31st Annual Meeting of the International Society for Psychophysics

FECHNER DAY 2015

Québec (Canada)

17 – 21 August 2015

Conference proceedings

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International Society for Psychophysics

Founded in Cassis, France, 22 October 1985

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Past Annual Meetings

Year	Venue	Organizer(s)
1985	Marseille, France	G. Canévet and B. Scharf
1986	Cassis, France	A. M. Bonnet, G. Canévet, C. A. Possamaï, B. Scharf, B. Berglund, and R. Teghtsoonian
1987	Durham (NH), USA	M. Teghtsoonian and R. Teghtsoonian
1988	Stirling, UK	H. Ross, R. MacDonald, C. A. Possamaï, R. Teghtsoonian, M. Treisman, and R. Warren
1989	Cassis, France	A. M. Bonnet, G. Canévet, C. A. Possamaï, and B. Scharf
1990	Würzburg, Germany	F. Müller
1991	Durham (NC), USA	G. R. Lockhead
1992	Stockholm, Sweden	G. Borg, Å. Hellström, and G. Neely
1993	Mallorca, Spain	A. Garriga-Trillo, P. R. Minón, C. García-Gallego, P. Lubin, J. M. Merino, M. J. Rubio-Gómez, and A. Villarino
1994	Vancouver, Canada	L. M. Ward
1995	Cassis, France	C. A. Possamaï, H. Ross, B. Scharf, R. Teghtsoonian, and L. M. Ward
1996	Padua, Italy	S. C. Masin
1997	Poznan, Poland	A. Gotebiewsky, E. Hojan, T. Hornowsky, P. Kokowsky, A. Majchrzak, P. Miecznik, M. Labowski, P. Pekala, A. Preis, E. Skrzodka, E. Wichlinska, and A. Wicher
1998	Québec, Canada	S. Grondin, Y. Lacouture, and R. Rousseau
1999	Tempe (AZ), USA	P. R. Killeen and W. R. Uttal
2000	Strasbourg, France	C. Bonnet
2001	Leipzig, Germany	E. Sommerfeld, T. Lachmann, and R. Kompass
2002	Rio de Janeiro, Brazil	J. A. da Silva, E. H. Matsushima, and N. P. Ribero-Philo
2003	Larnaca, Cyprus	B. Berglund and E. Borg
2004	Coimbra, Portugal	A. M. Oliveira, M. Teixeira, G. Borgess, and M. J. Ferro
2005	Traverse City (MI), USA	J. S. Monahan, S. M. Sheffert, and J. T. Townsend
2006	St. Albans, UK	D. E. Kornbrot, R. M. Msefti, and A. W. MacRae
2007	Tokyo, Japan	S. Mori, T. Miyaoka, and W. Wong
2008	Toronto, Canada	B. A. Schneider, B. M. Ben-David, S. Parker, and W. Wong
2009	Galway, Ireland	M. A. Elliott, S. Antonijevíc, P.Berthand, P. Mulcahy, C. Martyn, B. Bargery, and H. Schmidt
2010	Padua, Italy	A. Bastianelli and G. Vidotto
2011	Herzliya, Israel	D. Algom, D. Zakay, E. Chajut, S. Shaki, Y. Mama, and V. Shakuf
2012	Ottawa, Canada	S. R. Carroll, E. Gallitto, C. Leth-Steensen, W.M. Petrusic, J. R. Schoenherr, and D. A. Verger
2013	Freiburg, Germany	J. Wackermann, M. Wittmannm and W. Skrandies
2014	Lund, Sweden	G. R. Patching, Å Hellström, M. Johnson, E. Borg, and R. Bååth

Preface

It is an honor to host in Québec, for the second time, the Annual Meeting of the International Society for Psychophysics. Québec is the second oldest city in North America, and Fechner Day 2015 will actually be held in the Old Québec. For one afternoon though, the participants to the meeting will be moved to a newer part of the city where is now located Laval University, one of the oldest universities of the continent.

The meeting will begin with a keynote address by Bruce Schneider on the future of psychophysics, and will end on a series of talks by young psychophysicists. The meeting will include a series of talks and posters on several aspects of psychophysical research, and a brief “In memoriam” section dedicated to two long-standing members of the Society, Hannes Eisler and Bill Petrusic.

We would like to thank Geoff Patching, an organizer of Fechner Day 2014, for transmitting his knowledge, Zhuanghua Shi and Jordan Schoenherr who are taking care of ISP website and communication, and the members of the executive committee. We would like to extend special thanks to the city of Québec and the Faculty of Social Sciences of Laval University for their financial support. Finally, we also want to thank the personal of Hotel Clarendon for the most appreciated collaboration at various stages of the organization of the meeting.

We hope that Fechner Day 2015 will be, as is the tradition, a fine mixture of stimulating intellectual discussions and friendly social interactions.

Welcome to Québec!

Simon Grondin and Vincent Laflamme

Fechner Day 2015
Scientific Program and Meeting Schedule

Monday, August 17

17.00 – 19.00 Welcome reception: Lobby, Clarendon Hotel

Tuesday, August 18

9.15 – 9.30 Welcome and announcement

9.30 – 10.30 Keynote speaker

Bruce A. Schneider, University of Toronto

THE FUTURE OF PSYCHOPHYSICS: DEVOLUTION OR EVOLUTION?

10.30 – 10.50 Coffee break

10.50 – 12.05 Free talks

The effects of tone duration and inter-stimulus interval on spectral and dichotic TOJ
Leah Fostick and Harvey Babkoff

Loudness effect on pairwise comparisons and sorting tasks
Patrick Susini, Olivier Houix, Guillaume Saint Pierre and Emmanuel Ponsot

The effect of segment duration on the intelligibility of locally time-reversed speech: A multilingual comparison
Kazuo Ueda, Yoshitaka Nakajima, Shunsuke Tamura, Wolfgang Ellermeier, Florian Kattner, and Stephan Daebler

→ Lunch (included) and afternoon at Laval University

14.00 – 14.50 Free talks

Predicting and perceiving heaviness: the integration of material and size.
Michele Vicovaro and Luigi Burigana

Several examples of tactile illusion
Tetsu Miyaoka

14.50 – 16.00 Poster session

16.00 – 16.50 Free talks

The role of modality in time perception after tDCS applied over primary auditory and visual cortex
Giovanna Mioni, Margherita Forgione, Ilenia Levorato, Simon Grondin, Daniela Mapelli, and Franca Stablum

Perceived intensity, pleasantness and related fMRI-brain activity of olfactory stimuli
Friedrich Müller, Simona Negoias, Artin Arshamian, Thomas Hummel, Bernd Weber and Jennifer Faber

17.15 – 18.45 Visit of Villa Bagatelle (Exhibition : "L'art en soi")

Wednesday, August 19

9.00 – 10.15 Free talks

The Anisotropy of Visual Space as a Function of Distance from the Observer and Cue Conditions
Mark Wagner

Perceived durations of filled and empty intervals
Emi Hasuo, Yoshitaka Nakajima, Takuya Kishida, Gerard B. Remijn, and Kazuo Ueda

A comparison of the psychoacoustic profiles of young dyslexic VS normal readers and of the elderly VS the young indicate similar as well as different deficits
Harvey Babkoff and Leah Fostick

10.15 – 10.45 Coffee break
10.45 – 12.00 Free talks

Estimating the duration of decision process epochs
Stephen Link

Snake Oil or Super Solution? Statistical and Psychological Approaches to Binary Decision Making
Diana Kornbrot

Technology Then Science—The First Breeds the Last
Eugene Galanter

12.00 Group photo

No scientific activities in the afternoon

14h30 – 16h 30 **Guided visit of Old Québec**

Thursday, August 20

9.00 – 10.15 Free talks

Molyneux's Question and its Implications for Theories of Cross-Modal Binding
Nicholas Altieri

Dissociation of Perceived Force and Resistance: Implications for Phenomenal Causality and Naïve Physics
Timothy L. Hubbard and Susan E. Ruppel

Hedonic contrast within a meal
Debra Zellner

10.15 – 10.45 Coffee break

10.45 – 12.00 Free talks and In memoriam: Bill Petrusic and Hannes Eisler

Tracking the eyes during numerical comparison
Craig Leth-Steensen and Matthew Huebner

Scaling Internal Representations of Confidence: Effects of Range, Interval and Number of Response Categories
Jordan Richard Schoenherr and William M. Petrusic

In memoriam: William M. Petrusic
Jordan Richard Schoenherr and Craig Leth-Steensen

In memoriam: Hannes Eisler
Åke Hellström

13.45 – 15.00 Free talks

A psychophysical approach to human performance development
Patricia Hannan, Eugene Galanter, Millard F. Reschke and Christina Wight

How do we connect with the flow of events: the case of schizophrenia.
Anne Giersch, Céline Duval, and Dorine Blaison

Pain perception in infants and its relation to maternal emotional state
Rosana M. Tristão, Kelly C. S. C. Bonan and José A. L. Jesus

15.00 – 15.20 Coffee break
15.20 – Business Meeting

18.00: Departure from the Clarendon Hotel for the Conference Banquet at Manoir Montmorency

Friday, August 21

9.30 – 10.40 Free talks → **Young Psychophysicists**

Temporal weighting of loudness: Different psychophysical tasks reveal different evaluation strategies
Emmanuel Ponsot, Patrick Susini, and Daniel Oberfeld

On the critical number of power-fluctuation factors needed for Japanese noise-vocoded speech perception
Takuya Kishida, Yoshitaka Nakajima, Kazuo Ueda and Gerard B. Remijn

Relationship between Autonomic Activity and Time Perception Abilities
Nicola Cellini, Giovanna Mioni, Ilenia Levorato, Simon Grondin, Franca Stablum and Michela Sarlo

10.40 – 11.00 Coffee break

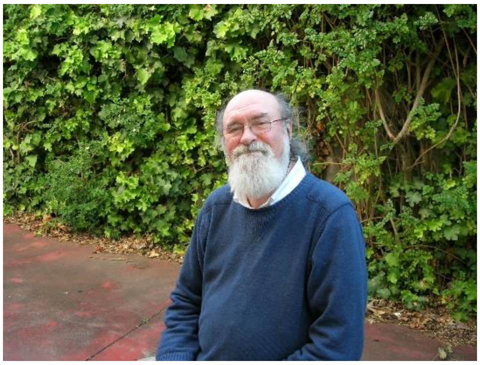
11.00 – 11.40 Free talks → **Young Psychophysicists**

The Effects of Emotional Facial Expression on Time Perception in Patients with Parkinson's Disease
Giovanna Mioni, Lucia Meligrana, Simon Grondin, Francesco Perini, Luigi Bartolomei. and Franca Stablum

Letters in the forest: global precedence effect disappears for letters but not for non-letters under reading-like conditions
Andreas Schmitt and Thomas Lachmann

William M. Petrusic, 1939-2014

Craig Leth-Steensen*
Carleton University, Canada



Our very distinguished and long-standing member, Professor William ("Bill") M. Petrusic has left us. He died on Dec. 12, 2014, at the age of 75. He is survived by his wife Elaine and his three children, Michele, Michael, and Christopher. Bill co-hosted Fechner Day 2013 in Ottawa, Canada, which sadly was his last appearance at the annual ISP conference.

Born in Hazeldell, Saskatchewan, on May 18, 1939, Bill received a BA in psychology from the University of British Columbia in 1961, an MA in mathematics from the University of Michigan in 1963, and a PhD in psychology from the University of Michigan in 1968 (where he was supervised by Clyde Coombs). After a stint at the University of British Columbia, he joined the Psychology Department at Carleton University in Ottawa, Canada as a professor in 1970 (eventually becoming a Distinguished Researcher and Professor Emeritus in 2004) where he remained until his untimely passing.

Bill's body of scientific work encompassed (exactly) 50 publications that addressed numerous issues of key importance to psychophysical and psychological researchers. His early published research focussed on the scaling of response time latencies and the study of short-term memory. In the late 70s, Bill published a large number of studies with his student Don Jamieson that dealt with important issues within such areas as duration judgement, preference judgement, and symbolic magnitude judgment (where, hopefully, the major aspect common to all of that work is self-evident). The late 80s and 90s led to a second large body of publications co-authored by another prolific student and eventual close colleague and friend, Joe Baranski. This period yielded seminal work on the semantic congruity effect, memory psychophysics, and the rendering of confidence. Finally, during the last 10 years, Sam Shaki and myself co-authored a number of studies with Bill that served to provide a wealth of novel results pertaining to both the semantic congruity effect and the spatial-numerical association of response codes (or SNARC) effect.

Bill has left behind an enduring legacy, both as a scientist and person, which a great number of the students he has mentored over the years would love to be able to emulate. His dedication to basic scientific work and the development of theory in mathematical terms inspired the people he collaborated with and solidified a place for him in the field as a serious and important researcher. I know that I, along with many others, will dearly miss hashing out research designs and theoretical standpoints with Bill (in addition to numerous discussions surrounding the merits of various 60s-era musical performers).

