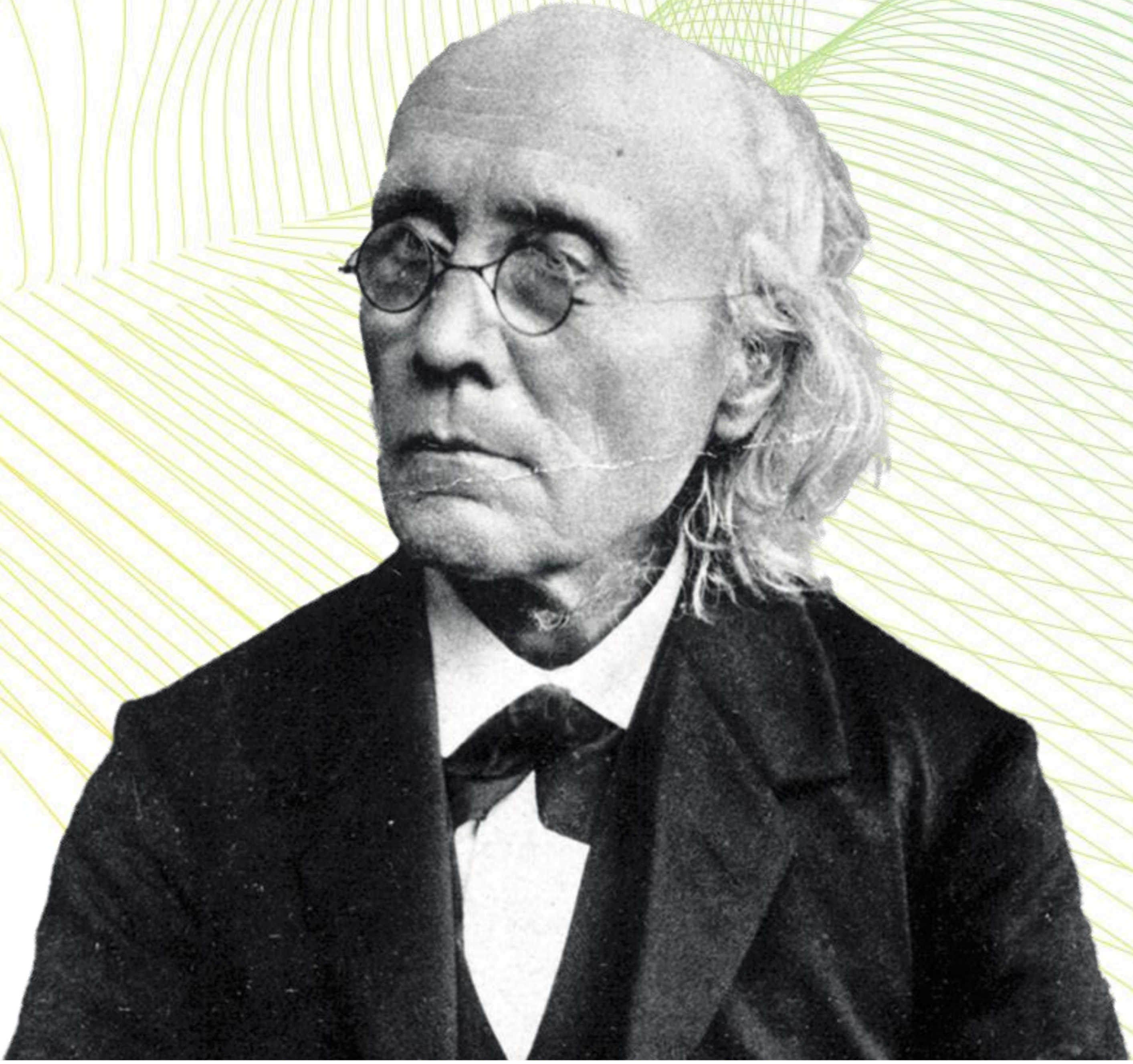
Proceedings of the
39th Annual Meeting of the International Society for Psychophysics

FECHNER DAY 2023

Assisi, Italy.
10-14 september

Editors: Tal Dotan Ben-Soussan, Michele Pellegrino, Fabio Marson, Patrizio Paoletti, Mark A. Elliott



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Editors:

Tal Dotan Ben Soussan, Michele Pellegrino, Fabio Marson,
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Preface

It is our honour to welcome the reader to the 39th Annual Meeting of the International Society of Psychophysics (ISP). We are happy to see many outstanding contributions from long standing members of the ISP and younger researchers, all willing to share together this wonderful occasion with us in Assisi, Italy, the City of Peace, which is very much needed in these times. Lectures and posters will cover different topics ranging from auditory and visual perception to the Symposium on Psychological Times and on the methodology of psychophysics.

Gustav-Theodor Fechner had a scientific approach to the soul, as a tangible measurable thing that could, at least theoretically, be quantified and its laws defined, measured and examined. Fechner believed that soul was a property of matter and inherent in its atomic organization, linked to the nervous system, but Fechner would have surely agreed with Saint Francis of Assisi, Patron Saint of Italy and the environment, as he believed that every living body had a soul and that natural laws were the unfolding of the perfection of the universe. Fechner fascinated by this perfection, studied aesthetics and demonstrated that certain forms and proportions are perceived as naturally pleasing to the human mind and brain. While we cannot yet study the nature of the soul and the perfection of the universe, we surely can learn from the nervous system and different sensory modalities how we perceive and understand the beauty of our environment. Thus, we would like to dedicate some of this 2023 edition of Fechner Day to the field of the neuroaesthetics and aesthetic perception with several talks on this topic, taking inspiration from Gustav-Theodor Fechner himself.

On behalf of the whole organizing team of Fechner Day 2023, we would like to wish you pleasant and fruitful days of scientific sharing. Finally, we would personally like to thank all attendees for their contributions to the 39th Fechner Day and all members of the executive committee of the ISP for their support and trust, to William (Bill) Wren Stine, president of the ISP and to give a special thanks to Mark A. Elliott who helped with the organization and shared with members of ISP his appreciation for this region of Italy.

Tal Dotan Ben-Soussan and Patrizio Paoletti
September 10th 2023, Assisi

Fechner Day 2023

Scientific Programme and Meeting Schedule

Note: All plenary, theme and poster sessions will take place in the Grand Hotel Assisi. Day 4 (13 September) of the conference will be held in San Biagio Monastery.

DAY 1 (10 September) Sunday

14.00 - Registration
15.00 - Ben-Soussan T.D. and Paoletti P.: Opening Remarks

Talks Session 1
Chair: Stine W.

- 15.30 - Scholz P.: Whispered speech causes disruption of serial short-term memory
- 16.00 - Nakajima Y.: Temporal proximity between sound edges is vital for the gap transfer illusion

16.30 - Coffee break

- 17.00 - Takeichi H.: Magnetoencephalography of checkerboard speech processing
- 17.30 - Ueda K.: Interrupted mosaic speech revisited: A curious biphasic effect of stretching on intelligibility
- 18.00 - Munechika K.: Phonemic Restoration and Energetic Masking with Checkerboard Speech Stimuli: Effects of Noise-Filling on the Intelligibility

18.30 - Welcome reception and Aperitivo

DAY 2 (11 September) Monday

Talks Session 2
Chair: Ellermeier W.

- 09.00 - Czernochowski D.: Timing matters: Distinct behavioral and EEG correlates of stimulus and response conflict in a combined priming and flanker task
- 09.30 - Lasaponara S.: Temporal and spatial uncertainty improves the distribution of visual attention and the availability of sensory information for conscious report
- 10.00 - Beck A.K.: Exploring the Neural Basis of Symbolic Number Processing: Insights from Behavioral and Event Related Potentials (ERPs) Study
- 10.30 - Del Percio C.: Improving cortical rsEEG mechanisms in amnesic mild cognitive impairment patients through Quadrato Motor Training

11.00 - Coffee break

- 11.30 - Johansson R.: Estimation, Latency and Intensity Coding in Vision
- 12.00 - Koc A.: Perceptual Biases in Ambiguous Dot Lattices: The Role of Cognitive vs. Perceptual Load
- 12.30 - White R.: Onset and Offset of Inhibition from Motion Masking During Motion Induced Blindness

13.00 - Lunch

Talks Session 3 - Symposium: Psychological Times
Chair: Kornbrot D.

- 14.30 - Elliott M.: Murky Mentalism Fights Back
- 15.00 - Glicksohn J.: Visually Detecting Outliers in a Time Production Task
- 15.30 - Grondin S.: Are Musicians Better for Processing Temporal Information?

16.00 - Coffee break

- 16.30 - Nakajima Y.: Inevitable Time Warp in Music Perception
- 17.00 - Wittmann M.: Subjective Time and Self during Altered States of Consciousness

17.30 - Poster session 1
19.30 - Social Event and Dinner

DAY 3 (12 September) Tuesday

Talks Session 4
Chair: Ueda K.

- 09.00 - Chopin A.: Comparison of methods for quick estimation of thresholds in monotonic and non-monotonic psychometric functions
- 09.30 - Nizami L.: Ratios Vs. Intervals: A Scaling Lesson, C/O Fagot et al.
- 10.00 - Goshen-Gottstein Y.: Stop Using d′ and Start Using da: Evidence from Empirical Data on how to Measure Sensitivity in Recognition Memory
- 10.30 - Kornbrot D.: Binary decisions information accrual models: tool & example

11.00 - Coffee break

- 11.30 - Mao J.: Sensory perception is a holistic inference process
- 12.00 - Ellermeier W.: Cross-modal and Intra-modal commutativity of magnitude productions compared

12.30 - Lunch

Talks Session 5
Chair: Mama Y.

- 14.00 - Hellström A.: Aesthetic Valence: psychophysical perspectives
- 14.30 - Basu S.: A method to measure metacognition of feelings
- 15.00 - Shoushtari S.: Activation in Supplementary Motor Area, Anterior Cingulate Cortex, and Insula during priming and flanker task: A systematic review

15.30 - Coffee break

- 16.00 - Quesada A.: Pain perception in toddlers born with Zika virus
- 16.30 - Arnò S.: Flavor and biphasic alcohol effects differences between organic and traditional wine
- 17.00 - Hannan P.: The PlayWisely Coaches Training Manual – Cognitive Card Sets and Motor Development Additions

17.30 - Poster session 2
18.30 - ISP Business meeting
19.30 - Dinner

DAY 4 (13 September) Wednesday – at San Biagio Monastery

09.00 - Opening and Institutional

Chair: Ben-Soussan T.D.

- 09.30 - Ben-Soussan T.D. and Paoletti P.: The importance of inner and outer silence: theoretical and practical implications in light of SMC
- 10.00 - Sitskoorn M.: The art of silence: The relation between neuroplasticity, art, silence and wellbeing
- 10.30 - Glicksohn J.: Discontinuity in time production, or inadequacy of psychophysical fit?

11.00 - Coffee break

- 11.30 - Srinivasan N.: Disinterested attention and aesthetic experience
- 12.00 - Lizio R.: rsEEG rhythms across neurodegenerative diseases
- 12.30 - Beziau J.Y.: The Logic of Silence

13.00 - Lunch

- 14.30 - Colonna A.: Landscape, architecture, and embodied cognition: notes for research, university education, and the profession
- 15.00 - Radin D.: Fechner's other psychophysics

15.30 - Coffee break

16.00 - Meditation Practice

I.C.O.N.S. Round Table
Chair: Di Giuseppe T.

