 200,274**

* Based on the real interest received on September 2008.
** The rate of exchange is 5.5098 Nis per 1 Euro (rate of September 30, 2009).

Note:
The rate of exchange reported in the Budget Proposal was: 4.9998 Nis per 1 Euro (rate of September 26, 2008). The relevant rate for the Budget Report (rate of September 30, 2009) is: 5.5098 Nis per 1 Euro. Due to this rates difference there are differences between the actual sums and the proposal sums.

g.2.2 Fiscal Report: For the Period 1.10.2009 – 30.9.2010

NAME OF MINERVA CENTER: **Max -Wertheimer Minerva Center for Cognitive Processes and Human Performance**

Total amount of endowment in:	€:	2,045,170
Invested in:	DM:	4,000,000
Interest received in % on endowment invested in	NIS:	569,035*
Nominal sum:	€:	114,097 **
Matching	€:	114,097 **
Total	€:	228,194 **

	University of Haifa		Technion		University & Technion	
	Original Proposal	**Actual Budget**	**Original Proposal**	**Actual Budget**	**Original Proposal**	**Actual Budget**
Salaries						
Personnel Rinat Gil, Baruch Kaplan, Dana Klein, Yafa Lev, Dan Manor, Ornit Tzuri. Sharon Denziger, Tomer Gilad, Maya Hasson, Galina Vertalia	40,000	48,327	8,000	3,854	48,000	52,181
Scholarships Orit Baruch, Orly Cohen-Feldman, Hadas Marciano, Yamit Provizor, Einat Rachal. Nirit Agai, Maya Arad, Yelena Bologolovski, Guy Hochman, Ilanit Hormnitz, Gilly Koritzki, Adi Luria, Nimrod Rozenblat, Dikla Segal, Michal Shelef, Yael Sidi, Ariel Telpaz	31,000	30,231	46,822	68,332	77,822	98,563
Student and Subjects labour 6 Research assistants and 1500 Research participants	25,000	24,494	12,000	9,342	37,000	33,836
Exchange of Scientists						
Visiting Israeli Scientists to Germany and abroad. Visiting scientists to Israel, Workshops, Symposia and other international meetings.	6,000	4,104	6,000	6,421	12,000	10,525

	University of Haifa		Technion		University & Technion	
	Original Proposal	**Actual Budget**	**Original Proposal**	**Actual Budget**	**Original Proposal**	**Actual Budget**
Operations Cost, Materials, Equipment						
Office Expenses	1,932	4,913	2,000	28	3,932	4,941
Travel Expenses	1,000	1,055	------	------	1,000	1,055
Membership in a professional society, Books and Publications	1,500	1,810	1,000	------	2,500	1,810
Computer time and services, Small appliances, Laboratory supplies, spare parts, Maintenance, installations	4,000	3,727	1,000	1,029	5,000	4,756
Other (Computer Insurance, Upgrade of computers and Peripheral Equipment, International communication)	7,800	10,993	1,000	149	8,800	11,142
Miscellaneous						
Joint Seminars, Production of Posters for Conferences, Refresher Courses.	1,500	1,591	2,000	794	3,500	2,385
Meeting of the Advisory Council						
Travel and accommodations expenses, Preparation of the report, meeting administration.	4,200	5,671	2,800	1,329	7,000	7,000
TOTAL EXPENDITURES:	**€ 123,932**	**€ 136,916**	**€ 82,622**	**€ 91,278**	**€ 206,554**	**€ 228,194**

* Based on the real interest received on September 2009.
** The rate of exchange is 4.9873 Nis per 1 Euro (rate of September 30, 2010).