Keywords: unfolding; stochastic; Dylan; Hays; memory; TOE; reference point; power law; mental rotation; feedback; counting; transitivity; analogue; difference threshold; CVC; cross-over; speed-accuracy; latency-probability; discrete accumulator; slow-and-fast guessing; hard-easy; calibration; context; evidence accrual; comparative instructions; mental number line

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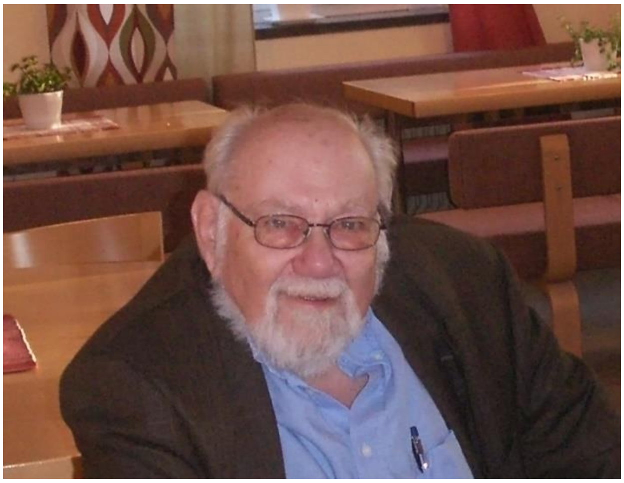
In Memoriam: Hannes Eisler, 1923-2015

Åke Hellström*
Stockholm University, Sweden



Our very distinguished member, Professor Hannes Eisler, Stockholm University, has left us. He died on May 28, 2015, at the age of 91. He was a member of the ISP from its beginnings. At Fechner Day 2014 in Lund, Sweden, Hannes lectured on "Some research tips from 55 years' psychophysics." Informally, he named this presentation his "swan song."

Hannes was Born in Vienna, Austria, 1923, and at the age of 15 fled to Sweden to escape the Nazis. Initially Hannes worked as a farm hand but quickly progressed to study at high school and later at Stockholm University, where he became an adept of Gösta Ekman, the Swedish pioneer of quantitative psychology. After spending a year in S. S. Stevens' lab at Harvard, Hannes was awarded his Ph.D. in Stockholm 1963. In 1994, as the result of a petition from all Swedish psychology professors, the Swedish government awarded Hannes Eisler the rank and honor of Professor – a rare recognition of scientific merit.

During his long career, Hannes authored a large number of publications and made many important contributions to our field. His doctoral dissertation was about the relation between magnitude and category scales. Later on, he turned much of his interest toward time perception in people as well as in mice. Perhaps the most impressive of his contributions is the Parallel Clock model for temporal reproduction and comparison[1], which arose from Hannes' arduous and meticulous investigation of long known anomalies in time perception; specifically, breaks in psychophysical functions. Noting the positions of those breaks in reproduction data led him to the counter-intuitive realization that participants use a seemingly odd strategy in immediate reproduction of temporal intervals: subjectively matching the reproduction, not to the standard, but to one-half of the total duration. Using this model it is possible to estimate the psycho-physical function for time from reproduction data, and

Hannes published a huge collection of temporal power function exponents[2] – much cited but all too often with no understanding of how they were determined.

Hannes was intellectually perspicacious and possessed research talent in abundance. Modes-ty, good nature, along with deep and diverse cultural interests, sense of humor, and appreciation of the good things in life, were some of his other characteristics. Scientific seminars on various topics were enriched by his insightful comments until a heart attack sadly ended his long life.

I miss Hannes immensely, as a very good old friend, a respected senior colleague, and a mentor – even the word *guru* feels very appropriate.

References
[1] Eisler, H. (1975). Psychological Review, 82, 429-450.
[2] Eisler, H. (1976). Psychological Bulletin, 83, 1154-1171.

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KEYNOTE ADDRESS: The future of psychophysics: Devolution or evolution?

Bruce A. Schneider[a]

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Devolution, as defined by the Oxford Dictionary, means "the transfer or delegation of power to a lower level, especially by central government to local or regional administration." In today's political climate devolution is usually considered to be beneficial in the sense that many people believe that local regions are better able to understand the needs of the people they are supposed to serve, and therefore are more likely to employ efficiently such centrally available resources as information, techniques, and above all, money, to meet these needs. A reasoned argument can be made that an analogous decentralization has happened to psychophysics. Our methods and the ways in which we approach the study of mental events have been, and continue to be, incorporated into a number of different disciplines, including sensory systems, cognition, memory, psycholinguistics, etc. In the process, our methods have often been modified to meet the special needs of these disciplines, and, have contributed significantly to the state of knowledge in each of these disciplines. Hence, I would argue that, in this respect, psychophysics has been immensely successful. However, this success raises an interesting and problematic question: What does this success imply about the future of psychophysics? Will it evolve, or will it disappear as a discipline?

One of the major strengths of our discipline is also the primary cause for its devolution, namely, our success in developing rigorous methods for evaluating and modeling mental events. As a result psychophysical methodologies and models (e.g., unidimensional and multidimensional scaling techniques, signal-detection models, choice theory, and random-walk models) have been so widely applied and adopted that the disciplinary origin of these methods and models has been either forgotten or ignored. If psychophysics is to continue to be recognized as a discipline, it will have to identify new issues where its expertise in measuring and modeling mental states and events may prove as useful in the future as it has in the past. An area that could benefit from such expertise is the interplay of sensory and cognitive processes. What we perceive and how we react to our environment is influenced both by top-down knowledge and the influx of bottom-up sensory information. For example, when one is in a situation where there is a strong possibility that the environment contains decaying and rotting organic substances, particularly strong and pungent odors are likely to elicit revulsion and avoidance. However, for someone with a discerning palate, the occurrence of the same odor in a fromagerie may be considered tantalizing, and lead to a request to sample the cheese responsible for the odor. In other words, how we perceive and respond to our environment reflects an interaction between two sources of information: 1) sensory input, and 2) top-down knowledge.

Unfortunately, the influence of sensory input on how we organize, perceive, and respond to our environment is usually examined by sensory scientists in situations where the contribution of higher-order knowledge-driven processes is minimized, while the contribution of top-down knowledge is typically evaluated by cognitive scientists in situations where the possible contribution of sensory factors is ignored. One possible evolutionary path that psychophysics could take is to expand the scope of its primary objective (measuring and modeling mental events) to include the influence of higher-order, knowledge-driven processes on an organism's interpretation of its environment. Several examples of steps in this direction are given.

Acknowledgement: The work reported here was supported by grants from NSERC (RGPIN 2690-02, RGPIN 9952-13) and from CIHR (MOP-15359, TEA-12497).

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Molyneux's Question and its Implications for Theories of Cross-Modal Binding

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In the 17th century, William Molyneux posed his now famous question to the philosopher John Locke concerning the origins of sensory experience. Molyneux's Question (MQ) was a thought experiment dealing with whether sensory categories are innate (i.e., nativism) and present from birth, or instead, must be acquired through perceptual learning (empiricism). Locke (Molyneux's Question, n.d.1)[1] phrased the question in his "Essay Concerning Human Understanding" as follows:

"*Suppose a man born blind, and now adult, and taught by his touch to distinguish between a Cube, and a Sphere of the same metal, and nighly of the same bigness, so as to tell, when he felt one and t'other, which is the Cube, which the Sphere. Suppose then the Cube and Sphere placed on a Table, and the Blind Man to be made to see. Quære, whether by his sight, before he touched them, he could now distinguish, and tell, which is the Globe, which the Cube.*"

After centuries of debate and empirical evidence from clinical neuroscience research involving newly sighted patients[2], we still lack a clear answer to MQ. While the case study suggested a "No" answer (the person could identify 3D objects only slightly above chance), the reason for this inability remains unclear. Nonetheless, even a definitive experimental answer would leave the original intent of the question unanswered: Do representations in a sensory modality require prior experience in that modality?

Instead of merely considering MQ as a thought experiment to determine the contents of sensory experience, I suggest that it be used to refine theories of multisensory perception. Relatedly, Altieri argued that at least two viable nativist frameworks predict a "No" answer to MQ.[3] These include (I) theories with innate representations, but those which require sufficient experience to give them content (i.e., knowing what a "sphere" is without being able to visually identify it). Additionally, nativism allows for (II) theories with innate unimodal representations; however, sharing of information across modalities requires perceptual learning. The line of thinking posed by MQ can also be used to develop testable predictions to better understand multisensory phenomena such as the McGurk effect (hearing "da" when auditory /ba/ is dubbed over a taker saying "ga"). In doing so I argue that theories I and II, for example, predict that McGurk fusions and multisensory integration skills will be reduced in listeners with hearing recently restored (e.g., cochlear implants). Theories I and II also assume that accumulation of sensory information occurs in parallel, where it can interact across modalities.[4] In conclusion, MQ has allowed us to sharpen questions regarding multisensory integration, and moreover, has contributed to discussion concerning ways that sensory inputs can be mapped onto representations in multidimensional space.

References

[1] In the Internet Encyclopedia of Philosophy. Retrieved from http://www.iep.utm.edu/molyneux/.

[2] R. Held et al. *Nat. Neurosci*. **14**, 551-553 (2011).

[3] N. Altieri, *Front. Psych*. **5**, 1-4 (2015).

[4] A. Eidels et al., *J. Math. Psych*. **55**, 176-190 (2011).

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A comparison of the psychoacoustic profiles of young dyslexic VS normal readers and of the elderly VS the young indicate similar as well as different deficits

Harvey Babkoff[a] and Leah Fostick[b]

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A large number of studies over the last twenty five years have shown that aging negatively impacts the auditory temporal processing of short duration stimuli. Simultaneously, in a parallel literature other studies have shown that child and adult dyslexic readers also manifest deficit in auditory temporal processing. Very few cross references appear in the psychoacoustic literature or in the aging or dyslexic literature.

Among the experimental paradigms used to compare auditory temporal processing among various groups at risk, are spectral and dichotic TOJ. Spectral TOJ involves the presentation of two tones of different frequencies, either delivered to both ears simultaneously or to one ear alone. The participant responds as to the order of presentation of the two frequencies. Dichotic TOJ involves the presentation of the same frequency tone to the two ears, asynchronous with respect to time and the participant responds as to which ear received the tone first. Both paradigms have been used to measure auditory temporal processing. We have conducted a large number of studies using both spectral and dichotic TOJ paradigms and found that the threshold distributions of the two paradigms differ significantly. The dichotic TOJ thresholds distribute in a Guassian manner with mean and standard deviation appropriately representing the distribution. In contrast, the spectral TOJ thresholds distribute as an inverted "J" with the left prominent mode at ISI= 0. Consequently, the left mode, rather than the mean and standard deviation of the spectral TOJ threshold distributions should be used to represent spectral TOJ threshold distributions.

When dyslexic readers and aging adults were examined on all of the spectral TOJ threshold distribution, across many studies, different tone frequencies and different durations, the following was found: Approximately **55%** of the young normal readers *are able* to discriminate the temporal order of two 15 msec tones of different frequency (Spectral TOJ) even when there is no inter-stimulus interval (ISI) separating them (ISI=0 msec). Only **25%** of the dyslexic readers and **28%** of the elderly can discriminate spectral temporal order when ISI= 0. Approximately **24%** of the young normal readers *are unable* to discriminate the temporal order of two tones of different frequency even when ISI> 120 msec. However, approximately **47%** of the dyslexic readers and **45%** of the elderly *are unable* to discriminate the temporal order of two tones of different frequency even when ISI> 120 msec. Mean dichotic TOJ for young participants was 59.18 msec (+/- 29.36) and 85.24 msec (+/- 39.14) for the elderly. The mean dichotic TOJ for the dyslexic readers was 119 msec (+/- 64.77).

The results of the present study imply that old age and dyslexia both impact the ability to correctly judge the order of two 15 msec tones that differ by their frequencies (spectral TOJ) to the same extent. In contrast, when the two tones *do not* differ in frequency and are presented to the two ears asynchronously (dichotic TOJ), it appears that dyslexia impacts the ability to correctly identify order to a greater extent than aging. Both the elderly and the dyslexic readers require significantly longer intervals between the tones presented to the two ears than the young normal readers to correctly identify their order. However, the dyslexics also require significantly longer intervals between the tones (ISI) than the elderly to correctly identify dichotic TOJ.

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Context effect or change in sensitivity? Investigating the Standard-Dependency of Power Law Exponents and Weber Fractions

Jana Birkenbusch and Wolfgang Ellermeier

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Previous axiomatic studies[1] on perceived duration found the exponent of Stevens' power law not to be invariant under changes of the reference stimulus. Thus, a meaningful interpretation of the shape of the psychophysical function is difficult. Therefore, the aim of the first experiment was to determine the exact functional relationship of the exponent β to the standard *t*. Since the parameters of the psychophysical function are often used to compare the sensitivity of different sensory modalities[2], it seems plausible to investigate, whether the exponent-standard-dependency is evidence for a change in sensitivity of perceived duration or whether it is just an artifact of the ratio production procedure. This question was examined in the second experiment by determining discrimination thresholds in an adaptive procedure[3].

N = 10 participants were required to adjust the duration of a comparison tone to specific ratios **p** (×2, ×3, and ×6) of six different standard durations (0.1, 0.2, 3.3, 0.4, 0.5, and 0.6 s). Furthermore, they completed a weighted-up down procedure to determine the size of the corresponding Weber fractions.

The results yielded increasing exponents β with increasing standard duration *t*. This relationship can be described by a positive exponential function of the form $\beta = 0.03t^{0.3}$ with a fit of $R^2 = 99\%$. Individual analyses revealed comparable relationships for seven of ten participants. Since a higher sensitivity is associated with greater exponents, one might therefore assume that differential sensitivity of duration perception increases with increasing standard magnitudes. Between the standard duration and the Weber fraction, a negative exponential relationship of the form $W = 0.84t^{-0.3}$ with a fit of $R^2 = 88\%$ was found. Therefore, an effect attributable to the method of ratio production can be ruled out.

Furthermore, the results contribute to the debate on the relationship between power function exponents and Weber fractions: A negative correlation of $r = -0.86$ was found between exponent and Weber fraction supporting previous assumptions that both measures are negatively correlated[4].

Reference

[1] : J. Birkenbusch et al., *Attention, Perception, & Psychophysics*. **77**, 1767-1780 (2015).

[2] : L. M. Ward et al., *Perception, & Psychophysics*. **58**, 793-801 (1975).

[3] : C. Kaernbach, *Attention, Perception, & Psychophysics*. **49**, 227-229 (1991).

[4] : R. Teghtsoonian, *Psychological Review*. **78**, 71-80 (1971).