- 16.30 - Round Table: Paoletti P., Di Giuseppe T., Vianello F., Serantoni G., Perasso G., Maculan A.
- 17.30 - Round Table: Discussion

18.30 - Harp Music Workshop: Marianne Gubrì
20.00 - Conference Dinner

DAY 5 (14 September) Thursday
09.00 - Tour of Assisi

Poster Sessions

Poster Session 1 – DAY 2 (11 September) Monday, 17.30

- Actis-Grosso R.: Icons as Affordances
- Alcalá-Quintana R.: Type-B order effects in duration discrimination: a procedural artifact?
- Appel O.: Eye movements reveal covert and overt spatial attention in conceptual cueing
- Chinchani A.: Investigating the causal relationship between attention and brain oscillations
- Clausen A.: Does speech intelligibility depend on affective valence?
- Ebrahimi Z.: Exploring the Interplay between Working Memory, Intelligence, and Creativity
- Fitousi D.: Extremely limited processing capacity of emotional face ensembles
- Hassanzadeh M.: The role of spatial location in irrelevant speech revisited: a replication of Jones & Macken (1995)
- Levy L.: The emotional Stroop effect in hearing: evidence for dramatic differences between the effect in vision and the effect in hearing
- Marson F.: Immersion in OVO Perceptual Deprivation chamber allows emersion of abstract meanings: ERP evidence from abstract and concrete spoken words processing
- Mendoza-Duran E.: Cultural differences in the temporal perception of faces expressing emotions
- Mitsukura E.: Rotational motion aftereffect induced by illusory rotation of a square: effect of test stimulus shape
- Nakajima Y.: How is a temporal gap in a longer glide perceived if a longer and a shorter tone glide crossing one another are heard as two bouncing trajectories
- Nizami L.: Hard and soft thresholds. Part 1: Concepts
- Nizami L.: Hard and soft thresholds. Part 2: Decision variables
- Pellegrino M.: The OVO-WBPD chamber: resting state EEG evidence
- Said R.: Perception of emotions in speech: the effect of speaker's age
- Seya Effect of attention on vection
- Tomimatsu E.: Effects of angles and motion lines in pictograms on perceived presentation duration
- Yamasaki T.: Effects of listening contexts on the perceived characteristics of musical pieces
- Zavagno D.: The affective character of abstract shapes

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- Appel O.: You are going to remember this one: predicting memory via pupillometry
- Chiarella S.G.: The effect of different meditative states on prospective and retrospective time perception
- Clermont A.: Autism, enhanced perceptual functioning, and time perception
- Cohen E.: Cannabis use and motivation: a new behavioral methodology to measure motivation
- Conrad S.: Auditory Task Switching and Distractor Filtering as a Function of Working Memory Capacity and Age
- Emelianova S.: Qualitative analysis of the psychological mediation in sensory task
- Jüttemann A.: Walter Blumenfeld and the beginning of psychotechnics in Saxony
- Marson F.: Dancing the body, cardinal directions in space and embodied concepts
- Pellegrino M.: Museum- and Art-based Interventions in Alzheimer Patients: A Systematic Review and the AIDA project
- Plueckebaum H.: Visual Global and Local Processing and Its Relationship to Autistic-like Traits in Non-Clinical Individuals
- Sheen J.: Extending Game Theoretical Frameworks to Cybersecurity
- Teehan M.: The Differential Diagnostic Technique: A Test Of and For Quantum Psychophysics
- Wolf A.: Altered information processing strategy among patients with schizophrenia in a liking task: an eye movement study

Contents

ICONS AS AFFORDANCES

Rossana Actis-Grosso
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Abstract

Inside the general framework of visual communication icons could be considered as “the unity” of visual language, such as words are the “unity” of verbal communication. Thus an icon works – in the sense that it fits its communicative goal - as long as it maintains an explicit perceptive autonomy, minimizing the cognitive effort and therefore the time required to understand its meaning. A set of 15 icons, specifically designed for the websites of the Public Administration (PA) of the Italian Government, has been tested with three different methods, which allowed understanding different aspects of the process of icons’ interpretation. (1) An initial Survey (n=150) was posted on-line: 5 icons were misinterpreted by all respondents. (2) Structured Interviews (n=20). By collecting qualitative data, the number and type of errors done before grasping the meaning of each icon has been analysed. Spontaneous comments allowed a better understanding of the perceived link between visual and verbal concepts conveyed by each icon. (3) Scenario-based usability testing (20 participants). An interactive simulation of three PA sites has been created, on which users have been asked to perform 15 different tasks (5 task for each site). Each task was presented in a feasible scenario, to facilitate the participant in visualizing the goal of the whole process. Each participant has been asked to accomplish the same 15 tasks, presented in different order. Results of (3) have been analysed in terms of both number of errors and time spent on each task. The comparison between the three studies put in evidence the importance of the interaction in icons’ understanding, underlying their role in inviting the user to do the appropriate action for a given task. Icons afford actions in a direct way, establishing a network of relations among all the visual elements in the web page.

TYPE-B ORDER EFFECTS IN DURATION DISCRIMINATION: A PROCEDURAL ARTIFACT?

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Abstract

As counterintuitive as it may seem, the outcome of the comparison of two stimuli is indeed affected by the order in which they are presented. This effect, first described by Fechner, has given rise to a vast literature. In research on duration discrimination, a widespread task consists of presenting a stimulus (the standard) of a given fixed duration and another stimulus (the test) whose duration varies from trial to trial. The observer has to report which stimulus was perceived as longer based on the comparison. Proportions of responses thus obtained are used to fit psychometric functions that describe the probability of reporting the test as longer, as a function of its physical duration. Two kinds of order effects have been found in this context. The so-called Type-A order effects manifest as a mere lateral shift of the psychometric function across presentation orders, whereas Type-B order effects involve a change in slope. In this work, we explore the phenomenon of Type-B order effects with a two-alternative duration discrimination task in which observers are also allowed to report that none of the durations appeared to be longer than the other. Three standard durations (200, 400, and 600 ms) were paired with test durations that roughly spanned the range between half and twice the corresponding standard duration. Our results clearly show that Type-B order effects can be at least partially caused by a procedural artifact related to how data are typically collected and analyzed in duration discrimination studies reporting this phenomenon.

EYE MOVEMENTS REVEAL COVERT AND OVERT SPATIAL ATTENTION IN CONCEPTUAL CUEING

Oria Appel[1], Samuel Shaki[1] and Martin H. Fischer[2]
[1]Department of Psychology, Ariel University
[2]Department of Psychology, University of Potsdam

Abstract

The current research aimed to shed more light on how spatially associated concepts (e.g., directional expressions, object names, metaphors) shape our cognitive experience. In two experiments (N=82) we investigated the mechanisms by which centrally presented prime words with either explicit or implicit spatial meaning induce spatial attention shifts. Participants performed a visual target detection task according to response rules that required different degrees of prime and target processing depth. We manipulated prime-target intervals (150, 350, 550 ms) and recorded target detection speed and spontaneous eye movements.

For explicit prime words, we found spatial congruency effects in detection speed independent of processing depth, while implicit prime words generated congruency effects only when participants had to compute the prime-target congruency relationship. Spontaneous eye movements reflected this superior strength of explicit compared to implicit conceptual priming. These results were robust across different prime-target intervals and imply that spatial connotations alone do not automatically activate spatial attention shifts. Instead, explicit semantic analysis is a prerequisite for conceptual cueing.

YOU ARE GOING TO REMEMBER THIS ONE: PREDICTING MEMORY VIA PUPILLOMETRY

Oria Appel, Yaniv Mama
Department of Psychology, Ariel University

Abstract

It is well known that pupil size depends on noradrenaline secretion from the locus coeruleus (LC) due to the sympathetic system's activity. This occurs autonomously as a survival mechanism in circumstances that require increased arousal. Prior studies showed that attentive task performance was best when the firing rate of LC was high (Aston-Jones et al., 1994). Cognitive studies have also shown an association between memory task success and larger pupil size (Kahneman & Beatty, 1966). In this research, we examined the relationship between pupil variability and the processes of encoding and retrieving memory to investigate whether this relationship is predictable. Sixty participants with adequate vision performed a recognition memory test while their eyes were recorded with an Eyelink Portable DUO. The results depict larger pupil size in the encoding phase for later successfully retrieved words than forgotten ones. This phenomenon also occurs before word presentation (during baseline), implying that pupillary changes indicate increased cognitive arousal while preparing to encode information.

FLAVOR AND BIPHASIC ALCOHOL EFFECTS DIFFERENCES BETWEEN ORGANIC AND TRADITIONAL WINE

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Abstract

Wine can have stimulating and sedative effects on wine consumers. In our study we compared the stimulating and sedative effects of two wine typologies: organic and traditional wine. Organic wine is characterized by a lower quantity of sulfites in comparison to traditional wine. The two wines were administered to a sample of normal wine consumers (n= 137). Participants also rated wine flavor components (fruitiness, sourness, bitterness and sweetness) and flavor intensity, duration and pleasantness of both wines. Results showed that organic wine has lower stimulating effect and higher sedative effect. Because of high stimulating and low sedative effect of alcohol is tendentially associated to the development of alcohol dependency, therefore organic wine seems a good option for reducing the risk of alcoholism in wine consumers. In relation to wine flavor, participants did not perceive relevant differences, except for a higher level of sourness and longer flavor duration for traditional wine.

Even if alcohol is considered a central nervous system depressant, it can produce biphasic effects with both sedative and stimulating effects. Substances with stimulating effects increase heart rate, breathing rate, blood pressure and suppress appetite. They can often cause euphoria and positive sensations. Studies showed that the wine effects are related to the individual characteristics of drinkers. Alcohol has stimulating effects for heavy drinkers and sedative effects in light drinkers (King et al., 2002). People with high sensibility to the stimulating effect of wine are at greater risk of abusing alcohol (Newlin & Thomson, 1990).

Wine is the one of the most used alcoholic drink. In 2020 it was estimated a world wine consumption of 234 million hectolitres (Karlsson, 2022). There is a debate related to the positive or negative effects of wine on human health. Studies showed that a moderate consumption of wine can have beneficial effects on health. Epidemiological research demonstrates that individuals who choose to drink wine in moderation exhibit improved cardiovascular health and, on average, live longer (German & Walzem, 2000). Moderate consumption of red wine showed positive effects in reducing cardiovascular diseases and inflammation (Snopek et al., 2018). In addition, moderate wine consumption showed appositive effects in psychological well-being, reducing, in particular, depression (Gea et al., 2013).

The effect of wine on physical and psychological conditions do not depend only on the presence of Ethanol, but also by the presence of other substances. Phenolic acids and polyphenols of grapes are to be the components with antioxidant properties (German & Walzem, 2000). Also, flavonoids showed beneficial effects on health, reducing oxidation, blood pressure, glucose absorption, inflammation and contrasting neurodegenerative disorder (Fernandes et al., 2017). Therefore, wines with high levels of healthy substances or low levels of unhealthy substances can be developed to furtherly reduce negative effects and increase positive effects on human health.

Organic wine is wine made with grapes grown in accordance with the principles of organic farming, which exclude the use of artificial chemical fertilizers, pesticides, fungicides, and herbicides. It should be differentiated form natural wine, that is wine made according to traditional methods and biodynamic wine, that is a product made according to biodynamic methods. The principal characteristics of organic wine is the very low level or absence of preservatives, in particular sulfur dioxide. There is no common agreement in relation to the presence and quantity of preservatives in organic wine, however the organic wine with its low levels of artificial substances and a more natural method of cultivation and production is a wine that has a low polluting impact and is healthier for people. The principal motivations for consumers for buying organic wine are safety, health and environmental protection (Misso & Catullo, 2012). Therefore, organic wine is a good option for people who like drinking wine and, at the same time, want a product with less negative impact on their and others' health.

There are few studies about the biphasic effects of organic wine on drinkers, in particular of the white wine (Addicott et al., 2007). Therefore, we carried on a study about the biphasic effects of white organic wine in relation to a conventional or traditional wine. The principal aim was to test if sedative and stimulating effects were different between organic and traditional wine. In addition, we measured the components of wine flavor and its characteristics (intensity, duration, pleasantness) to detect possible differences in wine perception between organic and traditional wine.

Method

Participants

137 participants (48% females) were recruited for the study. Mean age was 36.2 years (SD = 7.4). 89% were habitual wine consumers, while the remaining 8.5% were occasional consumers (2.5% missing). 24% of participants declared to drink wine 0/2 times per week; 56.9% participants declared to drink wine 2/3 times per week; 19% declared to drink wine every day per week. BMI mean value was 25.4 (SD = 4.8).

Measures

Biphasic Alcohol Effects Scale (BAES; Martin et al., 1993).

This scale consists of 24 adjectives. Seven adjectives describe the stimulating effect of wine (stimulating BAES or BAES-stim) and seven adjectives describe the sedative effect (sedative BAES or BAES-sed). The remaining adjectives are fillers. Participants rated the effects on a scale from 1 (labeled "not at all") to 10 (labeled "extremely").

Wine flavor:

We measured different components of wine flavor that are fruitiness, sourness, bitterness and sweetness (Oberfeld et al., 2009). In addition, we measured flavor intensity, duration and pleasantness (Oberfeld et al., 2009). Ratings varied from 0 ("not at all") to 9 ("extremely").

Procedure

Participants with chronic disease, endocrinological or metabolic disorders or with alcohol or drug dependencies were excluded from the study. Participants were organized in small groups with a minimum of 4 to a maximum of 12 elements. They had to drink an obscured glass of wine. We followed a double blind procedure for wine administration. The quantity of wine was determined in relation to participant's weight (about 0.4 gr of alcohol per 1 Kg). The mean dosage of wine was 235.1 ml (SD = 45.5 ml). The organic wine had a level of sulfite < 10 mg/1, while the traditional wine had a higher level (140 mg/1), and a level of malic acid < 0.3 g/l, while the traditional wine had levels of malic acid in the range 2.8 – 3.2 g/l. The organic wine was produced by a local winery (Chiusa Grande of Nocciano; URL: https://chiusagrande.com), while the traditional wine was purchased in various wine shops. Participants had to flavor and drink wine twice (one for the organic wine and one for the traditional wine). 20/30 minutes after drinking wine, participants complied the BAES questionnaire and rated wine flavor using a checklist for each components and characteristics (fruitiness, sourness, bitterness, sweetness, intensity, duration and pleasantness). Privacy of participants was guaranteed according to the Italian and European law (Italian law n. 196/2003 and EU GDPR 679/2016, respectively). This study followed the Declaration of Helsinki ethical principles for research involving human subjects and was approved by the regional ethical committee for biomedical research (prot. code = rich5u5wi). Questionnaires were administered online with Qualtrics Online Surveys.