Note:
The rate of exchange reported in the Budget Proposal was: 5.5098 Nis per 1 Euro (rate of September 30, 2009). The relevant rate for the Budget Report (rate of September 30, 2010) is: 4.9873 Nis per 1 Euro. Due to this rates difference there are differences between the actual sums and the proposal sums.

g.2.3 Fiscal Report: For the Period 1.10.2010 – 30.9.2011

NAME OF MINERVA CENTER: **Max -Wertheimer Minerva Center for Cognitive Processes and Human Performance**

Total amount of endowment in:	€:	2,045,170
Invested in:	DM:	4,000,000
Interest received in % on endowment invested in	NIS:	579,332[1]
Nominal sum:	€:	114,863 [2]
Matching	€:	114,863 [2]
Total	€:	229,726 [2]

	University of Haifa		Technion		University & Technion	
	Original Proposal	**Actual Budget**	**Original Proposal**	**Actual Budget**	**Original Proposal**	**Actual Budget**
Salaries						
Personnel Rinat Gil, Baruch Kaplan, Prof. Ruth Kimchi[3], Dan Manor. Avivit Barkan , Maya Hasson , Noam Herman.	42,000	47,251	8,000	8,718	50,000	55,969
Scholarships Shiri Adiv, Orit Baruch, Einat Rachal. Aharon Arazi , Anna Barlasov, Kinneret Teoderescu, Dotan Tzur.	32,000	25,537	58,930	62,043	90,930	87,580
Student & Subj. labour *University:* 18 persons; *Technion*: 1100 hrs	31,000	33,074	12,000	7,640	43,000	40,714
Exchange of Scientists						
Visiting Israeli Scientists to Germany & German Scientists to Israel, Workshops Symposia & other meetings	8,000	10,290	7,000	6,206	15,000	16,496

	University of Haifa		Technion		University & Technion	
	Original Proposal	**Actual Budget**	**Original Proposal**	**Actual Budget**	**Original Proposal**	**Actual Budget**
Operations Cost, Materials, Equipment						
Office Expenses	3,000	3,000	2,000	93	5,000	3,093
Travel Expenses	2,000	1,250	0	0	2,000	1,250
Membership in a professional society, Books and Publications	3,000	1,231	1,000	87	4,000	1,318
Computer time and services, Small appliances, Laboratory supplies, spare parts, Maintenance, installations	8,000	4,841	1,000	0	9,000	4,841
Other: Comp. Insurance, Upgrade of comp. & Peripheral Equipment, International communication	8,394	9,262	1,000	6,139	9,394	15,401
Miscellaneous						
Joint Seminars, Production of Posters for Conferences, Refresher Courses	2,000	2,100	2,000	964	4,000	3,064
TOTAL EXPENDITURES:	**€ 139,394**	**€ 137,836**	**€92,930**	**€ 91,890**	**€ 232,324**	**€ 229,726**

[1] Based on the real interest received on September 2010.
[2] The rate of exchange is 5.0437 Nis per 1 Euro (rate of September 27, 2011).
[3] Supplemental pay for center director.

Note:
The rate of exchange reported in the Budget Proposal was: 4.9873 Nis per 1 Euro (rate of September 30, 2010). The relevant rate for the Budget Report (rate of September 27, 2011) is: 5.0437 Nis per 1 Euro. Due to this rates difference there are differences between the actual sums and the proposal sums.

g.3 Budget Proposals

g.3.1 Budget Proposal from 1.10.2011 to 30.9.2012

NAME OF MINERVA CENTER: **Max -Wertheimer Minerva Center for Cognitive Processes and Human Performance**

Total amount of endowment in:		€	2,045,170		
Invested in:		DM	4,000,000		
Interest received in % on endowment	2.5%	invested in NIS			332,859[1]
Nominal sum:	1.	NIS	332,859	2. €	65,995 [2]
Matching:		NIS	332,859		
Funding from other sources:		None			
Total budget: (currency)	1.	NIS	665,718	2. €	131,990[2]

Please note: The Israeli fiscal market conditions in 2003, when the endowment was invested and closed for 7 years, provided an interest of 4.5%. Since those 7 years have elapsed, the endowment is now committed to the current market conditions, which provide only an interest of 2.5%. Hence, unfortunately, the current fruits have markedly reduced. The current available total sum and its subdivision appear in the following table:

ESTIMATED EXPENDITURES (€)	**University of Haifa**	**Technion**	**University & Technion**
Salaries			
Personnel (*University*: 4 persons: Supplemental Pay for Head of Center, Computer Programmer, Laboratory Coordinator, Research Coordinator; *Technion*: 3 Person)	40,909	5,000	45,909
Scholarships (*University:* 4; *Technion*: 7)	28,000	30,000	58,000
Student and Subjects labour **(***University:* 10 persons; *Technion*: *900 hrs*)	8,000	5,000	13,000
Exchange of Scientists			
Visiting Israeli Scientists to Germany Visiting German Scientists to Israel, Workshops, Symposia and other international meetings	800	4,000	4,800
Operations Cost, Materials, Equipment			
Office Expenses	300	1,000	1,300
Travel Expenses	235	0	235
Membership in a professional society, Books and Publications	350	2,000	2,350
Computer time and services, Small appliances, Laboratory supplies, spare parts, Maintenance, installations	200	4,000	4,200
Other (Computer Insurance, Upgrade of computers and Peripheral Equipment, International communication)	200	1,000	1,200
Miscellaneous			
Joint Seminars, Production of Posters for Conferences, Refresher Courses**.**	200	796	996
TOTAL ESTIMATED EXPENDITURES:	**€79,194**	**€52,796**	**€ 131,990**

[1] Based on the real interest received on September 2011.

[2]The rate of exchange is 5.0437 Nis per 1 Euro (rate of September 27, 2011).

g.3.2 Budget Proposal from 1.10.2012 to 30.9.2013

NAME OF MINERVA CENTER: **Max -Wertheimer Minerva Center for Cognitive Processes and Human Performance**

Total amount of endowment in:		€	2,045,170		
Invested in:		DM	4,000,000		
Interest received in % on endowment	2.5%	invested in NIS			332,859[1]
Nominal sum:	1.	NIS	332,859	2. €	65,995 [2]
Matching:		NIS	332,859		
Funding from other sources:		None			
Total budget: (currency)	1.	NIS	665,718	2. €	131,990[2]

Please note: The Israeli fiscal market conditions in 2003, when the endowment was invested and closed for 7 years, provided an interest of 4.5%. Since those 7 years have elapsed, the endowment is now committed to the current market conditions, which provide only an interest of 2.5%. Hence, unfortunately, the current fruits have markedly reduced. The current available total sum and its subdivision appear in the following table:

ESTIMATED EXPENDITURES (€)	**University of Haifa**	**Technion**	**University &Technion**
Salaries			
Personnel (*University*: 4 persons: Supplemental Pay for Head of Center, Computer Programmer, Laboratory Coordinator, Research Coordinator; *Technion*: 3 Person)	40,909	5,000	45,909
Scholarships (*University:* 4; *Technion*: 7)	28,000	26,996	54,996
Student and Subjects labour **(***University:* 10 persons; *Technion*: *900 hrs*)	5,000	5,000	10,000
Exchange of Scientists			
Visiting Israeli Scientists to Germany Visiting German Scientists to Israel, Workshops, Symposia and other international meetings	700	4,000	4,700
Operations Cost, Materials, Equipment			
Office Expenses	50	1,000	1,050
Travel Expenses	50	0	50
Membership in a professional society, Books and Publications	100	2,000	2,100
Computer time and services, Small appliances, Laboratory supplies, spare parts, Maintenance, installations	50	4,000	4,050
Other (Computer Insurance, Upgrade of computers and Peripheral Equipment, International communication)	50	1,000	1,050
Miscellaneous			
Joint Seminars, Production of Posters for Conferences, Refresher Courses**.**	85	1,000	1,085
Meeting of the Advisory Council			
Travel and accommodations expenses, Preparation of the report, meeting administration.	4,200	2,800	7,000
TOTAL ESTIMATED EXPENDITURES:	**€79,194**	**€52,796**	**€ 131,990**

[1] Based on the real interest received on September 2011.