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Relationship between Autonomic Activity and Time Perception Abilities

Nicola Cellini[a*], Giovanna Mioni[a], Ilenia Levorato[a], Simon Grondin[b], Franca Stablum[a] and Michela Sarlo[a,c]

[a] Department of General Psychology, University of Padova, Italy
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Accurate temporal abilities are crucial for adaptive behaviors. However, physiological changes such as changes in body temperature, skin conductance level and dopaminergic activity as a consequence, for example, of pharmacological substances and emotional stimulation, may increase errors in temporal productions and estimations[1]. Recent findings have also reported that *accuracy* in time estimation may be associated to vagal-mediated changes in cardiac activity[2]. These results are in line with studies showing that resting levels of heart rate variability (HRV), which is the variation in time between successive heartbeats and represents a reliable measure of the influence of the autonomic nervous system on heart function, are associated with higher working memory, sustained attention as well as with more efficient attentional control[3]. Thus, autonomic activity seems to play an important role in cognitive processing.

In the present study we aimed to explore the relationship between temporal abilities (for brief temporal intervals), autonomic activity and cardiac interoceptive awareness in thirty healthy university students (mean age 24.18 years; SD = 2.1). To this end, participants were asked to perform a time bisection task (short standard = 300 ms and long standard = 900 ms) and two finger tapping tasks (spontaneous and 1-sec tempo) measures of time perception. Prior to these tasks, by means of electrocardiogram, impedance cardiography and skin conductance recordings we measured several electrophysiological indices at rests followed by a heartbeat perception task. Overall our results showed that increased HRV was associated with higher temporal accuracy. Specifically, we observed that higher vagal activity was associated with lower error in producing 1-sec tempo, whereas higher overall HRV was related with lower error (measured by the constant error) in the time bisection task. Interestingly, no association was observed between physiological indices and the spontaneous tempo, suggesting that the HRV may modulate goal-oriented temporal processing (i.e., explicit timing requirements such as 1-sec tempo and time bisection). No associations were observed between interoceptive awareness and performance in the temporal tasks. We also control for levels of sleepiness, anxiety and personality traits, showing no association between these variables and temporal performances.

In conclusion, here we observed that the individual resting autonomic profile influence temporal accuracy, with people with higher HRV showing better accuracy in temporal tasks. Overall, our results are consistent with the idea that bodily signals may shape our perception of time.

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The FechDeck: a hand-tool for exploring psychophysics

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Teaching and learning psychophysics is made more difficult by the need to construct stimuli for example experiments and to develop procedures for collecting and analyzing experimental data. A package that included a universal stimulus set, efficient procedures for collecting data, and easy-to-use tools for data analysis, would facilitate psychophysics education. The FechDeck[1] is an ordinary deck of playing cards modified to support exploration of the methods of psychophysics. Card backs are printed with noise textures that span a range of densities. Faces are augmented with line segments arranged in "L" patterns. Jokers are printed with ruled faces and with backs that serve as noise standards. The FechDeck allows users to conduct threshold experiments using Fechner's[2] methods of adjustment, limits, and constant stimuli, and scaling experiments using Thurstone's[3] ranking, pair comparison, and categorical rating methods, and Stevens'[4] magnitude estimation method. Instructions and spreadsheets support clear use and efficient data processing. For example, for the method of adjustment, the user selects a card containing an "L" pattern, and places the joker face down on top. They then slide the top card until the arms of the exposed L match in length. Flipping the two cards and reading the ruler value indicates the accuracy of the match. Entering repeated measures into the spreadsheet estimates the psychometric function, the discrimination threshold, and the point of subjective equality. Similarly, for pair comparison scaling, the user separates the deck into suits, shuffles each suit and turns the piles face down. Using the spades as standards, they then repeatedly compare the other cards with the standards, sorting into piles of greater and lesser noise density. Turning the piles face up and entering their values in the spreadsheet populates the frequency matrix used by Thurstone's law of comparative judgment to derive an interval scale of perceived density. Additional instructions and analysis tools are provided for the other methods. Thus the FechDeck enables hands-on exploration and learning of the psychophysical methods. Finally, in addition to its valuable didactic purpose, the FechDeck, can be used for a serious round of Poker or a relaxing game of Hearts.

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The effects of tone duration and inter-stimulus interval on spectral and dichotic TOJ

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Temporal Order Judgments (TOJ) measure the individual's ability to perceive the order of a pair of brief stimuli separated by short inter-stimulus intervals (ISI). Auditory TOJ is mainly measured using either spectral or spatial (dichotic) TOJ. Spectral TOJ involves the presentation of two tones of different frequencies, either delivered to both ears simultaneously or to one ear alone. The participant responds as to the order of presentation of the two frequencies. Spatial TOJ involves the presentation of the same frequency tone to the two ears, asynchronous with respect to time and the participant responds as to which ear received the first and which second tone. Both paradigms have been used to measure auditory temporal processing. Stimulus onset asynchrony (SOA) is the time separating the first and the second stimulus in each pair and is equal to the sum of the duration of the first stimulus and ISI. In a previous study[1], we manipulated both stimulus duration and ISI and showed that for spatial TOJ, SOA predicted 97% of the variance in performance. However, for spectral TOJ, SOA predicted only 54% of the variance. These results imply that while for spatial TOJ almost all of the variance is predicted by SOA (i.e., temporal processing), an additional cue (perhaps non temporal or only partially temporal) is available when performing the spectral TOJ task. In another publication, we reported[2] that over 50% of the participants succeeded in performing spectral TOJ with ISI < 5 ms, while only 3% (one participant) succeeded in doing so in the spatial TOJ task. These results again suggest that spectral TOJ is not performed solely using the temporal cue, or else it wouldn't have been performed with such short ISIs.

In the current study, we examined the use of temporal processing (the use of the temporal cue) in each of the TOJ paradigms by fixing ISI=0 msec, and manipulating stimulus duration. The results showed that manipulating stimulus duration alone resulted in the ability to predict spatial TOJ with R^2=97%, the same amount of predicted variance as previously ($z=0.68$, $p>.05$). However, with spectral TOJ, we obtained R^2=78%, a significant increase in the amount of predicted variance, as compared with previous data ($z=1.66$, $p<.05$), although still smaller than that of the spatial TOJ ($z=4.51$, $p<.001$).

For spatial TOJ, it seems that the temporal separation between the stimuli is the main cue for performance, no matter how this separation is obtained, either by stimulus duration or ISI. This pattern is expected if temporal processing is the sole means used to judge temporal order. However, two lines of evidence suggest that spectral TOJ is not based solely on temporal processing. First, different results were obtained when ISI > 0, than when ISI= 0 and duration was manipulated. Second, longer stimulus durations with ISI=0 msec provided a better prediction than shorter stimulus duration with longer ISIs. This might suggest that the additional cue to the temporal one, when performing spectral TOJ, is a cue that is dependent on stimulus duration and not ISI. When stimulus duration is longer, this cue assists more than when stimulus duration is short. Therefore, we posit that spectral TOJ is performed with a combination of a temporal cue and a spectral cue, based on the frequency differences between the stimuli. This cue is absent or at least reduced when the tone duration is shortened.

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On Laws in Psychology

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The weakness of psychological science, qua science, is a consequence of the direction of our scientific effort—establishing causal laws. But the search for causal laws is not of science, but engineering and other practical pursuits. Scientists investigate the nature of things; not the cause of things. Most of experimental psychology is concerned with causal questions. Such knowledge, practical though it may be, is often irrelevant to the science.

Now what does it mean to say that an interest in causes is unscientific? When the farmer is told the cause of his stunted corn is inappropriate fertilization, he apprehends directly the value of "science." But we all know very well that no biological scientist can tell him what to do about his corn, it takes a sophisticated agricultural engineer. The causal laws in biology are what the bioengineer uses to arrive at his practical prescription. The laws of biological science are scientific, of engineering they are causal laws.

What are these two kinds of laws like? "Causal" assertions are a description and compression of a class of experimental hypotheses that constitute the engineering basis of the science. The scientific laws that follow may suggest new and fruitful causal conjectures the engineering communities may adopt. The first implication of the distinction is the primacy of engineering over science.

Try this, knowledge of combustion made prediction and control of fire possible. Rules for building fires, containing them, and extinguishing them ensued. If statistical paraphernalia had been available, great "scientific experiments" could have been done. The analysis of variance would have shown an interaction between the size of the sticks for fuel, and elapsed time since the start. Wind velocity may have been introduced as a third variable.

When Newton observed that a detached apple fell to the ground, he formed a causal conjecture that there is some "force" that operates to "attract" objects toward the earth. It was given a name, and "gravity" became the cause of falling objects. As a result of this causal explanation, we make statements: "the apple falls because the gravity exerts a force on it." About as scientifically valuable as the assertion that nature abhors a vacuum. Where then is the scientific law? These are invented abstractions like position and time. The question then becomes: how do forces act on objects to move them? The scientist proposes connections between variables. We can suggest such a scientific law connecting position and time:

$$s = gt^2$$

In this scientific law, g, is the cause of the motion: gravity. The scientist's interest in it is exactly nil. But if a rocket engineer wants to land a rocket on a new planet, g for that planet needs estimation.

Suppose we conjecture, derive, hallucinate, or copy from another discipline, a "scientific law" in linear form:

$$y = ax + b$$

The "dependent" variable y, and the "independent" variable x, are the representations of the obvious events of scientific interest. The parameters (or in an earlier age "constants") are, to the scientist, the to-be-estimated statistics of the experiment; what have here been called the "causal" factors. But, someone asks, if we re-write and solve for a, have we changed the causes into the events of scientific interest? Of course not, because we cannot, as scientists, re-write the equation. The mathematical equivalence of

$$b = y - ax$$

and the previous equation in no way guarantees that the structure of the phenomena represented by the first expression is capable of this, possibly outlandish description. Sometimes, e.g. axiomatic statements, the distinction is less than obvious. For example, the fact that force is the product of mass and acceleration leads one to believe that there are no causal parameters in the expression, but only scientific variables. Re-write it as

$$F = gm$$

and you see that acceleration is indeed the equivalent of our gravitational constant, as expressed in Newton's Law, not as a fixed parameter but as an experimental boundary condition. But who is to decide which expression is the parameter?

Now turn to our own field and see how the argument fares. Psychologists are lucky because it is fairly simple to distinguish between psychological variables and irrelevant variables. We all agree that a measure of behavior, say response latency or relative frequency, is a number that represents or is symptomatic of a psychological variable. On the other hand, the intensity of a stimulus or the degree of deprivation of an organism is a manipulation of a non-psychological variable, intensity or time. If this analysis is at all appropriate, it leads to the wholesale rejection of "psychological science" laws of the form R = f (S), and replaces them with what have been called R-R Laws.

The strongest case for this point of view is seen best in that area of perception classically called psychophysics. Here, because of the unlucky reliability of the relation of stimulus and response, psychologists have proposed laws in the same tradition that we can see in the field of learning. One axis plots a physical variable, the other a psychological variable, the laws show stimulus effects on specific and well-defined responses. By the middle nineteen thirties the breakdown of invariance of many psycho- physical functions had brought the entire field into disrepute.

Once again the problem arises through a failure to treat the causal basis of psychophysical judgments as a parameter. In 1956 Stevens and I[1] explored the relation between category and magnitude scales of sensation on a dozen perceptual continua. The most important result, unexplained to this day, is the striking invariance of the two forms of behavior in the face of the most disparate stimulating conditions. The relation connecting the two scales has been conjectured by Torgerson[2], and by Messick and myself as

$$T = a \log M + b.$$

This psychological law has a counterpart at the level of detection and discrimination derived from various detection theories[3]. We see the same subject's response may range from rarely hearing the signal to always hearing the signal. But underneath this observed variability is the coherent mind that drags his false alarms along the curve.

As laws of psychology become more clearly enunciated in the form of numerical equations, the parameters of the equations become an object of study in them-selves. These studies¬¬–sophisticated engineering research–may lead to the kinds of contributions people want for the solution of the mundane but important problems of daily life. How can we know if the mentally ill behave differently in some subtle sense if we do not have any laws of behavior? When people do behave differently are those differences ones of form or parameters? If they are parametric changes can we associate empirical variables with the parameters? Only when we place scientific psychology in a context that gives us some leverage on questions of this kind, can we expect the growth of the practice of psychology to exhibit the maturity it deserves.

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How do we connect with the flow of events: the case of schizophrenia.

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We usually feel we are subjected to the time flow, and process successive events as they occur. But is this enough to follow events and to derive temporal order, or does one need additional mechanisms? We explored this question in patients with schizophrenia, who are impaired at following events over time. As a matter of fact, these patients are impaired at detecting asynchronies between visual stimuli[1], and they have even more difficulties at judging temporal order, when stimuli are delayed by 100 ms, which is largely supra-threshold[2]. Patients also have difficulties to follow events over time automatically, at smaller time scales.

We discovered indeed in healthy volunteers that events can be automatically and unconsciously distinguished in time even when they are judged to be simultaneous[3]. Moreover events appear to be followed over time automatically. We used simple asynchrony/simultaneity discrimination paradigms, in which subjects are instructed to press on one side in case of an asynchrony and on the other side in case of simultaneous stimuli. We showed that for small asynchronies leading to the same amount of 'simultaneous' responses as perfect synchrony, subjects' responses were biased to the side of the 2d event. Patients with schizophrenia also showed a bias but to the side of the first event[3]. A bias is impossible at perfect synchrony, when all information is symmetrical on both sides of the screen, and the presence of a bias shows that the asynchrony is detected automatically.