Table 1. Descriptive statistics (mean and standard deviation), reliability (Cronbach's α) and *t*-test (*t* value, probability and effect size; *df* = 136) of mean differences between organic and traditional wine in wine effects, flavor components and flavor characteristics.

	organic wine				traditional wine				t-tests		
	Mean	SD	Cronbach's α	95% α	Mean	SD	Cronbach's α	95% α	*t*	*p*	Cohen's *d*
wine effects											
sedation	35.37	12.89	0.86	.84-.87	32.92	13.49	0.91	.90-.92	2.35	0.02	0.20
stimulation	14.99	8.23	0.83	.81-.84	16.58	9.74	0.86	.84-.87	-2.20	0.03	-0.19
flavor components[a]											
fruitiness	4.02	2.36			4.57	2.42			-1.84	0.07	-0.16
sourness	4.88	2.48			5.43	2.50			-2.11	0.04	-0.18
bitterness	2.88	2.55			2.96	2.58			-0.1 7	0.87	-0.02
fruitiness	2.73	2.30			3.17	2.41			-1.73	0.09	-0.15
flavor characteristics[a]											
intensity	5.25	1.87			5.46	1.90			-1.26	0.21	-0.11
duration	5.23	1.95			5.64	1.99			-2.23	0.03	-0.19
pleasantness	4.78	2.22			4.90	2.37			-0.31	0.76	-0.03

Note: SD = standard deviation. [a] = the degrees of freedom were 132 because of missing data.

Results and Discussion

Biphasic alcohol effect

Table 1 reports the descriptives (mean and standard deviation) and reliability (Cronbach's α) of the mean ratings of BAES-stim and BAES-sed. Both the scales have a good reliability. Table 1 shows also the results of the repeated *t* tests and figure 1 shows the descriptive plots for BAES-stim and BAES-sed mean ratings. There are significant differences between the organic and traditional wines in BAES-stim and BAES-sed mean ratings (t = -2.20 and t = 2.35, respectively, $p < .05$). In particular, the organic wine has a higher sedative effect and a lower stimulating effect than the traditional wine.

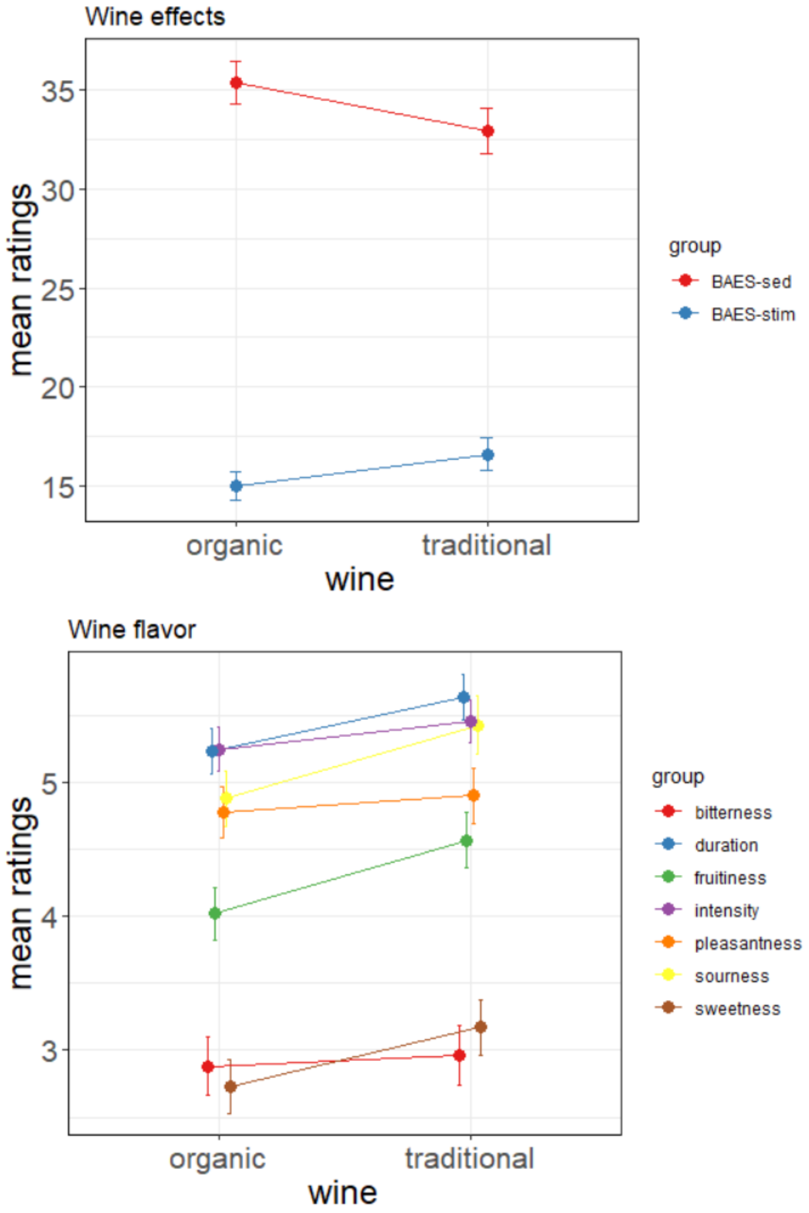

Fig. 1. Descriptive plot of wine effect (upper plot) and wine flavor (lower plot). Vertical bars indicate standard errors of mean.

Wine flavor

Table 1 reports the descriptives (mean, standard deviation and standard error) for each flavor component (fruitiness, sourness, bitterness, sweetness) and flavor properties as intensity, duration and pleasantness. Table 1 shows the results of the repeated t tests. Only sourness and flavor duration resulted significant (t = -2.11 and t = -2.23, respectively, $p < .05$).

Our results showed that organic wine has higher sedative effect and lower stimulation effect in comparison to traditional wine. The stimulating effect of alcohol is related to psychomotor stimulation, in particular it activates ventral tegmental dopaminergic neurons (Gessa et al., 1984). The sedative effect of alcohol is probably related to the reduction of serotonin and noradrenaline in the brain (Gursey & Olson, 1960). Higher stimulating effects of alcohol are not desirable, because they can induce people sensible to these effects to develop alcohol dependency (Newlin & Thomson, 1990). At the same time, sedative effect of alcohol is negatively correlated with drinking practices. Lower level of sedation, after alcohol consumption, may characterize persons at increased risk to develop alcoholism in future (Schuckit, 1980). In our study we evidenced that organic wine has higher sedative effect and lower stimulating effect in comparison to traditional wine. On the basis of these data, organic wine should have lower risk to induce or favor alcoholism in wine consumers.

In relation to wine flavor, we did not find significant differences in subjective judgments. Participants tended to judge traditional wine sourer than the organic one and noticed that the duration of wine flavor was longer in the case of traditional wine. Except for these differences, in all other cases participants gave the same judgments to both wines. Probably, the lack of detection of particular differences in taste between the two wines can be explained by the fact that our participants were normal wine consumers and not expert tasters or sommeliers. A future replication of our study with wine experts could be done in future to test if organic and traditional wines have consistent flavor differences.

In conclusion, we studied the differences in biphasic alcohol effects and in wine flavor between organic and traditional wine. Our results confirmed a lower stimulating and a higher sedative effect of organic wine in comparison to traditional wine. Because lower stimulating effect and higher sedative effects are more associated with the risk to develop alcoholism, therefore organic wine seems a good option not only for its healthier properties and lower negative impact on environment, that are positive characteristics on its own, but also because it has lower impact on the risk of alcohol dependency. Our results did not show particular differences for participants in judging the characteristics of organic and traditional wine. Therefore, the two typologies of wine do not have specific hedonistic effects on wine flavor.

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A METHOD TO MEASURE METACOGNITION OF FEELINGS

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Abstract

Metacognitive sensitivity measures one's ability to evaluate one's cognition. This is measured using ROC analysis based on people's confidence ratings and their correct/incorrect responses. Higher metacognitive sensitivity to one's own emotions is necessary, given emotion's social role. Unlike perceptual judgments, there is no easy normative way to measure accuracy for feelings. Here, we develop a method of measuring emotional meta-cognitive sensitivity using different potential normative measures of emotion and computing the difference between those normative ratings and their own emotional ratings. The difference is dichotomized into 'correct' and 'incorrect' emotion categories and used along with their confidence ratings about their felt emotions to construct ROCs. AUCs calculated were considered as measure of a person's metacognitive sensitivity about their felt emotions. 60 emotional scenes from IAPS database were shown and participants (N = 56) rated their valence, arousal, and familiarity, as well as confidence ratings for their own valence and arousal on a 100-point scale. Valence and arousal most people would feel while looking at these pictures were also rated. For each participant, AUC was calculated with four different normative measures: the mean value from IAPS database, the mean value for that picture from our participants, the mean value for ratings of 'other's feelings' from participants in our study and the value from the same participant on what others would feel. AUCs generally ranged around 0.45-0.65 for most participants. To check for consistency between these AUC values, we computed correlations between each of these AUCs. The correlations between the first three measures based on mean ratings were significant for both valence and arousal (ranging from 0.571 to 0.915). indicating consistency and the potential value of our developed metacognitive measure for feelings. Further studies would be needed to check the psychometric properties of the developed meta-cognitive measure for emotions.

EXPLORING THE NEURAL BASIS OF SYMBOLIC NUMBER PROCESSING: INSIGHTS FROM BEHAVIORAL AND EVENT RELATED POTENTIALS (ERPS) STUDY

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Abstract

Understanding how symbolic numbers are represented in the adult brain is crucial for unraveling the cognitive mechanisms underlying numerical cognition. This study investigates the spatial constituents involved in the representation of symbolic numbers and their relationship to effects such as size-value congruity, Spatial Numerical Association of Response Codes (SNARC), and numerical distance. While previous behavioral experiments have suggested distinct processing stages for these effects, the presence of overlapping responses in early and late Event-Related Potentials (ERPs) raises questions about the shared neural resources.

To address this issue, we conducted a numerical value comparison task that systematically combined all relevant stimulus and response conditions. In order to ensure the validity of the ERP measurements, we employed variable reference values when comparing the same numbers. This experimental design not only revealed previously unobserved interactions in behavior but inhibited the appearance of late ERP effects.

Interestingly, our findings indicate that all effects emerged early in the P1 component, occurring around 100 ms after stimulus onset, and exhibited a hemispheric specificity. The congruity and SNARC effects were found to be independent of each other, while the SNARC effect and numerical distance demonstrated a close interconnection. Notably, our results suggest that the independence of these effects is primarily driven by differences in hemispheric specificity rather than stage-wise separation.

By shedding light on the neural basis of symbolic number processing and the relationships between various effects, this study contributes to our understanding of the cognitive mechanisms underlying numerical cognition.

THE EFFECT OF DIFFERENT MEDITATIVE STATES ON PROSPECTIVE AND RETROSPECTIVE TIME PERCEPTION

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Abstract

Studies on time perception during meditation have reported conflicting results. These studies considered the variation of attentional resources as key element of the changes in time perception. However, also other mechanisms related to memory storage have been proposed. We contrasted two mindfulness meditations to investigate the role of attention and memory storage in time perception. A group of 32 non-meditators participated in a prospective judgment of short and long duration intervals, during two mindfulness practices (i.e., focused-attention and open-monitoring) and during a control condition (active listening of a story). Furthermore, at the end of each session, participants retrospectively self-reported time passage. Using a within-subjects design we contrasted prospective and retrospective estimations between the three conditions. Overall prospective time estimation's results showed that both FAM and OMM were judged shorter than control condition. Considering the two timescales, we observed no difference between FAM and OMM in the short intervals, although both were underestimated. For long intervals, FAM were shorter than control, whereas OMM and control were not different. Retrospective estimations showed that FAM and OMM time passage were experienced as slower than during control. Our study demonstrates that prospective estimation of short and long intervals is differently modulated during FAM and OMM. Prospective and retrospective result are discussed in light if the attentional-gate model and contextual change model.