[2]The rate of exchange is 5.0437 Nis per 1 Euro (rate of September 27, 2011).

h. Appendix

h.1 The "2009 Call for Applications: Minerva Centers Funding for Equipment" Documents

h.1.1 The Application Form

MINERVA STIFTUNG GESELLSCHAFT
FÜR DIE FORSCHUNG m.b.H.

2009 CALL FOR APPLICATIONS
MINERVA CENTERS
FUNDING FOR EQUIPMENT

Hofgartenstrasse 8
D-80539 München
Federal Republic of Germany

A. MINERVA CENTERS

1.Name of Minerva Center:
Max-Wertheimer Minerva Center for Cognitive Processes and Human Performance

2. Requested Funds:
(in EURO): **32,000 EURO**

3. Type of equipment

A Multiuser Integrative Laboratory for Research and Graduate Training in Cognition and Human Performance

4. Request submitted by (Principal Investigator):

Name	Institution	Department	Address
Prof. Asher Koriat	**University of Haifa**	**Psychology**	**Mount Carmel Haifa, Israel**

Date: **1 June 2009**

Signature

h.1.2 Justification for Funding Equipment

A Multiuser Integrative Laboratory for Research and Graduate Training in Cognition and Human Performance

Experimental research in Cognitive Psychology has become critically dependent on computers for controlling all aspects of the research process, such as running the experiment and collecting the data in real time, analyzing the results, etc. Most of the research stages rely on specialized computer resources, some of which require the assistance of professionally trained personnel such as computer programmers, technicians, and statistical assistants, creating large delays in the experimental process. However, scientific work today is headed towards an integration of all stages of research so that they may interactively and efficiently nourish each other, abolishing the conception of a serial, piecemeal, research process. As one example, today's researcher cannot afford to wait until an experiment is completed and all its data are analyzed in order to check whether her experimental design meets the predetermined aims of her project. She requires on-line presentation of experimental results after each experimental session so that she can keep abreast of any problems and make any necessary changes, thus saving precious time and resources.

Our Minerva center is in the process of adapting its research environment to this concept and the results so far are very promising. As the next step, we propose to establish an integrative research laboratory aimed at providing each researcher (whether a center member or graduate student) with the necessary software tools to conduct all stages of research independently, while also allowing flexibility regarding how each stage is implemented. The proposed software tools are all state-of-the-art, user-friendly, easy-to-learn packages, operating on one common platform -- *Microsoft Windows for PC* -- and are thus highly compatible. This lab is designed to minimize the researchers' dependence on professional personnel such as computer programmers, while providing them with greater interactivity, control, and flexibility regarding all phases of their research. The proposed system is also sufficiently flexible to support research on a broad range of topics, and is appropriate for implementing the majority of experimental paradigms employed by the members and students of our research center.

The main concept of this laboratory, which has been adopted by other research institutes in Cognitive Psychology around the world, is the utilization of "experiment generators." These are software tools that enable the computerized implementation of experiments in Psychology without requiring expertise in computer programming.

One main tool is the experiment generator, *E-Prime*. *E-Prime* is a "development studio" for the implementation of computerized psychological research including reaction time, perceptual detection, learning and questionnaire type paradigms. It includes an advanced, user-friendly, visual design environment, which allows graphical selection and specification of experimental functions. *E-Prime* allows the non-programmer to rapidly

create the majority of experimental designs, while allowing expert users to exploit *E-Prime*'s comprehensive scripting language and debugging methods for the more sophisticated experiments or options. The software is designed to monitor external devices such as a response box or microphone, and to measure response time with millisecond precision. It also allows the on-line presentation of experimental results. Working under the *Microsoft Windows* operating system, *E-Prime* has excellent connectivity with all of the other *Windows* applications such as *Microsoft Word*, graphical studios, statistical packages, etc.