On the basis of additional priming paradigms, we suggested biases reveal the ability of subjects to go from the first to the second event in healthy subjects[4], this being impaired in patients with schizophrenia. However, it was unclear whether patients process or not the second event in a series of two. It might have been possible that they were captured by the first event, and that the slowed processing of this event prevented them from processing the following one. We now have some arguments against this possibility. The main one is derived from EEG studies. When examining evoked potentials occurring after the first stimulus we observe that their latency increases with the SOA between the first and second stimulus. The latency thus reflects the ability to encode the second event precisely in time after the first one. Moreover, the results suggest this shift in latency is preserved in patients for steps of 24 ms. Patients would thus encode events precisely in time, but would be impaired at going from one event to the other. This might explain that their abnormal bias at small asynchronies predicts their difficulty at consciously detecting supra-threshold asynchronies and judging temporal order[5]. Moreover, it suggests that encoding events precisely in time is not enough to consciously organize events in time. Deriving temporal order might be a more active process than previously believed.

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A psychophysical approach to human performance development

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Extending Fechner's principles psychophysics can position itself in the modern era to include larger domains in human performance including learning and movement development, assessment and training from birth to the high level athlete.

Previous historic and modern technical contributions to the fields of audiology and optometry demonstrate the useful applications of psychophysical science. Applying new psychosensory and psychomotor research analogous applications and technologies can be revealed for enhancing Human Performance abilities. Measurement, assessment and training tools can be developed to enhance the observation, analysis and development of human performance including learning and movement capabilities.

We will present examples of how psychophysical principles can enhance essential cognitive processes required for successful learning. Psychophysical principles including signal to noise ratio, sensory property coordination and algorithmic cognitive techniques can provide valuable stimulation and exercise for strengthening critical sensory processes and the psychosensory field navigation skills necessary to be in place before successful learning can occur. [1]

We will also present a method for applying psychophysical principles in the athletic arena. A psychophysical approach to enhance the observation, analysis and training of gymnastics skills will be demonstrated. [2]

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Perceived durations of filled and empty intervals

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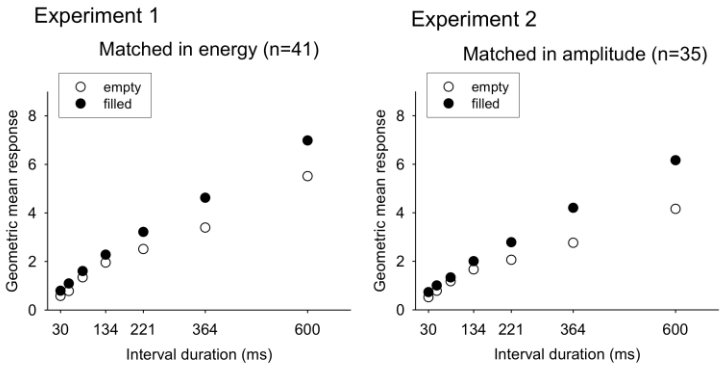
The duration between the onset and the offset of a sustained sound (filled interval) is often perceived to be longer than the duration between two very brief sounds (empty interval)[1]. This phenomenon is sometimes called the "filled duration illusion", and its occurrence seemed to vary with duration range, with a possible boundary at around 200 ms[2]. The present study examined whether the relationship between the perceived durations of empty and filled intervals changed for intervals shorter and longer than this boundary.

Perceived durations of filled and empty intervals of 30, 49, 81, 134, 221, 364, and 600 ms were measured using magnitude estimation. Empty intervals were marked by the onsets of two 20-ms sounds. Each sound included a rise and a fall time of 10 ms. In each trial, a time interval (either filled or empty) was presented once and the participants responded a positive numeric value that corresponded to the subjective duration of the interval. In Experiment 1, all filled-interval sounds were matched in energy, and in Experiment 2, all sounds were matched in amplitude.

Results of the two experiments were very similar: filled intervals were perceived to be longer than empty intervals, and this was clearer for 221 ms and above (Figure 1). In this longer-duration range, the overestimation of filled intervals became larger as the interval lengthened. For the filled intervals, the responded values increased almost linearly as the interval lengthened across the entire range, whereas for the empty intervals, the slope became gentler for intervals above 134 ms. This was consistent with our previous study[3]. The results suggest that the processing of empty intervals may be different for durations below and above a certain boundary in between 134 and 221 ms.



Results of Experiments 1 and 2: geometric means of the responses (magnitude estimations) obtained from all participants are plotted as functions of the interval duration and the interval types.

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Integration of stimulus dimensions in judgments of area and shape: Modeling guided by level curves

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In the horizontal-vertical (H-V) illusion[1] the judged V/H ratio is larger than the physical ratio. This tendency is not found in *V/H ratio judgments of rectangles*[2], but these are still not based on the physical ratio. If the power law holds for H and V, and V/H ratios are estimated as ψ_V / ψ_H, log-log plots should be straight parallel lines. But empirical plots deviate from this pattern.

L*evel curves* (iso-ratio contours) give a clearer picture (Fig. 1; whole-drawn: empirical; dashed: theoretical). For $\psi = f(H, V)$, the slope of the level curve at the point (h,v) is $-(\partial y/\partial H)/ (\partial y/\partial V)_{(h,v)}$. Here, log (max [H,V]) has a greater impact on log judged V/H ratio than log (min [H,V]), and log V has a slightly greater impact than log H. The pattern is well reproduced by a 3-parameter model where ψ_V and ψ_H follow a modified power law[3], $\psi = k\,(\phi - \phi_0)^{\beta}$ with negative ϕ_0 and with $\beta_V > \beta_H$.

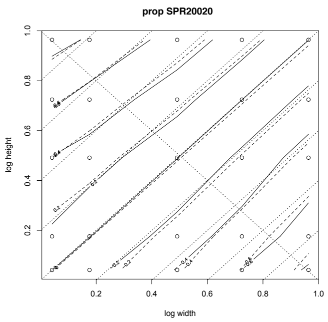

Fig. 1. *GM* judged V/H ratio = $(V+.512)^{1.124} / (H+.512)^{1.100}$ ($R^2 = .996$)

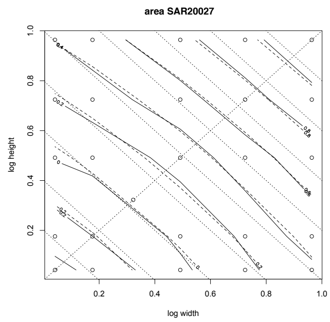

Fig. 2. *GM* judged area = $(V+.567)^{1.065} * (H+.567)^{0.864}$ ($R^2 = .997$)

If *magnitude estimates of rectangle area* are due to multiplication of subjective H and V magnitudes, $\psi_V * \psi_H$, and these follow the simple power law, log-log plots should be straight parallel lines. But the empirical plots[2] deviate from this, and level curves give a clearer picture (Fig. 2). The area estimates are closely reproduced by a 3-parameter model with $\phi_0 < 0$ and $\beta_V > \beta_H$. As the level curves show, for constant objective area, subjective area is smallest for a near-square rectangle. The present model gives a simpler explanation for this than an area-circumference compromise as has been suggested[2,4].

Judgment of rectangle area is thought to develop from addition of ψ_V and ψ_H in children to multiplication in adults. Level curves of age-group means[5] help confirm this.

In conclusion, (i) Allowing for ϕ_0, judgments of area and shape prove rather straightfor-ward. (ii) Level-curve plots (here, using R's *contour* function) are invaluable for graphic mo-deling guidance by displaying judgment tendencies that go unnoticed with conventional plots.

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Dissociation of Perceived Force and Resistance: Implications for Phenomenal Causality and Naïve Physics

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In Michotte's launching effect, an initially moving object (referred to as the *launcher*) approaches an initially stationary object (referred to as the *target*). When the launcher contacts the target, the launcher becomes stationary and the target begins moving at the same or slower velocity and in the same direction as previous motion of the launcher[1]. Subsequent theories of the perception of causality suggested the launcher possessed a "radius of action" within which motion of the target was attributed to the launcher[1,2], that only moving objects were perceived as causal[3], and that the target was not perceived as causal or as exerting influence on the launcher[4].

In a recent paper, Hubbard and Ruppel[5] presented observers with a standard launching effect display or a display in which the launcher stopped before contacting the target, at the moment of contact, or the launcher or the target shattered upon impact. Participants rated the perceived force and causality exerted by the launcher and by the target, and the target was rated as exerting more force and as more causal than the launcher when the launcher stopped or shattered upon contact with the target and the target did not move.

In the study to be presented, observers viewed a modified launching effect display in which the launcher stopped before or upon contact with the target and the target did not move. Participants rated the perceived force, resistance, and causality exerted by the launcher and by the target. Increases in the distance between the final location of the launcher and the location of the target led to (a) increases in ratings of perceived force and ratings of perceived causality and (b) decreases in ratings of perceived resistance. Causal asymmetries and force asymmetries between the launcher and the target that were reported in previous studies that presented launching effect stimuli did not occur.

The findings confirm that stationary targets can be perceived as causal and as exerting force. Also, the dissociation between perceived force and perceived resistance is not consistent with Newton's laws. An extension of Michotte's notion of "radius of action" to include effects of the target on the launcher is proposed, and implications of the findings for theories of phenomenal causality and for theories of naïve physics are considered.

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On the critical number of power-fluctuation factors needed for Japanese noise-vocoded speech perception

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Factor analysis (principal component analysis with varimax rotation) had shown that three or four common factors appear in 20 critical-band power fluctuations derived from spoken sentences of eight different languages[1]. The aim of this study was to examine the contributions of these power-fluctuation factors to speech intelligibility. The intelligibility of Japanese speech sounds resynthesized from extracted factor or factors was measured as a percentage of correctly identified Japanese morae (syllable-like units). Five men and four women participated in the experiment. All participants were native speakers of Japanese. The speech stimuli were Japanese noise-vocoded speech sounds of which 20 power fluctuations in critical-band filters were resynthesized from the extracted factors. Identification performances were determined when the number of factors was 1-9. Every increment of the number of factors (up to 6) caused a statistically significant improvement in intelligibility. A remarkable improvement appeared when the number of factors changed from 2 to 3, in which the average mora identification leaped from 5.4% to 79.7% (Figure 1). The present results suggest that three is a critical number of factors for intelligible speech perception, and the three power-fluctuation factors may reflect the universal characteristics of speech sounds across human languages.

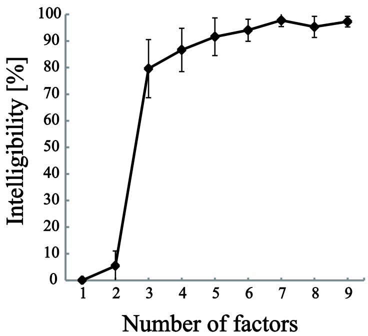

Figure 1. The results of the experiment derived from nine participants data. The x-axis indicates the number of factors utilized in resynthesizing speech sounds, and the y-axis indicates intelligibility measured as the average mora identification performances. Error bars show standard deviations.

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Snake Oil or Super Solution? Statistical and Psychological Approaches to Binary Decision Making

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Individuals and organisations are bombarded with binary decisions. Should one take statins for high cholesterol? Should this child be removed from its parents? Such decisions have major consequences, so *should* be '*evidence based*'. Sadly deciders often do not make the best (or even) any use of evidence. Statisticians and psychologists have contrasting approaches, this note outlines a key role for psychophysics in addressing current challenges in both disciplines.

General Formulation of the Problem

Two options (responses) exist. For each option the probability of success and the magnitude of the benefits and harms given known for two possible states of the real world (stimuli) is known.

Statistical Formulation

A decision is made by assessing the evidence that an intervention, works better than no intervention by a specified amount (0 for the null hypothesis). The *criteria* for the decision are set by conventions about the acceptable level of Type I errors the probability of assuming the null hypothesis when it is false, i.e. a false alarm. No account is taken of utilities

Recommendations, based on current criticisms, are to use *effect sizes* that for example measure the proportion of variance accounted for by an intervention. Quality of the evidence is measures using two *indices: sensitivity* = p (benefit|intervention); and *specificity* = p (no benefit|no intervention). Utilities are only sometimes used. The impact of high profile errors is rarely considered, e.g. a child left with parents, who is subsequently killed.

Psychological Formulation

Psychophysical approaches compare the distributions of outcomes according to what is true in the world. The Theory of Signal Detectability, TSD, uses normal distributions, (logits as in choice theory are also possible). The decision is made by setting a *criterion* that the intervention should be used. Crucially this criterion depends explicitly on a priori probability problem and of the utility of all four possible outcomes. The psychophysical sensitivity measure, d', is then defined from the probability of a hit (improvement|intervention) = sensitivity as (differently) defined by statisticians and probability of a false alarm (improvement|no intervention) = specificity. Response Operating Curves (ROC) *explicitly* show the effect of changing the criterion changes the frequency of hits and false alarms. TSD also allows comparison of setting criteria optimally according to distributions and using linear learning models

Summary

Insights from key work in psychophysics have the potential to improve statistical decision making in several ways. Firstly, d' provides a single measure of quality of evidence that combines statistical sensitivity and specificity. Secondly, psychophysics introduces utilities for all options explicitly. Finally, consequences of linear learning, where errors cause criteria swings against the bad outcome can be made clear and so lead to better use of all the evidence. Such insights should be used both in teaching and in formulating guidelines.

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Dichotic continuity illusion revisited

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A sound with a silence gap is perceived as continuous when the gap is filled with a louder sound. This continuity illusion has been explained in terms of the relation with peripheral masking[1]. The auditory system interprets the missing part of the discontinuous sound as being present but masked by the inserted sound, resulting in the restoration of the missing part. However, some limitations of this explanation have been voiced recently[2,3]. For example, a sound could be perceived as continuous even when its gap is not filled with sufficient sound energy[3].

A research group directed by L. Elfner[4] reported that the continuity illusion also occurs in dichotic presentation, i.e., when the discontinuous and the inserted sounds are presented at different ears. This dichotic mode of the illusion could be one of the evidence against the peripheral explanation, if this explanation links the illusion to the masking effect that is basically predicated from peripheral excitation pattern in a single ear. However, the dichotic continuity illusion has been tested in a very limited number of researches. The present experiment was conducted in order to examine the occurrence of the dichotic continuity illusion with various sound patterns.