INVESTIGATING THE CAUSAL RELATIONSHIP BETWEEN VISUAL ATTENTION AND BRAIN OSCILLATIONS

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Abstract

Visual attention enhances perceptual accuracy and reaction times for attended stimuli. In humans, visual attention is commonly studied using steady-state visually evoked potentials (SSVEPs). SSVEPs are occipital EEG potentials evoked by periodically flickering stimuli and their power exhibits modulation with attention. However, this link is only correlational and establishing a causal relationship requires experimental manipulation. In this study, we aim to investigate whether SSVEPs are causally involved in visual attention using transcranial alternating current stimulation (tACS). Healthy human participants (n=18) performed a perceptual attention task. Each trial consisted of a central flickering circle, designed to induce SSVEPs. A concentric ring may or may not appear within the flickering circle. Participants performed 3 blocks of this experiment. In the first and last blocks (PRE and POST) participants performed the task while their EEG was being recorded. In the stimulation block (STIM), tACS is delivered at the SSVEP frequency. In this study, we investigated whether tACS affected perceptual attention, as measured by accuracy on the detection task, in a phase-specific manner. In this regard, we estimated the phase of the SSVEP using the PRE and POST blocks using joint decorrelation. The phase of tACS was computed by FFT on the first PCA component of the EEG data during the STIM block. Trials were binned into four phase-differences (tACS-SSVEP) - 0^o, 90^o, 180^o, and 270^o. tACS did not affect perceptual attention, as measured by percent correct, in a phase-specific manner ($p>0.5$). This lack of online effects of tACS suggests that either the low-intensity electric fields (~0.2V/m) are insufficient to produce behavioral changes or SSVEPs are not causally involved in perceptual attention. Further experiments are needed to disambiguate between these possible explanations.

COMPARISON OF METHODS FOR QUICK ESTIMATION OF THRESHOLDS IN MONOTONIC AND NON-MONOTONIC PSYCHOMETRIC FUNCTIONS

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Abstract

Numerous psychophysical methods exist to quickly estimate the key parameters of psychometric functions, like the threshold. Psychometric functions are often assumed to be monotonically increasing over a range of stimulus intensities. However, they are sometimes better described as non-monotonic, where the probability of correct responses increases with stimulus intensity, reaches a peak and then decreases. Using Monte Carlo simulations, I investigated whether the psychophysical methods that were the most likely robust to non-monotony could effectively be used for that purpose, or adapted, keeping the number of trials for estimation between 60 and 120. I also assessed their ability to accurately identify random (chance level) performance. I found that none of the methods were robust to non-monotony when they were only assuming monotony. To evaluate that, I considered the median bias, the mean absolute error, test-retest reliability (limit of agreement) and the chance level. Zippy Estimation of Sequential Thresholds (ZEST) and the Method Of Constant Stimuli (MOCS) could not be efficiently adapted to non-monotony but Psi could be adapted when using two recent developments: the psi-marginal method (Prins, N. (2013). The psi-marginal adaptive method: How to give nuisance parameters the attention they deserve (no more, no less). Journal of Vision, 13(7), 3.) and an adaptive-search-grid method (psi-grid: Doire, C. S. J., Brookes, M., & Naylor, P. A. (2017). Robust and efficient Bayesian adaptive psychometric function estimation. The Journal of the Acoustical Society of America, 141(4), 2501–2512). The best methods were psi-marginal and psi-marg-grid, a new method presented here, which combines psi-marginal and psi-grid. There was no cost in using these two methods when psychometric functions were in fact monotonic.

DOES SPEECH INTELLIGIBILITY DEPEND ON AFFECTIVE VALENCE?

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Abstract

Emotional sounds can guide attention quickly to a particular object or location, and there is some indication that both prosodic and semantic cues to emotional valence in speech utterances may facilitate speech intelligibility in noisy conditions (e.g., Dor et al., 2021; Dupuis & Pichora-Fuller, 2014). Here we test whether negative and positive associations to the semantic meaning of words or to the timbre of voices tend to enhance speech intelligibility. In the first experiment, a group of participants had the task to recognize negative, positive, and neutral words while listening to partially masked recordings in an intelligibility test. In the second experiment, we experimentally manipulated the valence of voices pronouncing semantically neutral words through evaluative conditioning. In the conditioning phase, participants only heard vowels intonated by a specific voice, followed by either positive, neutral, or negative images. Subsequently, participants were asked to recognize words spoken by the previously conditioned voices in an intelligibility test similar to the first experiment. In both experiments, higher word recognition rates are expected with cues to negative (and potentially positive) valence.

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AUTISM, ENHANCED PERCEPTUAL FUNCTIONING, AND TIME PERCEPTION

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Abstract

This study investigated the capability of autistic and non-autistic participants to discriminate brief time intervals, embedded within local sequences of time intervals varying from 200 to 800 msec. The goal was to determine how modifying the global temporal properties of an experimental session, namely its average pace (arithmetic mean of 400 vs. 600 msec) and its heterogeneity (200 vs. 400 msec difference between the shortest and the largest intervals), affect the discrimination of local time intervals. The results indicate that the global context affected more non-autistic than autistic participants who showed better discrimination (lower WR) and more precision (lower CE). Autistic people's perceptual processes are more autonomous toward high level functions, which is a central characteristic of autistics cognitive functioning.

The current scientific literature paints a rather heterogeneous portrait of time perception in autistic people. To compare time perception of autistic and non-autistic people without intellectual impairment, many studies employed estimation, bisection, and interval comparison tasks. As a result, many articles state that autistic people's time perception is not as effective as that of non-autistics (Grondin, 2020). In a meta-analysis implying 45 different studies, Casassus et al. (2019) came to a similar conclusion. Nevertheless, some studies report that autistic participants are as good as control (Gil et al., 2012; Mostofsky et al., 2000), or even better (Soulières et al., 2010; Wallace & Happé, 2008). As the method and duration used vary from one study to the other, different cognitive processes are implied (Bernard et al., 2022; Maister & Plaisted-Grant, 2011). This makes any global conclusion difficult to draw.

It is interesting to underline that only a few studies have looked specifically at the perceptual and attentional mechanisms specific to the autistic population. For this purpose, the present study tests the interplay between bottom-up and top-down processes, discussed in the revisited version of the *enhanced perceptual functioning (EPF)* model of Mottron et al. (2006), in the temporal perception of people with autism. The role of global context, well documented in the literature in autism (Mottron et al., 2006; Happé & Frith, 2006; Wang et al., 2007), and the capacity to perceive it or to ignore it when it is not necessary, will be tested for the discrimination of local rhythmic intervals.

The investigation is based on an experiment by Jones and McAuley (2005), comparing intervals delimited by a series of short sounds, that showed that varying certain properties of an experimental session in which a given interval, called local, is integrated, automatically modifies the perceived duration of this interval. The local context is the steady rhythm that precedes each interval comparison in a trial during the experiment. Although the local context should be ignored, it does instill a sense of faster or slower pace to the participant's internal oscillators. Moreover, in their study, these authors refer to the distributional properties of the session in which a trial is integrated by the term *global context*. Two aspects of this global context are manipulated: the global context's average pace (fast vs. slow) and the global context's heterogeneity (low vs. high).

Method

Participants

The 11 autistic participants included all were diagnosed by a qualified psychologist or psychiatrist previously to the study. The autistic group includes all diagnosis on the autism spectrum, like Asperger syndrome, pervasive developmental disorder, and autism. To ensure they would be able to follow the instructions of the study, none of the participants selected had an intellectual deficiency (IQ below 70). The 13 control participants were mostly students from Université Laval. This study was performed in line with the principles of the Declaration of Helsinki. Approval was granted by the Ethics Committee of Université Laval (11-10-2018/No. 2018-005A-2).

Material

Participants performed the experiment sitting at a desk, 40 cm away from a *Lenovo Thinkpad XSeries* laptop screen. The experiment took place in a quiet room, free from distractions. Participants were wearing Sony MDR-XB950B1 model headphones. The intensity of the sound was adjusted to keep it comfortable for each participant. Two types of sounds were used during the experiment. Sound 1, corresponding to a preparation signal, had a 1-kHz frequency and lasted 500 ms; sounds marking the length of intervals to be judged had a 440-Hz frequency and lasted 60 ms. The experiment was controlled using E-Prime 2.0, and responses were collected using the computer keyboard.

Procedure

The structure of every trial was formed by using this basic unit of time called IOI (see Figure 1). After four empty intervals corresponding to the base IOI, including the standard itself, an inter-stimulus interval (ISI) was presented; this ISI was always twice the duration of an IOI. The standard was always equal to the base IOI and served as a reference during time comparison. Then a comparison interval, or comparator, was presented. Throughout the experiment, the comparator could be either 24 % shorter than the standard, 12 % shorter, equal to the standard, 12 % longer, or 24 % longer.

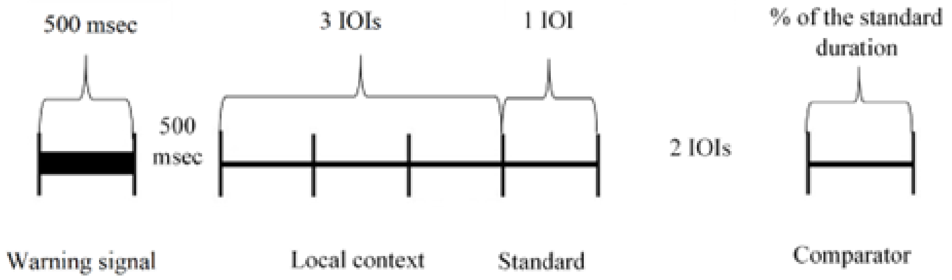

Fig. 1. Sequence of auditory stimuli used in one trial of the experiment.

Three independent variables were of interest: the different groups, the global context's average pace (fast vs. slow), and the global context's heterogeneity (low vs. high). In a fast average pace, the average duration of all base IOIs and standards in the session was 400 msec; in a slow-paced condition, it was 600 msec. As for the third independent variable, a low heterogeneity meant that there was a 200-msec span between the shortest and longest IOIs within a session, and a high heterogeneity meant that there was a 400-msec difference between the shortest and longest IOIs. Intervals were presented in a condition where the global context was either fast (arithmetic session mean of 400 msec) or slow (arithmetic session mean of 600 msec), and for each of these two conditions, the heterogeneity of the global context was low or high.

Four conditions (4 sessions divided into 2 meetings) resulted from the combination of two average pace conditions and two heterogeneity conditions: 1) fast pace and a low heterogeneity (300-msec and 500-msec IOIs); 2) fast pace combined and high heterogeneity (IOIs of 200, 300, 400, 500, and 600 msec); 3) slow pace and low heterogeneity (500-msec and 700-msec IOIs); 4) slow pace and high heterogeneity (IOIs of 400, 500, 600, 700, and 800 msec). Participants indicated whether the comparator was shorter, equal, or longer than the standard by pressing the keyboard key 1, 3, and 5, respectively.

Each 50-min session proceeded in the same way. To begin with, participants completed 12 practice trials with feedback indicating if they had the correct answer. Then, they performed five blocks of 36 trials without feedback. In every session, for each baseline IOI duration, there were 180 trials, with a random presentation of 60 comparison intervals equal to the standard and 30 intervals of each of the other four comparator durations.

Results

For each experimental condition and for each baseline IOI, individual psychometric functions were calculated as in Jones and McAuley (2005): the constant error (CE: point of subjective equality minus the standard, in absolute value), and the Weber ratio (WR: difference threshold divided by the standard) were kept to analyze perceived duration and sensitivity, respectively.

Only data of the 400-, 500-, and 600-ms conditions are reported here. Also, because some *goodness-of-fits* were low, the final number of autistics and control participants in these conditions were 10 and 7, 8 and 9, and 10 and 8, respectively. In the 500-msec base IOIs condition, a factorial design ANOVA 2 (group) × 2 (average pace) × 2 (heterogeneity) with repeated measures on the last two factors was performed on CE and WR. For the 400-msec and the 600-msec conditions, we used a 2 (group) × 2 (average pace) factorial design ANOVA.

Constant error

In the 500-msec condition, the average pace effect, $F(1, 15) = 5.960, p < 0.05, \eta^2 p = 0.284$, and the group by average pace interaction effect, $F(1, 15) = 5.302$, $p < 0.05$, $\eta^2 p = 0.261$, were significant. Other effects were not significant. Post hoc analyses revealed that the groups significantly differed in the slow pace condition, $F(1, 15) = 5.762, p = 0.030, \eta^2 p = 0.278$, but not in the fast pace condition, $p = 0.948$ (see Figure 2).