The basic infrastructure of the proposed integrative laboratory will consist of 12 computer workstations equipped with *E-Prime* and its associated hardware response box with voice key. Eight will be placed at the University of Haifa site and 4 at Technion site. In parallel, these workstations will be equipped with additional tools to allow for a better integration between the various segments of the research process, including literature search and review, the experimental design, collecting data, etc. One such tool is *EndNote*, a powerful reference managing software package. In this information era, each researcher is swamped with a vast amount of references he must search for, photocopy, organize, cite in his papers, list in his bibliographic lists, etc. It is extremely important that the researcher know which articles are pertinent to which projects (or which aspects of the project), which have been copied/read/cited, which remain to be copied/read/cited, and so forth. This is in addition to the problem of correctly citing the long list of references in each submitted article.

EndNote enables one to import references from online bibliographic databases into personal databases, update and search these databases, and generate formatted bibliographies in publications. Due to the huge number of references each researcher must deal with, this software is expected to save enormous time spent on technical operations having to do with reference management.

The research lab we are proposing is based on personal computers (*PC*s) working with *Windows*. This platform was chosen because it is the most widespread and economical and because it is the platform for which most of the up-to-date software packages are developed. Of course, in addition to *E-Prime* and *Endnote*, the computers will also be equipped with Windows-compatible statistical packages, such as SAS and SPSS, which are available by University license.

In addition, we set up a *web server*. Recently there is a growing need in Cognitive Psychology for performing research on large numbers of participants. This is particularly important for collecting normative data, but large sample size is also required to resolve issues of statistical power, and for the use of modern analysis techniques such as hierarchical-multilevel analysis and structural equation modeling. Running large numbers of subjects in the laboratory on an individual basis is extremely inefficient. Web-based and LAN-based applications offer an excellent solution to this problem. Applications placed on the web server can be run simultaneously on the other PCs in the integrative laboratory, allowing more efficient group administration of experiments. In

addition, such applications can be run from other locations on both campuses, such as large classrooms, or (depending on the type of experiment) or can be run by individual participants from their own homes. The use of similar and compatible workstations at the two sites of the Minerva Center will facilitate collaborations between members and graduate students in the two sites.

It is important to emphasize that the hallmark of our proposal is the idea of providing the Minerva Center members and students with a single integrative development environment, which will allow them to carry out all the stages of their research themselves. The laboratory is intended to provide all the self-operated tools to support the researcher from the very first stages of reference collection, through the development of the experimental software, running the experiment, analyzing the data, and preparing the publication. Notably, these are all affordable, up-to-date tools, which the researcher is likely to encounter in other environments, for example, when cooperating with other researchers from different academic or industrial institutes.

The proposed integrative developmental environment will provide the ideal framework for achieving a further central goal of the Minerva Center: training our students to become independent researchers in the fields of cognitive psychology and human performance. The proposed laboratory will have a crucial role in equipping them with the knowledge and experience needed in order to function as autonomous researchers in the academic and/or industrial world after their graduation, using tools they are likely to encounter in these establishments in the future.

h.1.3 Summary Table

Equipment	Quantity	
Dell Optiplex 760	12	The laboratory consists of 12 Dell desktop computers. They are brand name, versatile workstations, with the necessary processing power and reliability for running the planned applications.
Display monitor	12	19" LCD, 5 msec monitors connected to the computer workstations for visual/graphical output.
Dell PowerEdge R610	1	The Dell PowerEdge R610 is an Intel-based server, ideal for data centers and remote sites, which will function as our web server.
ENDNOTE software	12	Each computer station will be equipped with an EndNote software application for searching bibliography and organizing references.
E-Prime software	12	Each station is equipped with E-Prime for experiment generation. The E-prime software is affordable and perfectly suits our research needs.
Serial Response Box	12	A special response box that interfaces with the E-PRIME software is needed for obtaining completely accurate reaction time data.
Shipping, handling and import taxes		E-prime and the Serial Response box will be purchased directly from the manufacturer (PST; there is no local distributor in Israel), so we must add shipping, handling and import taxes that sum to almost 40% of the product price. (Note, however, that the list price paid directly to the manufacturer is substantially lower than what would be paid to a local distributor.)