The experiment consisted of four sessions for four target sounds: an ascending sound (from 500 to 2000 Hz), a steady sound (1000 Hz), a descending sound (from 2000 to 500 Hz), and a band noise (between 500 and 2000 Hz). Each lasted 1000 ms. The target was physically continuous or had a 12-ms silence gap at the temporal middle. The target was presented in isolation or with a distractor band noise of the same duration as the gap; this distractor was presented at the opposite ear to or the same ear as the target. The distractor noise was replaced with a sine burst for the noise target. The ear to which the target was presented was varied randomly across trials. The target and the distractor were at 30 and 50 dB SL, respectively. Each session begun with a practice block that included only the no-distractor condition; then, experimental blocks consisting of all conditions were conducted. Participants responded whether or not the target sound was continuous sixteen times for each condition.

The probability of responding “continuous” was increased in the with-distractor (dichotic and monaural) conditions compared with the no-distractor condition, indicating the replication of the dichotic continuity illusion. There might be some differences between the frequency-moving (ascending and descending) vs. the steady sounds; the former resulted in more continuous responses. This could be an avenue for future work.

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Duration reproduction across two hands: Relation with the kappa effect

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Empty time intervals are perceived as longer when these are bounded by two stimuli further away from each other in space[1,2,3]. This elongation of perceived duration, called the kappa effect, is typically produced by manipulating the space of stimuli that participants receive passively. We examined whether the similar spatiotemporal integration would occur when participants reproduce duration actively.

The present experiment consisted of two sessions. In the passive session, an inter-onset interval of 500, 1000, or 1500 ms was marked by two vibrotactile stimuli, each of which was delivered to either the left (L) or the right (R) hand. In other words, these two stimuli were delivered to an identical (LL and RR) or different hands (LR or RL); a typical kappa effect was expected in the latter case[4]. Participants reproduced this empty duration by pushing a button twice with the index finger of an identical hand. In the active session, the two stimuli were always delivered to an identical hand. However, the duration was reproduced by two button pushes with the index finger of an identical hand (LL and RR) or of different hands (LR or RL).

The reproduced duration was longer in the different-hand than the identical-hand condition in the passive session, indicating the occurrence of the kappa effect. Such elongation of reproduced duration did not occur in the active session, but the reproduction tended to be shorter in the different-hand than the identical-hand condition, especially when the physical interval was 1500 ms. There was no correlation between the two sessions for all durations. This indicates that the kappa effect is perception-specific, and its neural basis might be located outside the regions involving motor controls.
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The effect of disgusting food and disgusted faces on time perception.

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Recent studies have found that inducing disgust by presenting pictures of disliked food can compress one's perception of time [1]. The authors surmised that the root cause of that influence was the fact that when disgust is elicited through visual stimuli, one tends to dedicate more attention to the visual stimuli and less on time keeping. In contrast, another study by the same authors pointed out that that disgust had no effect on their participants' sense of time when said emotion was elicited through mimicry by showing pictures of faces expressing disgust[2]. It was also shown that showing pictures of mutilated bodies - a debatably disgusting type of stimuli – induces temporal overestimation compared to showing pictures of disgusted faces[3]. It would thus seem that it is not the emotion per se that drives the effect of putatively disgusting pictures on time perception, but rather one's adaptive reaction to the stimuli.

We aimed to measure the effect of truly disgust-inducing pictures of food on time perception and to contrast it directly with the effect of presenting pictures of disgusted faces. The pictures of disgusting food used in the present study were created and standardized in a short pilot study. In the main experiment, 30 participants completed a constant stimulus task where the standard duration lasted 1000 ms and the comparison interval lasted 400, 600, 800, 1000, 1200, 1400 or 1600 ms. The comparison interval was delimited by the onset and the offset of either a picture of disgusting food (DF), an empty plate (EP), a neutral face of the same gender as the participant (SGNF), a different gender neutral face (DGNF), a same gender disgusted face (SGDF) or a different gender disgusted face (DGDF). Considering the heterogeneous nature of the stimuli presented during the comparison interval, we used three types of stimuli for the standard duration: EP, SGNF and DGNF pictures.

When the standard was an EP picture, DF pictures led to significant overestimation compared to EPs, $p^{Tukey} = .0050$, $d_C = 0.44$. Also, both the duration of both SGDFs and DGDFs were significantly overestimated compared to that of EPs ($p^{Tukey} = .033$, $d_C = 0.33$ and $p^{Tukey} = .0096$, $d_C = 0.37$, respectively). When the standard duration was delimited by the presentation of a SGNF, the duration of DF and EP pictures were significantly overestimated compared to that of SGNF ($p^{Tukey} = .0025$, $d_C = 0.50$, and $p^{Tukey} = .0098$, $d_C = 0.44$, respectively). Finally, when the standard was delimited by the presentation of a DGNF, the duration of DF were significantly overestimated compared to that of SGNF ($p^{Tukey} = .0046$, $d_C = 0.51$) and DGNF ($p^{Tukey} = .010$, $d_C = 0.45$).

In conclusion, results showed that the presentation duration of DF pictures were consistently the most overestimated compared to the other stimuli, regardless of the type of stimulus used to present the standard. Thus, disgust elicited through DF may actually increase one's physiological arousal in order to trigger an avoidance response to the stimulus. Also, when the standard duration is not marked by pictures of faces, the presentation of disgusted faces may actually cause temporal overestimation.

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Tracking the eyes during numerical comparison

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In the current study, the eye movements made by participants while performing numerical comparisons of pairs of single digits were examined. The collection of eye-tracking data in cognitive studies can supplement in important ways the information provided by the standard measures of overall response time (RT). Given the on-line nature of eye-tracking data, such measures provide a more direct window into the moment-by-moment information processing that is occurring during a comparison trial. As well, eye-movements are generally regarded as providing a fairly veridical index of the allocation of attention during such trials[1].

Several key RT phenomenon are typically present when comparing symbolic number stimuli of this nature[2]. These include distance effects (faster responding as numerical differences increase), size effects (slower responding as numerical magnitude increases), semantic congruity effects (faster responding for smaller numbers when choosing the smaller and for larger numbers when choosing the larger), end effects (faster responding to numbers located at the end of the current range of number stimuli), and lexical markedness effects (faster responding when choosing the larger number).

On each trial of this study, participants were presented with pairs of numbers taken from the range of 1-5 and had to decide which one was either the smaller or the larger (in separate blocks of trials). Responses were made manually and number stimuli were presented on the far left and far right of a computer screen on each trial. Prior to the start of each trial, participants were asked to maintain fixation on one of the four corners of the screen. Eye movement data were collected pertaining to the timing, location, duration, and number of fixations made during each trial.

The obtained results can be summarized as follows. First, both distance and size effects were reflected in the durations of the first fixation to the second digit in the pair (faster for larger numerical differences and slower for larger digit magnitudes) and also in the number of trial fixations (less fixations for larger numerical differences and more fixations for larger digit magnitudes). Third, semantic congruity effects were reflected in the durations of the first digit fixations (which, unexpectedly, were slower for semantically congruent digits and faster for semantically incongruent digits). Fourth, both semantic congruity and end effects were reflected in the number of trial fixations (with less fixations when first fixating to semantically congruent end digits but not to semantically incongruent ones). Fifth, instruction effects were reflected in the number of fixations in a trial (with more fixations occurring when choosing the smaller in comparison to choosing the larger digit)

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Estimating the duration of decision process epochs

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Forty years have passed since the articles by Link[1] and Link and Heath[2] established the theoretical basis for a sequential theory of psychological discrimination. Previously, Abraham Wald[3] created formal methods of analysis for a theory of statistical decision making. The Wald theoretical ideas led to the prediction that for two choice decisions the correct and error responses, conditioned on the choice made, must be equal in their probability distributions. This prediction was not confirmed by psychological studies of choice. Therefore, this form of sequential analysis was not applicable to psychological processes.

The insight by Link that brought about the application of sequential processes to psychological processes was that the moment generating functions for comparative judgments did not require the symmetry assumed by Wald and other theorists. Link[1] provided theoretical and experimental results supporting new predictions of how correct and error times could differ. The prediction that correct and error times conditioned on the response made may be unequal is in some publications misunderstood. In some cases the interpretation of this prediction is that correct and error time conditioned on the stimulus presented may be unequal. This incorrect interpretation of the underlying basis for the application of sequential ideas to psychological processes led to a number of erroneous tests of supposed theoretical results.

In spite of these difficulties very powerful predictions relating response time and response probability allow for estimation of the temporal interval within which comparative processes occur. These predictions and applications to experimental data are the subject of current investigations of different comparative judgment processes.

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Cross-modality matches of intensity and attention capture dimensions of auditory and vibrotactile stimuli.

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Many complex environments are composed of multi-modal information processing of auditory and tactile stimuli which can be either intentionally or unintentionally processed and interrupt ongoing tasks. Previous research has shown that sudden and deviant changes in the auditory and tactile modality captures our attention in both a functionally similar and dissimilar manner[1].This example of involuntary attention capture is known as behavioral deviance distraction and has been reported in the tactile[1], auditory[2], and visual[3] modalities. Furthermore, stimulus strength has been found to be related to the magnitude of deviance distraction[4].

We investigated how the intensity of auditory and vibro-tactile stimuli is cross-modally linked to the subjective experience of intensity and its potency to capture attention. Thirty participants (17-42 years) conducted cross-modal matches between three fixed levels of vibration (Low: 2.3 m/s^2 R.M.S., Medium: 12 m/s^2 R.M.S., and High: 63 m/s^2 R.M.S.) administered by hand-held joysticks and a white noise sound that could be set between 40-80 dB (A). The participants performed two tasks; in one they were to match the sounds intensity level so that it matched the perceived intensity level of the vibrations. In the second task, they were to specifically match the sound intensity so that they matched the vibrations perceived ability to capture their attention. The order of the tasks was balanced across participants.

We found that the stronger the vibration intensity, the more participants increased the sounds intensity levels in both tasks and that there was a high correlation between subjective intensity and perceived distractibility of the crossmodal matches. Correlation between matches in the two tasks was as follows, Low: $r = .57$, $p < .05$; Medium $r = .68$, $p < .05$; High: $r = .84$, $p < .05$. We conclude that perceived intensity of sound and vibration is closely related to perceived attention capturing ability and that these results may have implications for behavioral research of distraction by irrelevant stimuli.

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The Effects of Emotional Facial Expression on Time Perception in Patients with Parkinson's Disease

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Objective: Temporal judgments are based on three processing stages: clock, memory, and decision.

Variations in arousal level are known to affect the rate of the pulses' emission: An increased level of arousal increased the speed of the pacemaker. For a given duration period, if the pacemaker runs faster, more pulses reach the accumulator, and this duration is judged to be longer. Variations in an individual's arousal level can be influenced by the presentation of emotional stimuli. Several studies showed that emotional pictures generating high arousal lead to greater overestimation of time, compared to emotional pictures generating less arousal. Parkinson's disease (PD) is a movement disorder characterized by dysfunctions of dopaminergic systems and it offers an opportunity to study the possible influence of the dopaminergic pathways on emotional processing. Moreover, previous studies showed that temporal dysfunctions in PD patients are also attributed to degeneration in the dopaminergic pathways. In the present study, we investigate the magnitude of temporal distortions caused by the presentation of emotional facial expressions (anger, shame, and neutral) in PD patients and controls.

Method: Twenty-five older adults with PD and 17 healthy older adults took part in the present study. PD patients were divided into two sub-groups, with and without mild cognitive impairment (MCI), based on their neuropsychological performance. Participants were tested with a time bisection task with standard intervals lasting 400 ms (shortest) and 1600 ms (longest).

Results: We calculated the proportion of "long" responses for each temporal interval presented. Significant main effects for emotion and temporal intervals were found. Moreover, the group × emotion × temporal interval interaction was significant. Post-hoc analyses showed that PD-MCI judged the long temporal intervals (1200, 1400 and 1600 ms) as shorter, and the short temporal intervals (400 and 600 ms) as longer, compared to PD-non-MCI and controls. PD-non-MCI and controls equally judged the temporal intervals in all emotions. Only in the case of PD-MCI, at 400 ms, were significant differences observed between emotional stimuli (anger and shame facial expressions) and neutral stimuli. This finding indicates that PD-MCI patients pressed more often "long" at 400 ms when the stimulus has a neutral emotional valence than when anger or shame is shown. Moreover, specific analyses on the effect of emotion on time perception showed that being exposed to facial expressions of anger produced an overestimation of temporal intervals whereas the facial expressions of shame produced an underestimation of temporal intervals.

Conclusions: The effect of facial emotional stimuli on time perception was evident in all participants, yet the effect was greater for PD-MCI patients. Further, PD-MCI patients were more likely to underestimate long and overestimate short temporal intervals than PD-non-MCI patients and controls. Temporal dysfunction in PD-MCI patients is caused by memory dysfunction.

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The role of modality in time perception after tDCS applied over primary auditory and visual cortex

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Aim: The mechanisms underlying the temporal representation of duration in milliseconds/seconds range are complex. A critical issue in the field of time perception is whether or not explicit judgments about time are processed by a central, internal clock or by a specific timing mechanism within each sensory mode. Many studies showed that visual stimuli are frequently experienced as shorter than equivalent auditory stimuli. These findings suggest that timing is distributed across many sensory areas and that "different clocks" might be involved in temporal processing. The aim of this study is to investigate, with the application of tDCS over V1 and A1, the specific role of primary sensory cortices (either visual or auditory) in temporal processing.