In the 400-msec condition, the ANOVA revealed a significant main effect of group, $F(1, 15) = 10.171, p < 0.01, \eta^2 p = 0.404$. Autistic participants had lower CE scores ($M = 8.16$ msec) than control participants ($M = 18.19$ msec). Also, there was a significant main effect of pace, $F(1, 15) = 10.690$, $p < 0.01$, $\eta^2 p = 0.416$. The CE was significantly lower in the fast average pace sessions ($M = 8.52$ msec) than in the slow average pace condition ($M = 16.07$ msec). The interaction was not significant ($p = 0.507$). In the 600-msec condition, only the pace effect was significant, $F(1, 16) = 6.271$, $p = 0.023$, $\eta^2 p = 0.282$. CE was lower in the fast ($M = 18.04$ msec) than in the slow ($M = 10.41$ msec) condition.

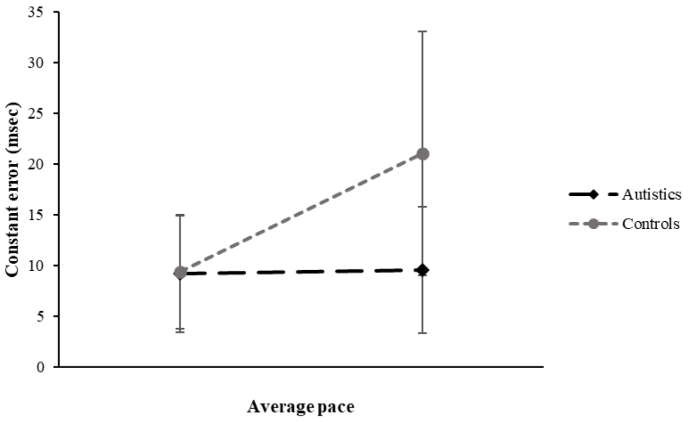

Fig. 2. Mean Constant Error for each group in each average pace condition for the trials where the base IOI and the standard were 500 msec. Error bars represent a 95% confidence interval. *: group means differ significantly ($p < .05$).

Weber ratio

In the 500-msec condition, only the pace by group interaction effect was significant, $F(1, 15) = 4.963$, $p < 0.05$, $\eta^2p = 0.249$. Post hoc analyses revealed no group difference in the fast pace condition, $F(1, 15) = 0.094$, $p = 0.764$, but indication that, in the slow pace condition, the WR of autistics ($M = .123$) in lower than the WR of control participants ($M = .147$), $F(1, 15) = 3.601$, $p = 0.077$.

In the 400-msec condition, the ANOVA revealed no significant group ($p = 0.179$) or pace ($p = 0.174$) effect, but their interaction was significant, $F(1, 15) = 17.838$, $p < 0.01$, η2p = 0.543 (see Figure 3). The post hoc tests revealed that the groups significantly differed in the slow pace condition, $F(1, 15) = 6.449$, $p < .05$, η2p = 0,301, with the autistic group having a significantly lower WR ($M = 0.134$) than the control group ($M = 0.174$). In the fast pace condition, there was no significant difference between the groups ($p = 0.964$).

In the 600-msec condition, the ANOVA revealed no significant main effect of group (but note: $p = 0.055$) or of pace (p = 0.368), but the interaction effect between these factors was significant, $F(1, 16) = 5.043$ $p < 0.05$, η2p = 0.240. The post hoc analyses revealed that the groups differed significantly in the fast pace conditions, $F(1, 16) = 6.828$, $p < 0.05$, η2p = 0.299, with the autistic group ($M = 0.128$) having a smaller WR than the control group ($M = 0.159$). The difference between the groups in the slow pace condition was not significant ($p = 0.798$).

Summary and Conclusion

Overall, the results reveal that there are conditions where autistic participants have better performance that control participants. With the 500-msec baseline, the average pace had a significant effect on CE. Despite the shift from a fast pace to a slow pace in the global context, the time estimate deviations of autistic participants remained closer to zero than those of non-

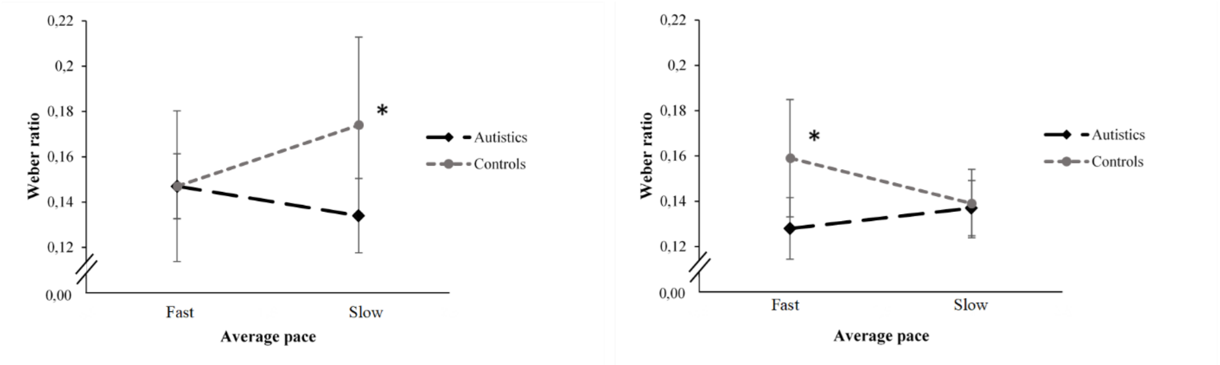

Figure 3: Mean Weber ratio for each group in each average pace condition for the trials where the base IOI and the standard were 400 msec (Left panel) and 600 msec (Right panel). Error bars represent a 95% confidence interval. * : group means differ significantly ($p <$ .05).

autistics. This critical finding indicates that autistic participants can ignore the global context that induces a bias in the time judgments of control participants.

When the base IOIs were 400 and 600 msec, there was no significant interaction effect between group and global context properties for the CE. However, the results show that, for the 400-msec condition, the autistic participants had a more accurate perception (lower CE) of time than the participants in the control group.

This study also aimed to determine whether the average pace and heterogeneity of the global context of the session affected the level of sensitivity (Weber ratio) of the control group, but not that of the experimental group. With the 400- and 600-msec base IOIs, there was a significant interaction between the average pace and group factors, with Weber's ratio scores of autistic participants being significantly lower than those of non-autistic participants when the mean rhythm is slow at 400 msec, which was not observed when the mean rhythm is fast at 600 msec.

For the WR, with the 500-msec base IOIs, there was an interaction effect between the average pace factor and the group, but, strictly speaking, single-effect tests showed no significant difference between the different levels of the average pace factor for each of the groups. Clearly, the autistic participants showed no difference at all between the fast and slow pace conditions, but non-autistic participants struggled more when the pace was slow (at 600 msec).

Overall, the results support the idea that the autonomy of perception toward the influence of higher-level functions favors the accuracy of temporal estimates in people with autism in certain circumstances. As expected, based on the EPF model (Mottron et al., 2006), autistic participants obtained lower CE and WR scores than controls in several IOI conditions. Autistic people were less vulnerable than participants of the control group to the potential global context effect. Note, however, that this finding does not mean that autistic people do not have the capability to perceive global features. Indeed, autistic participants of this study could alternate between a significant influence of the global context and a diminished effect of the latter on time perception. This is in line with the EPF model, which states that in some conditions, autistic people can typically process global information. They are subject to structural global bias, but to a lesser degree than non-autistic individuals (Mottron et al., 2006).

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CANNABIS USE AND MOTIVATION: A NEW BEHAVIORAL METHODOLOGY TO MEASURE MOTIVATION

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Abstract

Cannabis use is defined in DSM-5 as a "problematic pattern of cannabis use leading to clinically significant impairment" (5th ed.; DSM-5; American Psychiatric Association, 2013). One of the definitions for such problematic use is the recurrent use that can fail to fulfill significant role obligations at work, school, or home. Even though research is pointing to a demotivation disorder among cannabis users (Petrucci, LaFrance, & Cuttler, 2020), most of it is based on self-reports. In the current work, we suggest a new behavioral methodology to measure motivation and we hypothesized that cannabis users will show a significant difference in this new measurement than control participants.

To determine whether motivation is influenced by cannabis use, we used a novel methodology where motivation was defined as a factor of unpunctuality. Participants were invited to participate in an experiment (a cognitive task that was used as a filler-task). The participants were students from Ariel University, who received course credit coupons for their participation in the experiment. All participants filled out a demographic questionnaire and a cannabis-used questionnaire - Cannabis Used Disorder Identification Test-Revised - CUDIT-R (Adamson et al., 2010). The participants did not get a reminder prior to their arrival. To determine whether there is a demotivation effect among cannabis users, we defined a motivation scale as a function of time of arrival in comparison to the time of the scheduled meeting (i.e., minutes of delay), and whether they showed up or not (with or without cancelation).

Even though all participants received compensation for their participation, cannabis users showed a significant difference in their unpunctuality score. We argue that these results demonstrate an impairment in motivation among cannabis users.

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THE PLAYWISELY COACHES TRAINING MANUAL – COGNITIVE CARD SETS AND MOTOR DEVELOPMENT ADDITIONS

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PlayWisely

Abstract

The PlayWisely curriculum can enrich occupational therapy by enhancing the scope of practice and improving outcomes for children with a wide range of developmental needs. PlayWisely's evidence-based approach ensures that occupational therapists will use interventions proven to be effective and tailored to the unique needs of each child. The PlayWisely curriculum will be an essential tool for occupational therapists because it provides a fun and engaging way to help children develop functional skills needed to reach their full potential.

PlayWisely is the first psychophysical and neuropsychological approach to early childhood development (Leth-Steensen et al., 2018). Research has shown PlayWisely's curriculum significantly benefits neurotypical and neurodivergent children ranging in age from four months through three years due to PlayWisely's focus on developmental wellness through functional and purposeful play (Hannan et al., 2011). The cost of implementing a PlayWisely program is also radically lower than alternative interventions currently implemented in the occupational therapy scope of practice.

AUDITORY TASK SWITCHING AND DISTRACTOR FILTERING AS A FUNCTION OF WORKING MEMORY CAPACITY AND AGE

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Abstract

The ability to filter distractor information and to alternate between two different task sets are core mechanisms of cognitive control that have been studied for several decades, predominantly by using visual stimuli. While there is consensus about the importance of cognitive control in both distractor filtering and task switching, the role of age-related differences in cognitive functions (e.g., working memory capacity) remains inconclusive, in particular with regard to auditory processing. To test the hypothesis that individual task-switching performance in the auditory modality can be predicted based on cognitive abilities associated with a change throughout the lifespan, two age groups (18 to 30 years and over 60 years) completed a dichotic flanker task in which three utterances were presented simultaneously on each trial. The stimuli consisted of numbers and letters, with the target stimulus being presented to both ears while the distractors were presented to the left and right ear only (i.e., auditory flankers). The flankers were either from the same or a different category as the target stimulus (i.e., numbers only or numbers and letters), and associated response was either compatible or incompatible (i.e., same keys or different keys). The switch costs were calculated by subtracting response times on trials with a repetition of the category from response times on trials that required a different categorization compared to the previous trial. Participants working memory capacity and digit span was measured with an operation span task and a serial recall task. The results of this study support age differences as a predictor of individual task-switching performance. In addition, higher working memory capacity was associated with less performance cost due to switching task rules compared to repetition. In contrast to the task-switching ability, the only explanatory predictor for the auditory flanker effects was age but not working memory capacity.

TIMING MATTERS: DISTINCT BEHAVIORAL AND EEG CORRELATES OF STIMULUS AND RESPONSE CONFLICT IN A COMBINED PRIMING AND FLANKER TASK

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Abstract

Interference between relevant and irrelevant stimuli depends on the extent to which irrelevant stimuli are processed. Hence, large interference costs are expected when irrelevant incongruent stimuli (partially) initiate an incorrect motor response. Here, we focus on the temporal dynamics of incompatible response activation and (un)successful response inhibition. EEG was recorded while 48 young adults completed a task in which irrelevant flanker stimuli were presented before (SOA of 100 ms, 67 ms or 34 ms) or along with the target stimulus (SOA 0 ms). Behavioral interference costs increased along with SOA, and hazard analyses suggest that earliest responses for congruent trials start at ~250 ms with sustained response conflict for 150 ms. ERPs dissociate neural correlates of stimulus and response conflict: N2 latency in correct trials was only modulated by congruency, whereas N2 amplitudes were higher for error compared to correct trials except for the longest SOA. By contrast, LRPs illustrate partial activation of incorrect response mappings, with longer latencies and peak amplitudes as a function of SOA. Neural oscillations were modulated in the theta range. Together, these results illustrate the temporal dynamics of (partially) activated incongruent responses even on correct trials, particularly when irrelevant stimuli precede relevant targets by less than 100 ms.