The division between University of Haifa and Technion is as follows:

University of Haifa: 8 Dell Optiplex 760, 8 Display monitors, 1 Dell PowerEdge R610, 8 EndNote software packages, 8 E-Prime software packages, 8 Serial Response boxes.
Technion: 4 Dell Optiplex 760, 4 Display monitors, 4 EndNote software packages, 4 E-Prime software packages, 4 Serial Response boxes.

h.1.4 Cost Estimate

		Binat	Mediatek	Omnitech			
	Quantity	**price 1($)**	**price 2($)**	**price 3($)**	**total 1**	**total 2**	**total 3**
Dell Optiplex 760	12	695	765	820	8340	9180	9840
Display monitor	12	168	149	115	2016	1788	1380
Dell PoweEdge R610	1	4968	3765	3700	4968	3765	3700
ENDNOTE	12	179.9	224.4	310.1	2158.8	2692.8	3721.2
Total					17482.8	17425.8	18641.2
TAX (15.5%)					2709.8	2701	2889.4
Total + tax					20192.6	20126.8	21530.6
E-prime 2.0 Pro	12	995	995	995	11940	11940	11940
Serial Response Box	12	450	450	450	5400	5400	5400
shipping, handling and import (40%)					6936	6936	6936
Total in $					44468.6	44402.8	45806.6
Total in Euro					**32039.05**	**31991.64**	**33003.06**
26/05/2009							
$-NIS rate	**4**						
Euro NIS Rate	**5.5518**						

The division between University of Haifa and Technion is as follows:

University of Haifa: 8 Dell Optiplex 760, 8 Display monitors, 1 Dell PowerEdge R610, 8 EndNote software packages, 8 E-Prime software packages, 8 Serial Response boxes – **Cost Estimation -22,500 EURO**.

Technion: 4 Dell Optiplex 760, 4 Display monitors, 4 EndNote software packages, 4 E-Prime software packages, 4 Serial Response boxes – **Cost estimated – 9,500 EURO**.

h.1.5 Approval of Request

From : Nagel, Michael [mailto:Michael.Nagel@gv.mpg.de]
Sent : Tuesday, August 25, 2009 6:37 PM
To :akoriat@research.haifa.ac.il
Cc : Lange-Gao, Angelika
Subject : Funding Equipment Minerva Center

Dear Professor Koriat,
I should hereby like to inform you that the application of your Minerva Center for additional equipment funds was approved. We will send the contract to the Vice President for signature within the days. We will transfer the money once the contract has been signed.

With best regards,
Michael Nagel

Michael Nagel
Max-Planck-Society
Minerva Foundation
Division of International Relations
Hofgartenstr. 8
D-80539 Munich
Germany
Tel.: 49-89-2108-1258
Fax.: 49-89-2108-1222

h.2 The "2010 Call for Applications: Minerva Centers Funding for Equipment" Documents

h.2.1 The Application Form

MINERVA STIFTUNG GESELLSCHAFT
FÜR DIE FORSCHUNG m.b.H.

2010 CALL FOR APPLICATIONS
MINERVA CENTERS
FUNDING FOR EQUIPMENT

Hofgartenstrasse 8
D-80539 München
Federal Republic of Germany

COVER PAGE
APPLICATION FOR EQUIPMENT FUNDING

1.Name of Minerva Center:
Max-Wertheimer Minerva Center for Cognitive Processes and Human Performance

2. Requested Funds:
(in EURO): **105,000 EURO**

3. Type of equipment

University of Haifa Site: Laboratory for the Study of Dynamic Cognitive Processing

Technion Site: Eyetracker and PC's

4. Request submitted by (Principal Investigator):

Name	Institution	Department	Address
Prof. Ruth Kimchi	**University of Haifa**	**Psychology**	**Mount Carmel Haifa,Israel**

Date: **20 October 2010**

Signature

h.2.2 Justification for Funding Equipment

Our Minerva Center has two sites, and we are submitting different requests for each one.