Method: Twenty-four University students were included in the study. Twelve participants were stimulated over A1 and 12 participants were stimulated over V1. Participants performed time bisection tasks, in the visual and the auditory modalities, involving standard durations lasting 300 ms (shortest) and 900 ms (longest). A direct current of 1.5 mA intensity was delivered through two saline-soaked surface sponge electrodes. The stimulating electrode (anode or cathode area = 25 cm2) was then positioned over the right A1 or right V1, and the reference electrode (area = 35 cm2) was placed on the skin overlying the ipsilateral shoulder region. The position of the auditory cortex was localized according to Brodmann areas 41 and 42 and the stimulating electrode was placed over A1 or V1 according to the international 10/20 system for EEG electrode placement. The position of the visual cortex was localized as the position of Oz in the international 10/20 system. None of the participants reported experiencing pain caused by the stimulation, and all participants concluded all experimental sessions.

Results: We calculated the proportion of "long" responses for each temporal interval presented. Results showed significant main effects of stimulation and temporal intervals. Participants had a tendency to respond "long" more times under cathodic stimulation than anodic and sham; moreover, participants responded more often "long" as duration of intervals increased. The area × modality × temporal intervals interaction was significant. When A1 was targeted, participants judged long temporal intervals (from 600 ms) in visual modality lasting longer than temporal intervals in auditory modality. When V1 was targeted, participants responded more often "long" for auditory than for visual intervals. Analyses of constant error showed a significant a significant area × modality × stimulation interaction. Post-hoc analyses showed that participants made larger errors when cathodic stimulation was applied over A1 and the stimuli were in visual modality and when the cathodic stimulation was applied over V1 and the stimuli were in auditory modality. Also, when the stimuli were in auditory modality, participants made larger errors when the cathodic stimulation was over V1 than when over A1; and when the modality was visual, participants made larger errors when the cathodic stimulation was over A1 than V1. Significant differences between anodic and cathodic stimulation was observed in A1 when the stimuli were in visual modality indicating that participants made larger errors under cathodic stimulation.

Conclusion: Our data support the hypothesis stipulating that time is primarily processed in the auditory system.

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Several examples of tactile illusion

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1) The Velvet Hand Illusion: The participant easily feels the Velvet Hand Illusion (VHI) by holding a coarse-wire net between both hands and moving them simultaneously on the net. The surface of each contralateral hand is felt to be very soft and smooth. However, a wire is not needed for experiencing the VHI: two rods positioned parallel to each other will also suffice. Miyaoka[1] showed a mathematical model to explain relations between the distance of the two rods and the illusion amount.

2) The Fishbone Illusion: The pattern shown in Fig. 1 is a stimulus example for the fishbone illusion. When the participant moves his/her fingertip on the "spine", he/she feels that the spine is concave although all of the ridges are of the same height (Fig. 2).

3) The Lattice Illusion: The pattern shown in Fig.3 is a stimulus example for the lattice illusion. When the participant moves his/her fingertip in a direction orthogonal to the thin ridges, he/she feels the ridges to rise although all of the ridges are of the same height (Fig. 4).

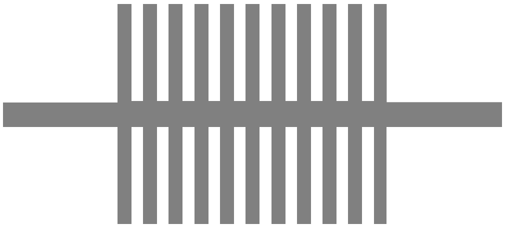

Fig. 1

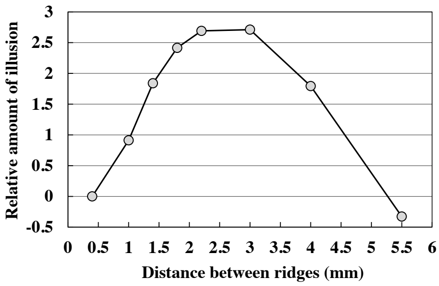

Fig. 2

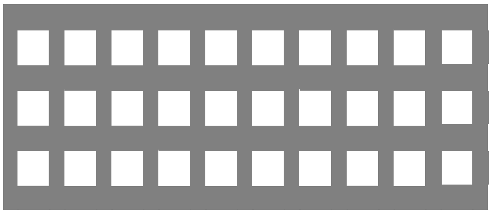

Fig. 3

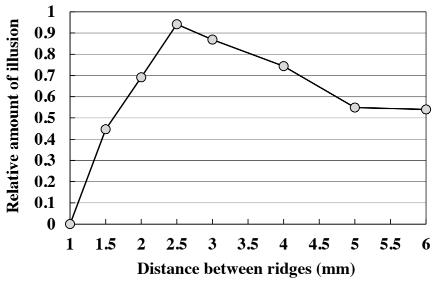

Fig. 4

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Overall Significance versus Individual Outcome in Reverse Vocal Stroop

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Psychophysical models attempt to describe the sensory behavior of individuals. When such data are aggregated, one can perform statistical tests to demonstrate support for a particular model. Sometimes, although the overall results describe the behavior of some participants, they fail to describe the behavior of others. In the following two experiments performance varies greatly among individuals and fails to fit established theory.

Experiment 1

The 132 students tested pronounced a color word presented on a black screen. The words were presented in white (neutral), the color named by the word (congruent), or in a color named by a different response word (incongruent). There were two trial blocks each consisting of 12 practice trials and 48 data trials. Stimulus types were presented in groups of 16 trials separately within each trial block. Data were analyzed as reverse Stroop interference (incongruent RT – neutral RT), congruity (incongruent RT – congruent RT), and facilitation (neutral RT – congruent RT). Both automaticity^1 and translation^2 theories, as well as all other Stroop theories, predict that none of the measures will be significant with reverse vocal Stroop responding.

Results for all participants showed significant positive interference and congruity but no significant facilitation. Results for those showing positive interference on both trial blocks (n=58) were the same as the overall results except facilitation was significant and negative. For those with positive interference on one trial block but not the other (n=56), there was significant positive interference, but not congruity or facilitation. . For those with negative interference on both trial blocks (n=18), there was significant negative interference and congruity, but no significant facilitation.

Experiment 2

The 99 students tested also pronounced a color word. Experiment 2 was similar to Experiment 1 except stimulus types were randomized within trial blocks. Results for all participants and for those with positive interference on both trial blocks (n=38) were statistically the same as in Experiment 1 except the values for interference and congruity were considerably lower. Those with positive interference on one block but not the other (n=48) showed no significant interference, but significant positive congruity and facilitation. Those with negative interference on both trial blocks (n=13) showed significant negative interference and facilitation, but no significant congruity.

Discussion. Participants who showed positive interference on both trial blocks in both experiments also showed, on average, results similar to the overall results. Participants who had one of more trial blocks with negative interference, tended to show less similar results. Participants who showed positive interference in both trial blocks also showed positive congruity and negative facilitation; indication that neutral stimuli were processed faster than congruent. Participants who showed negative interference in both trial blocks, showed negative or non-significant congruity and positive facilitation, indicating the opposite, that congruent stimuli were processed faster than neutral. It would appear that the task was somehow different for different participants, and in any case, the theories are inadequate explanations for reverse vocal Stroop behavior.

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Perceived intensity, pleasantness and related fMRI-brain activity of olfactory stimuli

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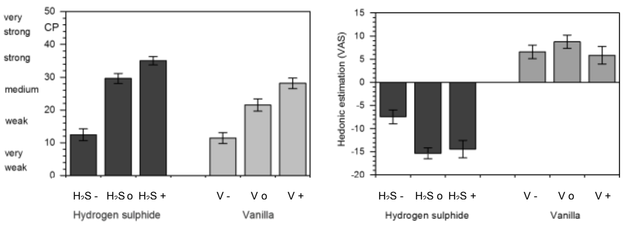
Objective of this study was to explore the psychophysical relation between i) the quality and intensity of odor stimuli, ii) the perceived intensity and hedonic impression and iii) the relation between stimuli and observable blood oxygen level-dependent (BOLD) signals. Special attention was drawn to the psychological scaling procedures applied. Using the Sniffin`Sticks-Test (SnS) 28 subjects were chosen from primarily 40 persons and served as subjects in fMRI-studies. In a first experimental session they rated the intensity of olfactometrically presented H_2S and Vanilla-stimuli using a Category-Partitioning Scale (CP) and the pleasantness of the same stimuli using a bipolar category anchored visual analogue scale. From psychophysical functions fitted to these scaling data, for each subject 3 intensity-levels were chosen representing perceived intensities: just above perception threshold (CP5), weak (CP15) and strong (CP35). In a 2nd session each subject received the odors at these intensities via olfactometer in the operating tomograph for sensory evaluation only. After sensory evaluation brain activity was recorded. Stimuli were presented randomly to the right nostrils whereby each of the 6 pulsed stimuli (H_2S and Vanilla in the individual concentration for low, weak and high intensity) was presented for 20 sec separated by odorless inter-stimulus-intervals of 30 sec. For the main effect of odor vs. rest we observed activity in the bilateral insula, bilateral amygdala and the left VLPFC ($p<0.001$). The intensity ratings correlated with the right amygdala activity ($p<0.001$). Hedonic ratings were negatively correlated with right amygdala and bilateral insula activity ($p<0.001$).



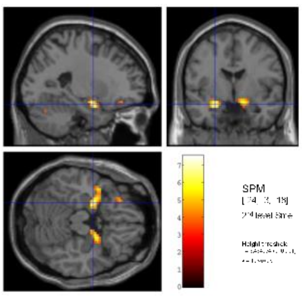


Figure 1. Perceived intensity (left), the related pleasantness (middle) and main odor effect (right) of H_2S and vanilla stimuli

Decent results thus far. Looking with critical eyes on the ı es, however, it seems that fMRI data don't follow a common rule. The findings indicate that basic research on the method itself is urgently needed.

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About the intermodality and uncertainty effect on the discrimination of empty time intervals when the first signal is tactile

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Recently, an explanation[1] was offered to reconcile the single-clock theory with the empirical fact that temporal interval marked by auditory signals are easier to discriminate than those marked by visual signals. According to it, signals in some modalities tend to create less noise in the temporal perception process than those other modalities. This gives rise to better or worse discrimination ability depending on the modality marking the intervals. If the sensory noise is that critical, then the discrimination level shown for time interval delimited by an auditory signal (A) and a visual signal (V) should be somewhere between that of intervals marked by two auditory signals and that of intervals marked by two visual signals. Surprisingly, empirical studies on the subject reported that presenting intervals in AV or VA causes poorer discrimination levels than in either AA or VV conditions[2]. The aim of the present study is to understand the effect of intermodality –the fact that an interval is marked by signals from different modalities– on temporal discrimination by investigating how knowing (or not) in advance the modality of the signals marking the intervals influences performance.

Method

Eleven participants (mean age= 22. SD= 3.55) completed a bisection task over the course of eight experimental sessions. Three factors were manipulated: uncertainty (uncertainty, no uncertainty), duration set (200 to 400 ms or 600 to 1200 ms) and marker modality (tactile-tactile, tactile-auditory, tactile-visual). Sensitivity was measured with the Weber Fraction and perceived duration, with the Constant Error.

Results

Sensitivity. In general, tactile-tactile intervals were better discriminated than tactile-visual. The same was true regarding tactile-tactile and tactile-auditory intervals, but the difference in performance was greater for the shorter duration set (200-400 ms) than the longer one (600-1200 ms).

Perceived Duration. Globally, the duration of tactile-visual intervals was underestimated compared to that of tactile-auditory ones. The duration of tactile-tactile intervals was also underestimated compared to that of tactile-visual ones, but the difference was greater when participants were uncertain about the modality of the second marker.

Conclusion

This study confirmed that intervals presented with markers in the same modality are better discriminated and judged as lasting longer than those marked by signals in different modalities. However, this gain in sensitivity/perceived duration is modulated by two factors: the duration set used and uncertainty about the modality of the second marker. A way to explain those results is to conceptualize temporal perception as being the result of two separate mechanisms. One is subconscious and is modality-specific and the other is aspecific to modality and requires a greater amount of attentional resources.

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Temporal weighting of loudness: Different psychophysical tasks reveal different evaluation strategies

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Over the last few years, psychophysical reverse correlation has been employed to characterize temporal weighting processes underlying loudness judgments of time-varying sounds [1–3]. Using sample discrimination tasks, in which observers were asked to discriminate one or more stimuli in loudness, several studies indicated the presence of non-uniform temporal weighting in loudness judgments. The first and, to a lesser extent, the last temporal portions of the stimuli were found to be weighted more heavily than the others; this was shown to reflect primacy and recency effects, respectively[2] .

Can similar non-uniform temporal weightings mechanisms be found using other traditional psychophysical methods such as direct scaling methods? This question was addressed in the present study by comparing temporal weighting patterns underlying global loudness judgments between two types of psychophysical tasks: Level-Discrimination tasks (LD) and Absolute Magnitude Estimation tasks (AME). In the LD tasks, listeners were asked to classify the stimulus as soft or loud[2] (i.e., in a binary fashion) while in the AME tasks, they had to select a number that, in their impression, best represented the overall loudness of the stimulus. Two within-subjects experiments (N=7 in each experiment) were conducted with different conditions that allowed a control of potentially influential factors. Our hypothesis was that similar weighting patterns should be found in the two tasks, since the same internal variable (i.e., *global loudness*) is involved.

In both tasks, we observed consistent non-uniform temporal weighting patterns. However, these patterns differed significantly between the two tasks. In particular, the temporal weighting patterns in the AME tasks displayed significant primacy effects but no recency, whereas in the LD tasks, only recency effects were obtained. Thus, this result did not support our initial hypothesis. However, we propose an explanation based on the differences in complexity between the evaluation processes underlying level-discrimination and magnitude estimation tasks, respectively. It is assumed that the type of decision (binary vs. continuous) might affect attentional sharing during stimuli presentation, thus modifying underlying temporal weighting processes. Therefore, we argue that the present results do not invalidate temporal weighting processes typically inferred from sample discrimination tasks, but rather suggest that the magnitude estimation tasks repeated over hundreds of trials might lead participants to adopt specific strategies minimizing the cost of their evaluation process.