IMPROVING CORTICAL RSEEG MECHANISMS IN AMNESIC MILD COGNITIVE IMPAIRMENT PATIENTS THROUGH QUADRATO MOTOR TRAINING

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Abstract

Physical exercise produces beneficial effects in patients with amnesic mild cognitive impairment (aMCI). Here we tested whether, contrasted with a simple Walking Motor Training (WMT), the Quadrato Motor Training (QMT) would induce a beneficial enhancement of the resting state eyes-closed electroencephalographic (rsEEG)deranging in aMCI patients.

Sixty aMCI individuals were enrolled. Among them, 29 aMCI subjects performed 28 daily QMT sessions (aMCI-QMT subjects), and 31 aMCI subjects completed 28 daily WMT sessions (aMCI-CTR subjects). Standard neuropsychological testing and rsEEG recordings were performed before and after 28 days of the training program with QMT or WMT. Exact low-resolution brain electromagnetic tomography (eLORETA) estimated the current neural density and lagged linear connectivity of the rsEEG cortical sources at delta (2-4 Hz), theta (4-8 Hz), alpha 1 (8-10.5 Hz), alpha 2 (10.5-13 Hz), beta 1 (13-20 Hz), beta 2 (20-30 Hz), and gamma (30-40 Hz) frequency bands of interest.

Statistical results ($p < 0.05$) exhibited better performance scores in the execution of the QMT in the last than the first training session as evidence of the learning effects. No statistical effect was observed in the neuropsychological scores of the baseline (before the training) vs. follow up (after the training) in both the QMT and the WMT group ($p>0.05$), as expected after the short period of 1 month. As a novel finding, compared with the WMT, the QMT did induce an enhancement of the functional connectivity from right occipital to right parietal and temporal rsEEG source activity at alpha 1 and alpha 2 frequency bands ($p < 0.05$).

The results of that original study suggest that the QMT may represent a useful, practical, psychophysical training to slow down the deterioration of rsEEG markers in aMCI patients if the above findings receive further control and cross-validation.

EXPLORING THE INTERPLAY BETWEEN WORKING MEMORY, INTELLIGENCE, AND CREATIVITY

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Abstract

This study investigated the interplay between working memory, creativity, and intelligence, providing a comprehensive understanding of their relationships. Adopting a multidimensional approach, verbal and visuospatial components of working memory were examined, along with their effects on fluid intelligence in well and ill-defined problem spaces. Additionally, the study explored the correlation between intelligence and creativity and the relationship between visual and verbal working memory. The hypotheses were tested using a sample of 46 adults. Various tasks were employed to assess working memory, creativity (based on a visuo-spatial task), and intelligence. Applying multiple linear regression analysis for both verbal and visual working memory as predictors of fluid intelligence, the results indicated that visual working memory was a robust predictor in both well and ill-defined problem spaces. In contrast, verbal working memory exhibited no predictive power in either problem space. These findings highlight the critical role of visual working memory in reasoning and problem-solving, particularly in complex and ill-defined problem spaces. Furthermore, a positive correlation was found between visual working memory and creativity, suggesting that individuals with higher visual working memory capacity are more likely to exhibit enhanced creative performance. In contrast, verbal working memory showed no relationship with creativity, indicating that it may not be as influential in facilitating visual creative thinking, at least in the visuo-spatial creativity task. These results expand upon previous research and underscore the distinct contributions of visual and verbal working memory to cognitive abilities. Moreover, the study explored the relationship between intelligence and creativity, revealing that higher creativity may enhance performance in ill-defined problem spaces. Regarding the relationship between visual and verbal working memory, the findings supported the hypothesis that they are separate cognitive systems functioning independently. Nonetheless, it is essential to note that these cognitive systems may interact in complex ways, contributing to mental imagery and problem-solving processes.

CROSS-MODAL AND INTRA-MODAL COMMUTATIVITY OF MAGNITUDE PRODUCTIONS COMPARED

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Abstract

Luce, Steingrimsson, and Narens (2010, Psychological Review, 117, 1247-1258) postulated that if ratio magnitude productions involving two perceptual dimensions exhibit 'cross-dimensional commutativity', they may be represented on a single internal scale of subjective intensity. Commutativity here refers to the order independence of successive magnitude productions, e.g., adjusting the subjective intensity of a stimulus successively by the factor 2 and 3 should produce the same result regardless of which factor comes first (2x3x = 3x2x). In the present experiment, these operations were performed (1) within the same modality (here: loudness or brightness), and (2) across modalities, i.e., making productions from light to sound ("make the sound twice as loud as the light is bright") and back ("now make the light three times as bright as the sound is loud"), or vice versa. In individual, within-subjects laboratory experiments involving repeated loudness and brightness productions, 13 participants made adjustments to evaluate both kinds of commutativity. In line with previous findings, both intramodal and cross-modal commutativity were rarely violated (compare Ellermeier, Kattner & Raum, 2021, Perception, & Psychophysics, 83(7), 2955–2967), but the net results of cross-modal and intramodal adjustments (e.g., of the type 2x3x) typically did not coincide. That suggests that while intramodal, and even cross-modal adjustments are made on an underlying ratio scale, the idea that all operations performed refer to a single internal yardstick is not supported by the data.

QUALITATIVE ANALYSIS OF THE PSYCHOLOGICAL MEDIATION IN SENSORY TASK

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Abstract

The central contradiction in the performance of a threshold task is the conflict between the need to effectively discriminate between signals and observer`s available resources. This contradiction can be resolved in the form of additional efforts directed to compensate for resource deficiency or, on the contrary, in moving away from the task and an intention to reduce resource costs. The purpose of our research is to clarify the role of the mechanisms of personal self-control defining the observer`s strategies that are used for the loudness discrimination of two tonal signals. The psychophysical research on loudness discrimination of tonal signals (method 2AFC) has been carried out, N=106. The influence of self-regulation on RT and sensory sensitivity index A' was found out. The qualitative analysis of individual ways of discrimination of signals was carried out. The relationships between loudness discrimination effectiveness and self-regulation processes characteristics mediating the sensory task decision were revealed.

The terms for resolving of a threshold sensory task define its specific features comparing with other educational problems of a person: 1) sensory information deficit; 2) unpredictable and random for an observer nature of stimulus presentation; 3) increased information loading upon an observer. Such terms cause high information uncertainty for an observer and a necessity for a high concentration of attention to the stimulus material presented as well as some efforts to support arbitrary attention in time. Solving of this sensory problem is subjected to information loading on a person that is confirmed by studies on mental stress assessment caused by different experimental tasks (Gusev, 2004).

Efficiency of resolving of threshold sensory tasks is conditioned by the influence of situational factors – the terms for resolving of a sensory task and individual features of observers. Thus, we have clearly established the influence of some situational and individual factors on changing of the level of observers' activity: time of the day, duration of experience, sleep deprivation, extroversion and introversion, etc. (Gusev, 2004). In this work we are considering the influence of the following situational and individual factors on the efficiency of solving of threshold and near-threshold sensory discrimination tasks: complexity level of a sensory task, features of self-regulation of a test subject (observer).

Observer`s performance in the near-threshold area takes place under the conditions of sensory information deficit and high rate of stimulus presentation. Therefore, the central contradiction in the performance of a threshold task is an intrapsychic conflict between the need to reach the goals provided by the instruction, for example, to effectively discriminate between signals and available resources of a system for information processing. This contradiction can be clearly seen in the form of additional efforts directed to compensate for resource deficiency and to overcome stimulus uncertainty or, on the contrary, in a desire to reduce resource costs and in moving away from activity. A few studies showed a role of the process of motivational and volitional regulation when performing psychophysical tasks on discrimination and detection of sensory signals (Skotnikova, 2008; Gusev and Shapkin, 2001).

We assumed that in order to explain the mechanisms of solving of the conflict described above it is useful to apply theoretical frame of a metacognitive model to control an action by J. Kuhl (Kuhl, 1992). According to Kuhl's conception and ideas a process to control an action – in this case a sensory action - , is mediated by a strategy actively realized by a subject that is expressed in orientation to the action taken or to one's own state.

Methods and procedure of the research

Observers

The research comprises 106 persons (average age is 31 years old), 88 women and 18 men.

Stimulation.

Tonal signals lasting 200 msec with a frequency of 1000 Hz. An interval between trials - 3 sec, an interval between stimuli - 500 msec. The difference between stimuli in different series were equal to 1, 2 (basic) or 4 dB (training).

Equipment and software

Registration of the responses and stimulus presentation was done with the help of personal computers with standard audio cards and stereo earphones AKG (K-44). Motor responses were recorded through special consoles that could ensure accurate registration and avoid measurement errors of response time (RT). Sound stimuli were synthesized by program "Sound Forge 4.5".

Procedure

A psychophysical research of loudness discrimination of tonal signals (method 2AFC). The observer had to listen to two sound signals and decide which of them – the first one or the second one – is louder. Within two days a participant of the experiment took part in two tests corresponding to a simple (2 dB) and more complicated (1 dB) task of signal discrimination. A separate test included training and introductory series (20-60 trial with a difference of 4 dB) and main series that consisted of four blocks each having 100 trials. In case if the observer carried out the training series without errors then he moved to the main series.

Upon completing each of the blocks of trial presentation the observer was shown the outcomes of his work – a screen displayed an estimated probability of correct responses, percentage of correct responses and false alerts. There was a break after. During that break, the observer shared his subjective impressions with the tester that he experienced during implementation of the task. Reply protocol of the observer was recorded via voice recorder and then it was decoded. When the observer detected the characteristics different from loudness in sound of the stimuli presented to him during the test the observer filled out a standard self-control questionnaire. Before the research the observers filled out a questionnaire "Control over an action" (HAKEMP-90) adapted by C.A. (Shapkin, 1997: 22-32).

For each series the indicators to estimate efficiency of sensory task implementation were calculated: 1) sensory sensitivity index A′, 2) RT. The data obtained were processed with the help of one-factor analysis of variance (ANOVA) in SPSS statistical package for Windows 17.0. Independent variables (of the factors) were 3 scales of the factor "Control over an action": "Control over an action when planning", "Control over an action in case of failure", "Control over an action in case of action realization". Each subfactor was presented by two levels –

«state orientation» (OS) and «action orientation» (OA). To determine levels of the factors the values obtained through the scales of HAKEMP-90 questionnaire ("Control over an action") were split at the midpoint that is for each scale the groups of OA-observers and OS-observers were created.

Results and Discussion

The inter-group comparison between average values of indicators of performance of threshold and near-threshold sensory tasks showed that among Action Oriented observers (in comparison with State Oriented) more stable motor responses are more prevalent that means lower values of mean-square deviation of RT for all types of responses when implementing a "simple" task (difference between stimuli - 2 dB). We also established that among State Oriented observers average RT during the test is higher in general than among Action Oriented observers. It means that in general they spend more time to discriminate between loudness of signals. It is shown that when resolving a more complicated threshold sensory task (difference between stimuli - 1 dB), OS-observers demonstrate a higher level of differential hearing than OA-observers (F(1.78)=7.341; p=0.008). Moreover, in a "simple" task the main effect of "Control over an action" factor was not significant for sensory sensitivity indicator – sensory sensitivity indicator between two groups were the same.

Analysis of a great amount of self-report data made it possible to separate and present general specific features of individual ways of work of OA- and OS-observers. We found out that in general OS-observers mentioned their emotions more often, they described the feelings they experienced when they were having difficulties or successfully implementing certain blocks of trials, they alluded to the features of their functional states. Earlier the works by K.V. Bardin et al. showed that auditory sensory task is resolved based on additional sensory cues occurring during the audition of sound stimuli (Bardin: 104-108). It is reflected in catching of "additional sensory cues" (ASC) – modal and nonspecific characteristics which represent sensory qualities of not only auditory, but other modality acoustic features – sensory qualities of auditory modality (Bardin: 117-123). We found out that most of ASC determined by OS-observers represented complex kinetic space images, visual color experiences, but not every ASC determined could be used, table 1. OA-observers, on the contrary, were focused on the task implementation and following the instruction literally. In comparison with OS-observers OA-observers used small sets of ASC or did not use them at all applying the methods of work that excluded ASC involving, partially or completely. Sharing their impressions during the break OS-observers told about difficulties to initiate the task, made a lot of explanations discussing their work during the test, gave examples from their everyday life, paid close attention to the reasons why the task is implemented successfully and to their failures. Unlike them OA-observers did not find thoughts and feelings in their subjective emotions that could affect or prevent them from realization of the activity initiated. In our opinion, mentioned specific features of the groups of observers being compared naturally explain the differences between the indicators of response time.

However, State Oriented observers showed more efficiency in comparison with OA-observers when resolving a more "complicated" threshold task. This advantage was reflected in a sensory component of task resolution. As we assume, a higher level of sensory sensitivity in a group of OS-observers may be considered as proof that a greater amount of cognitive resources were involved to resolve a threshold task.