University of Haifa Site: Laboratory for the Study of Dynamic Cognitive Processing

A fundamental question in cognitive science is how we understand and act upon the world around us. Real, natural environments are typically highly complex. They are rich, multifaceted, and dynamic, consisting of continuous changes due primarily to motion – either objects move around us or we move in the environment. Although we have gained a great deal of insights about cognitive processing using static, simplified stimuli, it has become increasingly clear that in order to achieve a better and more comprehensive understanding of cognitive processing in the natural ecology, it is important to bring aspects of the dynamic interaction with the environment into the laboratory. Thus, it is necessary to study the perception and interpretation of dynamic natural scenes without compromising experimental rigor.

Having this aim in mind, we propose to establish a laboratory for the study of dynamic cognitive processing, which will be equipped with advanced technologies, including high-performance computing architecture, top-quality graphic capabilities with powerful visualization displays of 2D and 3D graphics, and video application support. These will allow us to produce in the controlled environment of the laboratory, visual displays that capture real-life scenes, such as those involving complex 3-D movements presented stereoscopically. These displays will allow us to study the perceptual, attentional, and memory processes that are critical for the active interaction with the environment. Tracking eye movements will provide us with continuous, on-line measurements of performance with complex, dynamic displays, and will provide insight into the processes involved in scene interpretation.

The basic infrastructure of the proposed integrative laboratory will consist of 8 graphic workstations equipped with Photoshop software, LCD monitors with 3D capabilities, and a powerful server, which will be used as a centralized repository for behavioral data, thus supporting secondary analyses on exiting data and collaboration between researchers. Such centralized repository will increase the synergy of looking at the same data from multiple perspectives. We are also requesting laptops that will allow us to run some of the experiments on special populations that cannot come to the laboratory (e.g., children, brain-damaged patients, and elderly).

The eyetracker we request will have a major role in the proposed laboratory: It will allow us to perform a fine, online analysis of performance with the complex, dynamic displays. Furthermore, the requested eyetracker will advance various current research projects in our center. Yaffa Yeshurun is currently looking at the effects of spatial covert attention – the selection of information from a specific location without eye movements – on various spatial and temporal aspects of visual perception (e.g., spatial resolution, temporal resolution, temporal impulse response function, texture segmentation, etc.). Joel

Norman and Yaffa Yeshurun examine the effects of perceptual load at the road (e.g., number of cars) and the sides of the road (e.g., billboards) on driving behavior of experienced drivers in a driving simulator. Monitoring eye movements will allow for fine, online analysis of the drivers' attention allocation to the various sources of information as they drive through the dynamically changing environment. Ruth Kimchi and Yaffa Yeshurun examine the effects of perceptual organization on the spontaneous deployment of attention. Thus far, this study did not differentiate the effects of covert attention and eye movements. With the aid of the eye tracker such differentiation will be possible, and it will allow a more detailed comparison of the mutual effects between these two mechanisms and perceptual organization. Morris Goldsmith examines the "navigation" of visual attention in hierarchically structured objects and displays—how attention is directed from one part to another, from the whole to the parts and vice versa. Because covert attention and overt eye movements are generally tightly coupled, eye tracking data will provide valuable direct evidence to supplement the indirect behavioral measures that have been used so far. Asher Koriat and Morris Goldsmith study the metacognitive monitoring and control processes contribute to the efficient encoding and retrieval of information from memory. Their theoretical framework has been applied mainly to episodic and semantic memory of verbal materials. The use of dynamic 3D displays together with eyetracking equipment will allow this work to be extended to the monitoring and control processes involved in learning and memory of complex and dynamically changing scenes, typical of real-life memory situations.

The establishment of this laboratory will provide the Minerva center members and students with the ideal environment for performing behavioral cutting-edge research in human cognition.

The Technion Site

An eyetracker and 10 personal computers are requested for the Technion Site of our Minerva Center. The new equipment will facilitate two lines of new research.