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The effect of numerical digit value on perceived duration does not depend on the mere number categories of low and high values

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An increasing number of psychophysical studies provided evidence that large numerical digit values (e.g., 8 or 9) are judged to last longer than small digit values (e.g., 1 or 2) presented for exactly the same time. Unfortunately, these studies did not report the effects of single digit values on perceived duration, but rather presented mean results for the small- (e.g., 1 or 2) and large-magnitude (e.g., 8 or 9) digit sets. Therefore, it remained unclear whether this effect can be considered a linearly increasing function of numerical digit value. The present experiment was designed to further elucidate the influence of numerical digit value on perceived duration.

Participants were eight male and 34 female students ranging in age from 18 to 29 years. They were required to reproduce three different target intervals (800 ms, 1000 ms, and 1200 ms). There were 16 presentations of each target interval. These 16 presentations consisted of four presentations of each possible numerical value (1, 2, 8, and 9). As it is not known whether numerical stimulus magnitude has to be processed consciously to effectively influence temporal processing, a dual-task paradigm was applied to identify a possible intervening influence of attention. In one version of the task, attention was directed to numerical parity and, in the other version, attention was directed to the numerical digit value.

Analysis of variance revealed a statistically significant main effect of numerical value, $F(3, 123) = 3.00$, $p < .05$, $\eta p2 = .068$. A post hoc Tukey's HSD test showed that the digit 8 was reproduced significantly longer than the digit 1. It is important to note, however, that the effect of numerical value was effectively moderated by attention paid to either numerical parity or numerical value, $F(3, 123) = 4.05$, $p < .01$, $\eta p2 = .090$. Post hoc analysis revealed no statistically significant differences in reproduced duration when attention was directed to digit parity. When attention was directed to numerical digit value though, the digit 8 was reproduced significantly longer than digit 1 ($p < .05$) and digit 2 ($p < .01$). At the same time, digit 9 did not differ significantly from any of the other digits.

Taken together, it seems that nontemporal stimulus magnitude in form of numerical digit value has to be processed consciously and intentionally to effectively influence perceived duration. Furthermore, the present findings clearly argue against the common, implicit assumption that the effect of numerical digit value on duration judgment or perceived duration depends on the relative digit value or the mere number categories of low and high values. Consequently, the present data do not support the implicit notion of a positive linear relationship between numerical digit value and perceived duration.

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Letters in the forest: global precedence effect disappears for letters but not for non-letters under reading-like conditions

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On the basis of previous studies, we argue that in normally skilled readers an abstract letter code leads to the preferred usage of analytic strategies for the processing of letters, while non-letters are preferably processed via holistic strategies[1]. The well-known global precedence effect (GPE)[2] seems to contradict this assumption, since, with compound, hierarchical figures, including letter items, faster responses are observed in the global than in the local level of the figure, as well as an asymmetrical interference effect from the global to the local level.

We argue that with letters, these effects depend on presentation conditions: only when they elicit the processing strategies automatized for reading, an analytic strategy for letters in contrast to non-letters is to be expected.

We used a two-alternative-forced-identification-task to compare the GPE for letters and non-letters in central viewing, with the global stimulus size close to the functional visual field in whole word reading (6.5° of visual angle), and local stimuli close to the critical size for fluent reading of individual letters (0.5° of visual angle)[3].

Under these conditions, GPE remained robust for non-letters, whereas it disappeared for letters: no overall response time advantage for the global level and symmetric congruence effects (local-to-global as well as global-to-local interference). We interpret these results according to the view that reading is based on resident analytical visual processing strategies for letters.

In a training study we tested if the letter - non-letter distinction in GPE disappears when the non-letters become systematically associated with phonemes in various training sessions. Participants randomly were divided either in a phonological or in a non-phonological training group and were trained to associate the non-letters either with phonological or with non-phonological sounds. After this training, participants performed the same task as before.

Against our hypothesis, results before and after training were found to be the same both in the phonological and the non phonological training group.

We concluded the GPE disappears for letters but not for non-letters under reading-like conditions and this distinction cannot be vanished by a short-term training of non-letters associated with phonemes.

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Scaling Internal Representations of Confidence: Effects of Range, Interval and Number of Response Categories

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Confidence reports represent one of the earliest methods used in experimental psychology[1,2]. In contemporary research, they have been used to assess participants' awareness of their performance in studies of categorization, metamemory, reasoning, perception. and general knowledge. In a typical experiment, participants make a decision or learn sets of stimuli and are then required to assess their performance using a confidence scale. Considerable attention has been paid to whether confidence reports reflect different kinds of knowledge[2,3] and how task difficulty influences confidence ratings4. In contrast, properties of confidence scales have rarely been considered[5,6,7]. The present study examined how scale properties influence subjective confidence reports in terms of calibration indices.

Previous studies appear to provide support for the effect of scale range on confidence processing. Ronis and Yates5 and Juslin et al.[6] conducted studies that used both full-range (0-100) and half-range (50-100) scales. Ronis and Yates[5] had participants predict the outcome of games as well as answer two-alternative general knowledge questions. They were assigned to half-scale and full-scale confidence conditions in a between-subjects design. Ronis and Yates found the lowest levels of overconfidence bias when participants used the full-range format. Using identical scaling methods, Juslin et al. employed tasks that required predicting the frequency of car models (Experiment 1) and the populations of European countries (Experiment 2). Juslin et al. also observed the lowest levels of overconfidence bias when participants used the full-range. Taken together, these studies appear to support the conclusion that scale range is an important determinant of miscalibration. In this case miscalibration is a result of a mismatch between the underlying psychological continuum of certainty and the available labels.

Our study examined the three factors that were assumed to affect the mapping of subjective confidence onto an external scale. Three experiments produced findings which suggest that the range, the interval, and the number of categories that define a scale influence subjective confidence reports. In Experiment 1, we provided two different groups of participants with full- and half-range scales. On one block of trials participants used all confidence categories (e.g., 0 through 100) whereas on another block of trials participants used only the end points (e.g., 0 and 100). We replicated findings that suggested that range was an important determinant of calibration, but found evidence that the number of confidence categories also influenced calibration. In Experiment 2, we provided participants the full- and half-range conditions of Experiment 1 on one block of trials. In another block of trials, we additionally provided participants with either 6- or a 11-category variant of the full- and half-range scales. For the full-range condition (0 through 100), participants were provided with a 6-category scale (i.e., 20-unit interval) whereas in the half-range condition (50 through 100), participants were provided with a 11-category scale (i.e., 5-unit interval). This allowed us to compare the effects of the number of categories (6 or 11) with range and interval. We found that once scale properties were equated, the greatest effect on performance was the number of categories used to report confidence. In a third Experiment, participants used either the 2- (Experiment 1), 6- (Experiment 2), or 11-category category scale. However, participants did not know in advance which scale they would be presented with on a trial-to-trial basis to make their post-decisional confidence reports. We found that participants had the poorest calibration in the full-range conditions suggesting that they failed to map their internal representation of magnitude onto an external scale. Implications for the representation of certainty are discussed.

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Loudness effect on pairwise comparisons and sorting tasks

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Effect of loudness on timbre perception is investigated by two experimental methods: pairwise comparisons and sorting tasks. In each experiment, the sounds are presented in two conditions: with their ecological loudness, and equalized in loudness. The sounds are similar in terms of source in order to let listeners focus on timbre differences.

The number of dimensions of the MDS Euclidean space derived from the dissimilarity ratings experiment (N=30) was: two, one correlated with the level difference between sounds, for the non-loudness-equalized corpus; and three dimensions for the equalized corpus, two correlated with two sound descriptors, Perceptual Spectral Centroid (PSC) and Harmonic-to-Noise Ratio (HNR), respectively, as previously obtained by Misdariis[1].

For the sorting task experiment (N=24), participants based their classification solely on the difference in sound pressure level when loudness was not equalized. However, when loudness was equalized, two dimensions were revealed, one correlated with the HNR parameter. No dimension was correlated with the PSC parameter; it seems that this auditory attribute has not been revealed to be a factor in the grouping task. It appears that sorting data used as input for the MDS analysis revealed a lower number of continuous dimensions. This statement is in line with the study by Giordano[2] proposing to adopt sorting tasks as an alternative to dissimilarity ratings only when strictly necessary to model distances in a Euclidean space.

On the whole, the present results suggest that, when loudness is a factor in the comparison of sounds, it might dominate participants' judgements, especially in a sorting task. It appears that loudness has affected the perceptual structure underlying timbre as if loudness was a "hard" dimension compared to "soft" dimensions such as timbre. Another possibility is that participants are unable to attend selectively to several timbre dimensions when loudness is varying across the sounds.

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Face color affects identification of facial expression.

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Color role in visual system is partly revealed. Color effect has been found in scene[1] and object recognition[2] when stimuli had their typical colors (e.g. lemon is yellow) or when stimuli were difficult to identify[1.2.3]. A hypothesis that human's trichromatic system was developed to discriminate skin color[4,5] suggests the importance of face color in facial expression as a social signal. Therefore, we investigate the color effect on facial expressions.

Presuming that the color effect will be activated when the stimuli are difficult to identify, the schematic faces as experimental stimuli have various degree of facial expression. The schematic faces were colored five colors respectively. Four colors correspond to emotions such as red to anger, blue to sadness, yellow to joy, white to no emotion, and another was green, do not correspond. A set of stimuli was displayed one by one. Participants responded to whether the face was emotional or not, and to which emotion they read.

We conducted repeated measures ANOVA. As a result of 48 participants, in the judgment of whether emotional or not, main effect of color was significant in all emotions for correct response, while only in anger for reaction time. Fig.1 shows correct response and reaction time for anger and Fig.2 for sadness. For the correct response, red and blue were higher in anger, and blue was higher in sadness. Besides, when facial expressions were ambiguous, color effect appeared more activated. For reaction time, red in anger and blue in sadness were shorter. The facilitation of corresponding color to emotion suggests the importance of face color in identification of facial expressions.
anger and blue in sadness were shorter. The facilitation of corresponding color to emotion suggests the importance of face color in identification of facial expressions.

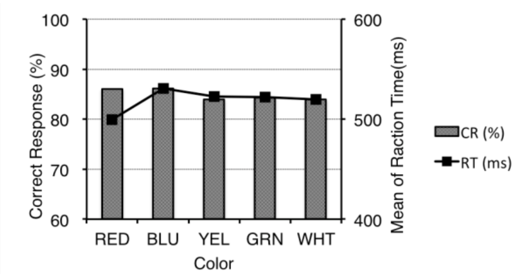

Fig.1

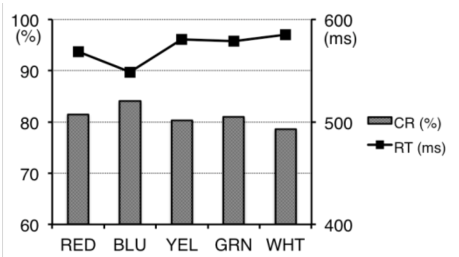

Fig.2

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Pain perception in infants and its relation to maternal emotional state

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There are evidences of the association between stress and persistent changes in neuroendocrine and behavioural systems in children who have experienced early life stress[1] and therefore, changing the patter of adaptive response for repetitive painful stimulation. Newborn infants of mothers who have suffered from postpartum depression, thus creating a stressful environment for the newborn, showed neurological and behavioural findings such as lower vocalization, delayed motor and mental development[2].

Behavioral adaptation after repeated painful procedures has been seen as evidence of habituation to pain, which is a protective factor in chronic or repeated states of pain. This can be a result of functional plasticity of nociceptors, capable of activating brain areas that inhibit or reduce the pain response[3]. The exact neurobiological mechanism of this phenomenon remains unclear. The aim of this study was to observe the ability of adaptive response to pain in 13 newborns by means of a comparative analysis with the maternal previous stress level and emotional state. Mothers were investigated for prenatal stress index by Holmes & Rahe scale[4], for assessment of maternal postpartum depression and anxiety we applied the Edinburgh Postnatal Depression Scale[5] and to assess the mothers' perceptions of their ability to parent it was applied the Perceived Maternal Parenting Self-Efficacy scale[6]. The infants underwent four trials of heel lance for blood glucose curve during a period of 24 hours at the first day of life. Visual Analogue Scale–VAS[7] and COMFORT Behavior Pain Scale[8] assessed their pain perception response to repetitive heel lance. Physiological stress measure by salivary cortisol of mother-infant dyad was taken for baseline and for infants before and after all trials.

The results showed that maternal cortisol was related to infant cortisol after birth. COMFORT behaviour scores decayed significantly in time for the entire sample ($R= .33$, $R^2= .11$, $p= .014$) in special for infants of more stressed mothers ($R= .46$, $R^2= .22$, $p= .025$). VAS scores of infants didn't differ all over time ($R= .36$, $R^2= .001$, $p= .891$). Maternal stress exposition history during pregnancy had influence over COMFORT scores especially at 1st trial. Maternal positive beliefs about the relationship between mother and baby, as responsiveness, good interaction and affection, reduced COMFORT scores at 1st trial. Some specific items from the EDPS scale had special effects showing that suicidal thoughts, unhappiness, fell scared or panicky induced high cortisol levels while being positive toward the future lowered the cortisol.

We concluded that higher maternal cortisol levels, perception of parental self-efficacy, reported stress and anxiety were related to higher infants' salivary cortisol at baseline and also predicted COMFORT scores in infants of higher stress mothers. VAS scores didn't differed between time points and showed tendency to sensitization and were interpreted as evidence of distress. These conclusions are supported by previous findings pointing that mild-to-moderate maternal levels of stress can accelerate cognitive function in infants, but also leads to enhancement in anxiety levels[9].