Table 1. Additional sensory cues, nonspecific characteristics. Data of self-reports.

Additional sensory cues, nonspecific characteristics	observers (%)	
	OS-	OA-
Images of objects	87.2	72.5
Graphic schemes	89.0	49.0
Size	92.7	80.3
Verbal designation of signals, naming	85.4	58.8
Vision length	30.9	35.2
Arrangement in surrounding space	43.6	41.1
Localization of a sound in head space	50.9	25.4
Direction of the movement of a sound	69.0	9.8
Color feelings	56.3	15.6
Motor sense, proprioceptive sensation	7.2	3.9
Kinesthetic response and tactile feelings	16.3	13.7
Sounding duration	60.0	29.4
Brightness, intensity of a vision	90.9	62.7
Capacity	23.6	13.7
Density	7.27	9.8
Speed of increase in loudness	38.1	50.9
Accent, emphasis on louder signal	69.0	52.9

The data presented in this research are consistent with the outcomes obtained during studying of psychological mechanisms of resolving tasks to detect/discriminate between visual and auditory signals and it showed that variation of the type of stimulus uncertainty leads to transformation of a functional system of signal detection. It its turn it is reflected in changing of operational composition of observer’s activity (Utochkin and Gusev, 2007: 154-155). In general the data obtained comply with the Theoretical model of multidimensional sensory space by Y.M. Zaborodin as well as with the Model of compensatory discrimination/detection mechanism offered of K.V. Bardin (Bardin: 108-114). It suggests that when there is a great difference between stimuli it the process of taking decisions in relatively simple near-threshold sensory tasks one basic sensory axis takes part where all sensory impressions are distributed according to “loudness” parameter. To resolve a more complicated sensory task effectively when the difference between stimuli is very small one single cue – loudness- is not enough. Then with the help of determination and application of ASC of sensory images by observers new axes of sensory space begin to be formed.

Therefore, observer’s feeling of high informational uncertainty conditioned by low stimulus intensity or their minor differences between them makes the observer to choose and determine a resolution strategy. We showed that when resolving threshold or near-threshold sensory tasks sensory information is not the only factor and in case of the deficit thereof not the main one that condition the outcome. Analysis of psychological mediation of sensory task resolution shows they are conditioned by observer’s activity. What is especially interesting is an answer to the question about how this activity is expressed. Control over decisions and actions in an uncertain situation is associated with processes of setting goals and motives by an observer as well as with observer’s estimation of his own efficiency. When the level of self-regulation is low the effect of extraneous factors in a situation of uncertainty is higher that leads to unstable response time. If the level of self-regulation is high, the observers are more "focused" on the task and on the instruction for it but they pay less attention to their own experiences. Experimental and theoretical approach to an observer as a subject of psychophysical measurement makes it possible to describe and study observers' methods to obtain sensory information in a situation of uncertainty.

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EXTREMELY LIMITED PROCESSING CAPACITY OF EMOTIONAL FACE ENSEMBLES

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Abstract

Studies have shown that people are capable of perceptual averaging of emotions from an ensemble of faces (Haberman & Whitney, 2007, 2009; Sweeny et al., 2009). The current effort offers a fresh look at this ability from the vantage point of processing efficiency of multiple faces. To measure the efficiency of multiple face processing, I have harnessed the capacity coefficient (Townsend & Wenger, 2004) – a measure of processing efficiency on the entire RT distributions. The capacity coefficient was applied to multiple face displays with happy or angry, familiar, or unfamiliar faces. The results showed that the processing-capacity of ensemble faces is extremely limited, irrespective of the emotion conveyed by the faces, or their familiarity. These severe capacity-limitations entail that: (a) additional redundant items (faces) in the set hamper rather than facilitate performance (for both accuracy and RTs), and (b) individual faces in the ensemble suppress rather than enhance each other. These results are consistent with suppression or competition neuronal models (Desimone & Duncan, 1995). With respect to averaging, if we assume that each face exerts a suppression that is proportional to its emotional strength, then these results can explain averaging as the consequence of an interactive architecture with negatively correlated channels by which averaging is deduced from the amount of overall suppression in the ensemble.

STOP USING D' AND START USING DA: EVIDENCE FROM EMPIRICAL DATA ON HOW TO MEASURE SENSITIVITY IN RECOGNITION MEMORY

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Abstract

We ran simulations that suggest that all old-new recognition studies that used d' or H-F to establish changes in sensitivity between two conditions, reached conclusions not supported by the data. Our simulations revealed high Type I error rates between two iso-sensitive recognition-memory conditions that only differed in bias. In contrast, the simulations revealed d_a to be a bias-free measure of sensitivity. Importantly, the simulations make assumptions that may not be true of empirical data. For example, simulations test a finite set of data-generating models, specifically Gaussian unequal variance, and if these are not true (e.g., Rouder and Pratt, 2010) then da would fail to distinguish between bias and sensitivity. Also, while the values of confidence judgments were sampled independently in our simulations, empirical confidence ratings show sequential dependencies (Kantner et al., 2018). To estimate the Type I error rate for d_a, we ran 20 identical experiments (N = 1500) in which only bias was manipulated between conditions. Type I error rates were comparable to those found in our simulations. We campaign for the use of d_a in single-interval tasks such as recognition.

THE ROLE OF SPATIAL LOCATION IN IRRELEVANT SPEECH REVISITED: A REPLICATION OF JONES & MACKEN (1995)

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Abstract

The Changing-State Effect (CSE) refers to the disruptive impact of temporally changing background sound on serial short-term memory (as compared to repeated sounds). Here we intend to replicate Jones and Macken's (1995) finding that the CSE can be eliminated through spatial streaming, that is, when the changing-state sound can be split perceptually into different steady-state streams. In a pre-registered replication $N = 54$ participants will be presented with mono and stereo versions of task-irrelevant steady-state ('J-J-J…') and changing-state speech ('V-J-X…') while memorizing a sequence of visually presented letters (F, K, L, M, Q, R, Y). The two conditions critical for the spatial streaming account are illustrated in Figure 1. With monophonic presentation (identical signals in both earphones, left part of Figure 1) it is expected that the commonly observed changing-state effect (i.e., the difference in recall accuracy during steady-state and changing-state speech) will emerge. In the stereophonic presentation mode, by contrast (which presents a given letter to either the right, the left, or both ears in succession, right part of Figure 1), the disruptive effect of irrelevant speech is expected to be eliminated or attenuated, since spatial streaming should result in the percept of three steady-state streams emanating from three distinct locations (bottom right depiction in Figure 1). If the spatial streaming effects observed by Jones & Macken (1995) are not replicated, future studies are required to test whether this is due to the restricted spatial resolution of the sound reproduction method (relying on 'in-the-head localizations' only), or whether auditory distraction is based entirely on the spectro-temporal processing of the irrelevant sound. Overall, these findings will provide further support for the importance of organizational factors in the ISE and may have practical consequences for the design of workplaces and learning environments in the future.

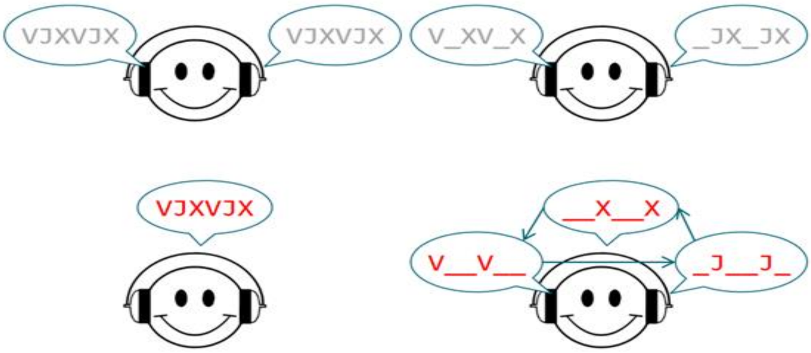

Fig. 1. Mono (left column) versus stereo (right column) presentation of a changing-state sound sequence. The top row illustrates what is presented, the bottom row, what is perceived.

AESTHETIC VALENCE: PSYCHOPHYSICAL PERSPECTIVES

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Abstract

Gustav Fechner founded not only psychophysics, but also *empirical aesthetics,* applying similar methods and lines of thought to beauty as to other subjective qualities. In Englund & Hellström (2012) preference judgments were made for successively presented jingles and color patterns. Results showed that preference can depend on presentation order, in much the same way as, for instance, heaviness. Various physical and informational characteristics of objects have been proposed as determinants of their aesthetic valence. An alternative approach is to look into what other *subjective* attributes might relate to aesthetic valence. In exploratory studies, my students and I found that *rated modernity* had a clear, but somewhat complex, relation to aesthetic valence. Although there was a general tendency to prefer less modern objects, we often found a U-shaped relation, with a minimal valence for an intermediate rated modernity. This was true for objects in practical use, such as cars and buildings. The degree of modernity yielding minimal valence tended to be higher for extraverts and, regarding ladies' clothes, for females – perhaps due to faster habituation. An optimal level of evoked arousal has been proposed as the foundation of pleasure. As predicted by Helson's "butterfly curve," moderate deviations from the adaptation level, in either direction, lead to an optimal degree of arousal. Perhaps arousal, caused by deviations from what one is habituated to, could then link modernity with aesthetic valence? For works of art, the relation between modernity and valence tended to have an inverted U-shape, possibly due to habituation being less important than for everyday objects. If a limited number of characteristics determine the aesthetic valence of works of art, multidimensional analyses might reveal which these characteristics are, and help define "styles" empirically. A factor-analytic study was conducted, based on 100 participants' aesthetic evaluations of 42 paintings. A four-factor solution was found.

ESTIMATION, LATENCY AND INTENSITY CODING IN VISION

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Abstract

Magnitude estimation and simple response time (SRT) are two essential indices of perceived stimulus intensity. By analyzing brightness estimation and visual SRT data conjointly, this paper contrasts two different approaches to intensity coding in vision. The first model embodies a neural response which is a power function of the stimulus intensity, and the other embodies a respose which gradually saturates due to a dead-time elaboration. For the estimation task, the observer is assumed to first gauge the frequency of the sensory transduction process and then apply a linear transformation to map their frequency estimate to the line of real numbers. For detection latencies, the same process serves as input to a central accumulator which counts neural pulses until a criterion is reached. We show that the exponentiated model accounts best for empirical brightness estimation and visual SRT data, yet struggles somewhat with estimation points in the lower stimulus range. These results hint at a sensation function which is not wholly captured by a power law.

A central theoretical issue in psychophysics is how physical stimulus intensity maps onto perceived intensity. Stevens (1956) devised direct scaling as the methodological gold standard for gauging sensation magnitude behaviorally in his new psychophysics. Based on estimation data, Stevens showed that the magnitude $\psi(I)$ of perceived intensity can be described as $\psi(I) = k \cdot I^{\beta}$ where the variable I denotes the physical intensity, and k and ß are empirical constants. In parallel with studies in traditional psychophysics, chronometrically oriented researchers have looked at the influence of stimulus intensity on reaction time (Luce, 1986). Already Cattell (1886) reported that reaction time decreases monotonically with increasing intensity I, a relationship that Piéron (1920) described with a simple law, that is, $E[RT] = r + k \cdot I^{(-\beta)}$, where E[RT] is the expected reaction time, r the residual time, and k and ß are again empirical positive constants.

Concerning vision, the empirical values of the ß coefficients for perceived brightness and visual reaction time appear to be the same (as noted by Pins & Bonnet, 2000). It is therefore pertinent to investigate if they emanate from a common mechanism. For this purpose Steven's and Piéron's psychophysical laws have limited explanatory scope, because they are merely empirical laws and therefore necessarily mute regarding the underlying neurocognitive substrate of estimation and latency functions.

An idea endorsed by Stevens (1970) is that peripheral visual units encode a power transformation of the stimulus intensity in their firing rates. Under this view, human estimation functions merely reflect an early encoding strategy at the level of the single unit. This influential idea was later incorporated into stochastic models of SRT (Luce & Green, 1972). The present work seeks to contrast Stevens' view with an alternative way of linking visual estimation and latency functions via a dead-time elaborated Poisson process.

Such a modified Poisson process was advanced by Teich, Matin & Cantor (1978) in their analysis of waiting times between pulses in the retinal ganglion cell of the cat. They modeled neural waiting times as the convolution of an exponential random variable with an additional constant latency. The exponential component represents the "proper" waiting time of the cell, and the additional component represents the transient neural refractory state. The mass action of many such dead-time modified transducers operating in parallel is in agreement with empirical Weber and estimation functions (Lachs et al., 1984).