The first is the study of the effect of the incentive structure on eye movements. Yechiam and his co-authors plan to investigate the eye movement as the dependent variable. That is, to examine how people learn to modify their eye movement, and examine the relationship between this learning process, and learning among explicit choices. The first study in this project will address a process model of the effect of losses suggested by Yechiam and colleagues (e.g., Hochman and Yechiam, in press; JBDM). Eye tracking is a state of the art method for assessing implicit preferences. Moreover, the eye tracker planned to be purchased also provides a pupil diameter measure, considered a sensitive measure of autonomic arousal. The simultaneous measuring of arousal along with the choice alternative viewed in the given period would constitute a strong tool for evaluating process models of decision making and learning.

The second facilitated line of research is the choice prediction competitions project. Erev and Carlos Alos-Ferrer (from the University of Konstanz) have started a large

project in which they try to address some of the most important debates in the social sciences with the organization of open choice prediction competitions. Each competition is based on two large sets of experimental studies. The organizers publish the results of their first set of results with the best published baseline models (in the new journal Games that was designed to advance this method), and then challenge other researchers to predict the result of the second experiment. We plan to increase our laboratory (with the addition of the 10 new computers that allow simulation modeling as well as experimentation) to support this research.

h.2.3 Summary Table

Equipment (U. of Haifa)	**Quantity**	
HP Z400 graphic workstation	12	The laboratory consists of 12 HP Z400 graphic workstations with high end NVIDIA graphic card for stereo applications and dynamic graphic stimuli presentation.
Photoshop software License	12	Photoshop software for building complex displays for the experiments.
UPS system	1	Uninterruptable Power Supply system to protect all the laboratory equipment.
3D 120hz LCD monitor	2	120hz LCD monitors with 3D capabilities, good refresh rate timing and precision.
Dell Laptop	2	Dell laptops for running experiments outside the campus (e.g. hospitals, schools)
HP DL380G7 server	1	The HP DL380G7 server is an Intel-based server, ideal for data centers which will serve as a centralized repository for behavioral data collected.
Projector	1	The projector enables to run experiments for a large group of participants.
EyeLink eye-tracker system	1	Eyelink 1000 eyetracker - The unique design of the EyeLink 1000 makes it possible for the system to be used with a chin or forehead rest (**Head Supported**) or without any head support (**Remote / Head Free**).
Shipping, handling and import taxes		Eyelink 1000 Eyetracker will be purchased directly from the manufacturer (SR research Ltd. there is no local distributor in Israel), so we must add shipping, handling and import taxes that sum to almost 40% of the product price. (Note, however, that the list price paid directly to the manufacturer is substantially lower than what would be paid to a local distributor.)
Equipment (Technion)		
Arrington eye tracker	1	The eye tracker provides a pupil diameter measure, considered a sensitive measure of autonomic arousal which is necessary for the research planned.
Computers	10	10 computers to allow simulation modeling as well as experimentation.

h.2.4 Cost Estimate

University of Haifa	Quantity	Price	$/Euro	Total
HP Z400 graphic workstation	12	2,300	$	27,600
Photoshop Extended Cs5 License	12	240	$	2,880
UPS system	1	1,500	$	1,500
3D 120HZ LCD monitor	2	350	$	700
Dell Laptop	2	2,100	$	4,200
HP DL380G7 server	1	4,968	$	4,968
Projector	1	1,000	$	1,000
Total				42,848
TAX (16%)				6,856
Total + tax			$	49,704
Eyelink eye tracker	1	40,000	$	40,000
Shipping, handling and import (40%)		16,000	$	16,000
Total			$	105,704
Total – University			Euro	**75,010**
Technion				
Arrington eye tracker	1	15,000	Euro	15,000
Computers	10	1,500	Euro	15,000
Total – Technion			Euro	**30,000**
Total in Euro (both sites)			Euro	**105,010**
15/09/2010 rates	**$-NIS**	**3.569**	**Euro-NIS**	**5.0294**

h.2.5 Approval of Request

Dear Professor Kimchi,
Dear Professor Erev,
I should hereby like to inform you that the application of your Minerva Center for additional equipment funds was approved in principle. We still have to wait for the release of funds by the Federal Ministry of Education and Research, however. As soon as we have green light, we will contact you officially.

With best regards,
Michael Nagel

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h.3 A Poster Summarizing the DIP Project