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The effect of segment duration on the intelligibility of locally time-reversed speech: A multilingual comparison

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Following the pioneering work by Steffen and Werani[1], Saberi and Perrott[2] reported intelligibility degradation of locally time-reversed speech. Their stimuli were based on natural speech utterances divided into segments of equal duration of up to 300 ms; each segment was reversed in time. Intelligibility deteriorated as segment duration increased, and reached the 50% threshold around 130 ms. Other studies[3] in English, French, and German, however, found 50% of intelligibility for shorter segment durations (i.e., 60-80 ms) as compared to Saberi and Perrott. It is unknown what values apply to different types of (i.e., non-Indo-European) languages such as Chinese and Japanese.

The purpose of the present investigation was to examine how the intelligibility of spoken sentences in Chinese, German, and Japanese changes as the duration of locally time-reversed segments increases. Thirty-five sentences spoken by both a male and a female speaker in each language were extracted from a database[4]. The sentences were divided into segments of equal duration (20-170 ms); each segment was shaped with 7.5-ms cosine ramps, reversed in time, and subsequently joined with the other segments in the original order. The resulting utterances were presented diotically to native speakers (21 or 28, depending on language) through headphones. The participants were instructed to write down what they heard without guessing. Percentage of correct morae or syllables was measured as an index of intelligibility. Intelligibility was above 90% when segment duration was 45 ms, but dropped with increasing segment duration to below 10% at 120 ms. The 50% intelligibility point was observed for segment durations of around 65-70 ms irrespective of language. This finding and the majority of the previous literature[3] strongly suggest that a common time-averaging mechanism works in speech perception across different languages.

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Predicting and perceiving heaviness: the integration of material and size.

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When two objects of the same physical mass but different size are lifted, the larger object usually feels lighter than the smaller one. Moreover, when two objects of the same physical mass but covered with different surface materials are lifted, the object covered with the denser material (e.g., metal), usually feels lighter than the object covered with the less dense material (e.g., polystyrene). These two phenomena are known as the *size-weight illusion* and as the *material-weight illusion*, respectively. According to the *expectancy model* of weight perception[1], both phenomena can be explained in terms of contrast between expected and actual weight: larger objects (or objects covered with denser materials) are expected to be heavier, and therefore feel lighter, compared with smaller objects (or objects covered with less dense materials).

The aim of our study was to quantify the influence of surface material and size on the expected and the perceived weight of objects. The stimuli were 15 cubic boxes all weighing 1.19 kg and built according to a 3 (surface material) × 5 (size) factorial design. The three levels of factor 'surface material' were polystyrene (density = 0.017 g/cm^3), wood (0.44 g/cm^3), and terracotta (1.44 g/cm^3). The side of the cubic boxes could be 14, 17, 20, 23, or 26 cm. The experiment was designed according to a variant of the paradigm of '*Random conjoint measurement*'[2]. In order to minimize the number of trials without losing relevant information, we presented the participants with a convenient subset of the possible 15×14=210 ordered pairs of stimuli differing in surface material and/or size.

In the first part of the experiment the participants had to judge the *expected weight* of the stimuli. They had to indicate which stimulus in each pair appeared to be heavier based on their visual appearance (touching the stimuli was not permitted). The second part of the experiment was the same as the first part, except that the participants had to lift consecutively and with both hands the stimuli in each pair. In this way, judgments of the *perceived weight* of the stimuli were obtained. The indifference response was always allowed.

Nested hypothesis testing revealed that an additive response model best fitted the data of all the participants. The contribution of each level of the two factors was quantified by maximum-likelihood estimation. In line with the expectancy model of weight perception, *expected weight* increased with the density of the surface material and with the size of the stimuli, whereas *perceived weight* decreased with both factors. Interestingly, however, the three levels of factor 'surface material' had a strong influence on the *expected weight* of the stimuli, while having a relatively small influence on their *perceived weight*. The opposite was true for the five levels of factor 'size'. These results constitute a challenge for the expectancy model of weight perception, as they reveal that a noteworthy discrepancy exists between the relative contribution of factors 'surface material' and 'size' to the *expected* and the *perceived* weight of objects.

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When does a collision look natural? The role of the elasticity of the colliding objects.

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Intuitive physics concerns people's intuitive understanding of elementary laws of physics. In this study, we explore the intuitive physics of *horizontal collisions*, which are physical events with the following four characteristics: 1) A collision involves two spherical bodies, the masses of which are uniformly distributed (e.g., billiard balls); 2) The spheres have no spin; 3) The collision takes place in a frictionless, isolated environment; and 4) The spheres move horizontally on the observer's frontal plane.

Probably due to their simplicity, horizontal collisions have long been used as a privileged case for exploring the degree of consistency between intuitive and Newtonian physics[1-3]. Researchers have implicitly or explicitly assumed that perceptual and cognitive judgments of collisions are not influenced by the materials from which the colliding objects are made. From a physical viewpoint, however, *material properties* exert a dramatic influence on objects' motion. In the case of horizontal collisions, if the forces acting on the spheres are kept constant (i.e., their masses and velocities are kept constant) but the materials from which both spheres are made vary (e.g., wood vs. plasticine), then the kinematic pattern of the collisions will vary conspicuously with their materials. Indeed, the relative post-collision velocity of plasticine spheres will be much smaller than that of wooden spheres.

In our study, we presented the participants with virtually simulated horizontal collisions, and manipulated the simulated material of the colliding spheres, which could be wood, polystyrene, or plasticine. The size of the spheres was kept constant throughout the experiment, and the two spheres involved in one collision always had the same simulated material. This implies that the colliding spheres had the same implied mass in each simulated collision. For each simulated material, we determined the value of *coefficient of restitution* (*C*) implicit in collisions that had the highest probability of appearing as "natural". In Experiment 1, for each participant and each simulated material, we determined the collision with the greatest probability of appearing "natural" using the method of 'randomly interleaved staircases', whereas in Experiment 2 we used a variant of the method of 'adjustment'.

The results of both experiments reveal that the participants intuitively understood that collisions between somewhat elastic objects such as wood or polystyrene spheres imply higher values of *C* compared with collisions between less elastic objects such as plasticine spheres. This finding supports the hypothesis that people intuitively understand that the kinematic pattern of collisions is prominently influenced by the material properties of the colliding objects. However, the results also reveal that the participants were somewhat insensitive to violations of the principle of energy conservation.

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The Anisotropy of Visual Space as a Function of Distance from the Observer and Cue Conditions.

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Many studies have shown that the in-depth of dimension of visual space is perceptually compressed compared to the frontal dimensions[1]. This compression or *anisotropy* of visual space makes in-depth oriented stimuli seem shorter than physically equal stimuli oriented frontally.

The compression parameter, c, is the ratio of in-depth to frontal judgments for physically equivalent stimuli under the same conditions. I performed a small meta-analysis of articles for which this calculation is possible using data contained in their figures, resulting in 59 cases across 10 studies. This analysis shows that the degree of compression of the in-depth dimension of visual space relative to the frontal dimension becomes more pronounced as distance from the observer increases. Under binocular conditions, stimuli very near the observer actually show an expansion of the in-depth dimension of visual space ($c>1.0$), but the compression parameter rapidly declines until about 7m from the observer. For even greater distances, the compression parameter approaches an asymptote at about $c=0.5$. Monocular judgments produce slightly smaller compression parameters than binocular judgments. Reduced-cue conditions produce markedly smaller compression parameters than full-cue conditions. The compression parameter is largely unaffected by instructions (objective vs. apparent) and judgment method.

To confirm the results of the meta-analysis, a simple experiment was performed using 39 undergraduates. Tape, 4.78cm wide and 80 cm long, was used to make two rows of seven standard line-segments. Half of the line segments were oriented frontally, while the other half were oriented in-depth (along the median plane). The centers of each line segment ranged from 1m to 20m from the participant arrayed along their line of sight. The unmarked backside of an adjustable tape measure served as an adjustable comparison. The instructions emphasized that participants should judge the apparent length of each line, rather than objective length.

The results showed that mean apparent size judgments for line segments oriented in-depth were smaller than those oriented frontally after the first measurement at 1 m, that there was a steady decline in apparent length as the distance from the observer increased, and that the decline is swifter for in-depth oriented stimuli than for frontally oriented ones. Thus, under these instructions that emphasized apparent size, both frontal and in-depth oriented stimuli showed strong under constancy, with greater under constancy for the in-depth oriented stimuli. The compression parameter, c, was calculated by dividing the mean apparent size judgments for in-depth oriented stimuli by the mean size judgments for frontally oriented stimuli at each distance from the observer. As in the meta-analysis, the compression parameter is larger than one for very near stimuli. It rapidly declines in size as a function of distance until about 7m from the observer where the decline is less rapid. Once again, the compression parameter appears to reach an asymptote at about $c=0.5$ for the most distant stimuli.

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No evidence of a new kind of condensation

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'Negative hedonic contrast' occurs when something mediocre (e.g., a painting) is preceded by a very good one and is liked less than it would have been without the preceding better item. Negative contrast is often accompanied by 'condensation'; not only are mediocre stimuli rendered less good, they also become less different in hedonic value. We looked for contrast and condensation in judgments of the quality of the individual players' performances in chess games.

We created four mid-game 12 half-move (6 moves by each of White and Black) chess sequences. In sequences A and B ("Good"), both White and Black played well, whereas in C and D ("Bad") they did not play so well. White always outplayed Black. Some subjects saw the Good sequences A and B first (Group GB); others saw Bad sequences C and D first (Group BG).

In Experiment 1, 24 expert chess-players (USCF Elo ratings > 1300) watched every sequence on a computer and estimated each player's Elo rating. Negative contrast occurred in the averaged judgments of the players' Elo ratings ([White Elo + Black Elo]/ 2 in each sequence). Group GB gave lower estimates to the average Bad sequence player's Elo rating ($M = 1059.4$) than did Group BG ($M = 1240.4$); $t(22) = 1.86$, $p<.04$ one-tailed, Cohen's $d = .79$).

Condensation in perceived playing quality would occur if there was a smaller difference between the estimated Elo ratings for White and Black within each bad sequence for Group GB than for Group BG. But sadly we saw no evidence of that. The average differences between estimated Elo ratings of White and Black in the Bad sequences were 207.9 for Group BG and 195.8 for Group GB ($p>.8$). Thus there is no evidence of the result of interest, condensation of the ratings of the play of White and Black within the Bad sequences.

However, subjects' estimates of Elo ratings proved to be, for the Good sequences, strongly correlated with the subjects' own self-reported Elo ratings ($r \approx .58$). No such correlation was found for the Bad sequences, but we were nervous that estimated Elo ratings might be subject to biases that we can't think of. So we tried again with a different approach that avoided Elo ratings.

In Experiment 2, another 24 expert chess-players (USCF Elo > 1300) saw four chess-move sequences (A, B, and D repeated; C a new one). Instead of questions about the Elo ratings of the players, we asked, "How much better did the winner play than the loser?" on a rating scale ranging from 1 (a little) to 10 (a lot). The average rating for the Bad sequences was 6.38 for Group BG and 6.40 for Group GB ($p = .98$). So once again, there is no evidence of condensation in the perceived quality of play by Black and White within sequences whose quality is degraded by contrast.

Surprisingly, subjects' responses to that "how much better" question for the Good sequences were strongly negatively correlated with their own self-reported Elo ratings ($r \approx -.60$). The source and meaning of this result remain mysterious to us.

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Hedonic contrast within a meal

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Psychophysicists, starting with Fechner, have been interested in how context can influence hedonic ratings. Context effects have been found when stimuli occur close together in time, either simultaneously or sequentially. Two types of hedonic context effects have been seen: assimilation and contrast. Assimilation is when the target stimulus becomes more hedonically similar to the context stimuli when it is judged in the context of those stimuli[1]. It has been suggested that such effects occur with simultaneous stimulus presentation. On the other hand, contrast is when the hedonic judgment of the target stimulus moves away from the context stimuli[1]. It has been suggested that contrast occurs with sequential stimulus presentation.

In a meal there is usually more than one food served. A meal is divided into courses in many cultures (e.g., appetizer, main course, and dessert) that consist of different foods. Within the main course there are often a number of foods served together. Because a food is often served following or with foods of either greater or lesser hedonic value context effects should occur while eating a meal, affecting the hedonic value of the food we eat.

Two studies, one in the laboratory and one in the lunchroom, demonstrate the effect of liked or disliked foods on target foods presented on the same plate. In the laboratory study[2], an imitation chicken tender was rated as more hedonically positive when presented on the same plate with two disliked than with two liked side dishes. An elementary school lunchroom study showed greater consumption of cauliflower that was presented with a less-liked than a more-liked main dish. Thus, simultaneous presentation of other foods with a target food resulted in hedonic contrast.

Similarly, in two additional studies, hedonic contrast occurred when foods were presented sequentially. In a laboratory study[3] subjects drank diluted fruit juices either preceded by more hedonically positive full-strength juices or no juices. Those subjects who first drank the hedonically positive juices, rated the diluted target juice as hedonically negative, whereas those who drank the same target juices by themselves rated them as hedonically positive. Using real foods, in a café, a similar effect was seen when the context and target foods were presented as courses in a meal. Subjects rated a bowl of pasta with garlic and oil (main course) following either a mediocre bruschetta appetizer or a very good bruschetta appetizer. The subjects who first got the very good bruschetta rated the pasta as hedonically negative whereas those subjects who first got the mediocre bruschetta rated the same pasta as hedonically positive. Thus, sequential presentation of a target food with other foods resulted in hedonic contrast as well. This supports Fechner[4] who thought that both simultaneous and sequential presentation of stimuli produce hedonic contrast. It suggests that chefs should be aware of such effects when creating meals.

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