Consider an idealized single-channel model where the output of one sensory unit represents the entire sensory message. Assume that the number of responses per unit time in the input channel is determined by a Poisson process modified such that the refractory mechanism entails a constant dead time in the channel whenever a pulse is emitted. This refractory time is represented by a single, positive-valued number yielding a shifted exponential density for waiting times. The channel is assumed to be non-paralyzable, meaning that the transduction mechanism is unresponsive to input in the refractory state (Parzen, 1962). These assumptions yield an explicit formula of the predicted response function of the single unit as follows

$$\nu(I) = \left[\frac{1}{k \times I} + \rho\right]^{-1} \tag{1}$$

where ν(I) denotes the average frequency of pulses induced by a stimulus with luminous intensity I. The variable k is a scaling coefficient and ρ is the duration of the refractory period. Equation (1) can be seen to describe a sigmoidal tuning curve when plotted in logarithmic coordinates of I. When the radiation statistics of the light source is known so that I denotes the number of photons available to the channel per unit time, one can conceive of k as the quantum transduction efficiency of the system, that is, the probability that a single light quanta produces a neural response.

We can now calculate the expected value of the observer's estimate of sensation magnitude by assuming that they multiply the frequency estimate by a number coefficient n such that

$$\Psi(I) = n \times \nu(I) \tag{2}$$

The coefficient n reflects the observer's conception of number magnitude and therefore represents a mostly arbitrary response strategy. Although it is malleable via experimenter instructions (“restrict your responses to numbers ranging from 0 to 10”) we shall assume that once observers are familiar with the task, they settle on a single unique response strategy and stick to it for the entirety of the experiment.

For the function relating intensity to reaction time, suppose each pulse emitted by the sensory transduction process is transmitted to a central counter which gates the response mechanism. This gate opens as soon as c pulses have been recorded like in a standard accumulator model (e.g., Miller & Ulrich, 2003) and emits a detection signal which initiates the observer's manual response. When the target signal is of infinite or response-terminated duration such that it never offsets before the criterion has been reached, this yields the expected mean response time

$$E[RT] = c\left[\frac{1}{k \times I} + \rho\right] + r - \rho \tag{3}$$

The predicted response times will be distributed according to a c^{th} order gamma density shifted by $(c\text{-}1)\rho + r$ units into the positive domain. With finite signal duration d_s there is a non-zero probability that signal offset occurs before response initiation, so the response times will be truncated at $r + d_s$. We would therefore expect that $E[RT]$ deviates somewhat from Equation (3) when some stimuli are too faint and/or brief to be detected.

We now turn to an experiment aimed at testing the two model frameworks. To provide a strict test, we collected measurements of both visual SRT and brightness estimation from two naive observers. This allowed us to compare the refractory and power models with respect to their ability to account for performance measures (latency) and subjective reports.

Methods

Participants

Observers A.L. (left-handed, male, 21 years old) and P.C. (right-handed, female, 20 years old) were recruited from the student pool at Tübingen University. They were paid at an hourly rate of 12 €.

Stimuli and apparatus

An experimental script in PsychoPy controlled stimulus presentation and response recording on a 32-bit Esprimo P956/E90+ computer (Fujitsu Limited, Tokyo). Visual stimuli were presented on a 24.1-inch FlexScan EV2495 LCD monitor (EIZO Corporation, Hakusan) with a pixel resolution of 1900 × 1200 and 60 Hz refresh rate. The stimuli were square patches of white light measuring 3.3 cm width × 3.3 cm height presented binocularly in the center on the monitor for a duration of 500 milliseconds (msec). RT was measured with a spacebar response on a QWERTZ keyboard. Numerical magnitude estimates were also entered on the same keyboard using the numeric keys. Twelve levels of luminous intensity defined the stimuli for both experimental tasks. These were 0.39, 0.48, 0.675, 1, 1.35, 3, 6.75, 13.5, 30, 67.5, 135 and 300 cd/m2, respectively. Background illumination was held constant at 0.3 cd/m2. Luminous intensity of stimulus materials was measured with a P-9201-TF photometer (Gigahertz Optik, Türkenfeld). A BlackBox Toolkit (Version 2) for external chronometry was used to verify the requested timing of the setup. The experiment was conducted in a sound- and light-attenuated booth.

Procedure

Each observer took part in 10 experimental sessions. The sessions started with 10 minutes of dark adaptation. After the adaptation phase, a testing phase started comprising 420 reaction time trials and 120 magnitude estimation trials in counterbalanced ABBA-order across sessions. For both tasks, the start of a trial was signaled by the appearance of a faint fixation cross in the center of the screen for 500 msec. Following fixation offset, a target would appear on the screen after 1,000 msec (added to a random exponential latency with mean 1,285 msec in the speeded task). To estimate false alarm rates, there was a ⅕ probability of a blank trial in the SRT task. If a SRT response was slower than 1,000 msec, the words “too slow” printed in a red font appeared on the screen for 500 msec. In the estimation task there was no deadline. An entire session lasted about an hour. The dependent measures were response time and response probability in the speeded task and numeric magnitude estimate in the estimation task. The University of Tübingen’s local ethics board for psychological research approved the experiment.

Data Analysis

First, the RT data were inspected for anticipations (RTs < 200 msec) and the estimation data were inspected for outliers (we used a stringent criterion so that only those estimation points deviating > 5σ from the participant mean were excluded). For each observer, simulated data were fitted jointly to mean-averaged SRTs, detection probabilities and magnitude estimates using the downhill simplex method (Nelder & Mead, 1965). Parameters k, ρ, c, r, and n were used to fit the refractory model to the data. Then the same procedure was repeated using a power transformation for the pulse rates instead of a dead-time elaboration. The power model similarly used five parameters: k, b, c, r, and n. For both models, the rate parameter for the process was a function of the contrast between stimulus and monitor background C = I - I0. Model agreement to data is reported below in terms of the $\chi2$ fit between empirical and simulated mean SRT, detection probability and estimation data.

Results

Very few estimates (< 0.06%) were treated as outliers and even fewer SRTs were too fast (< 0.2%). False alarm rate for observer A.L. was 0.46 % and for observer P.C. it was 0.1 %. For A.L. the parameter estimates for the refractory model were $k = 302$, $\rho = 0.007$, $c = 3$, $r = 0.340$ and $n = 0.36$ yielding a fit of $\chi^2 = 37.97$. Power law model parameter estimates for A.L. were $k = 208.07$, $b = 0.21$, $c = 3$, $r = 0.330$ and $n = 0.52$ yielding a better fit of $\chi^2 = 10.31$. For P.C. the estimates for the refractory model parameters were $k = 300$, $\rho = 0.009$, $c = 3$, $r = 0.380$ and $n = 0.37$ yielding a fit of $\chi^2 = 28$. Correspondingly, the power model parameters for P.C. were $k = 30$, $b = 0.17$, $c = 3$, $r = 0.350$ and $n = 0.74$ again yielding a better fit of $\chi^2 = 4.52$. Experimental data and model fits are visualized in Figure 1 below.

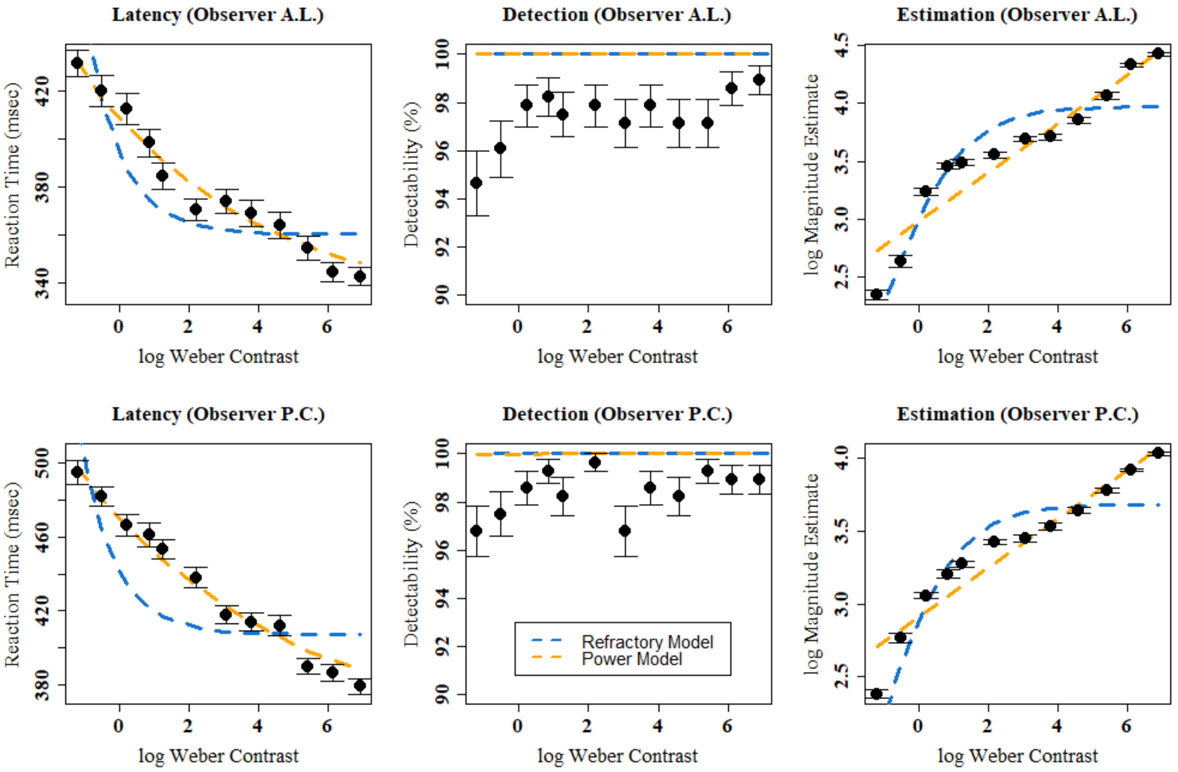

Fig.1. Latency functions (left column), detection probabilities (middle column) and log estimation functions (right column) separately for observers A.L (upper rows) and P.C. (lower rows). Error bars show ± 1 standard error. The x-axes are scaled by the logarithm of the Weber contrast (Peli, 1990) given by log $\frac{I-I_0}{I_0}$ where I is the stimulus intensity and I_0 is the background luminance.

Discussion

In summary, the present work compared two Poisson models of intensity coding with respect to their ability to account for brightness estimation and visual SRT data. The models differed in that one incorporated a neural refractory mechanism and the other incorporated a power transformation of the input intensity. The following conclusions can be drawn from the results at hand.

First, the power model yielded a decent numerical fit to the data, whereas the refractory model was fairly off the mark. This state of affairs held true for both observers. Yet with regard to the lower stimulus range, the refractory model seems to capture a certain tendency towards curvature in the estimation functions as depicted in log-log coordinates (rightmost panels of Figure 1). Because the power transformation model predicts a straight line here, our results suggest a "near-miss" to Stevens power law for perceived brightness in the lower luminance range. Similar tendencies towards more steep estimation functions for faint tones compared to loud tones have been observed in the context of loudness estimation (Florentine & Epstein, 2006). One interpretation is that this empirical regularity might necessitate a compromise between the two models so that a refractory mechanism and power scaling of the neural response both contribute to observed latency and estimation functions.

On a final note, it bears remarking that both models produce much richer predictions than those reported here. This includes the complete distributional characteristics of SRT and estimation data such as variances and higher-order moments. A comprehensive treatment of these characteristics was omitted here for brevity. Both models also predict neural response functions and interpulse time distributions. Combined investigations of neuroelectric responses and estimation functions have been conducted (e.g., Borg et al., 1967) but usually within relatively narrow stimulus ranges. In our opinion, joint investigations of electrophysiology and behavior hint at a promising avenue for conducting stricter and more informative tests of psychophysical intensity processing models.

Acknowledgments

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WALTER BLUMENFELD AND THE BEGINNING OF PSYCHOTECHNICS IN SAXONY

(ADDENDUM: FUTURE FOR THE FORMER WILHELM WUNDT HOUSE GROSSBOTHEN: EXHIBITION OF THE SAXONIAN PSYCHOTECHNICAL COLLECTION?)

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Abstract

The speaker, psychologist and medical historian, is part of a group of researchers seeking to reuse the historic Wilhelm Wundt House near Leipzig, Germany (Saxony). The house in the small village of Großbothen is the only surviving home of the famous scientist, who is considered the most important founding figure of academic psychology. It had been vacant since 1990 and fell into disrepair. Thanks to the efforts of a preservationist, the property, which had already become dilapidated, was saved from further decay with the help of publicly raised funds. The renovation of the building should be completed in 2024, while the future use of the building is still open. The goal is to find and fund a use that relates to the history of psychology. One idea is to show the development of psychotechnics in professional psychology, which had its beginning in Saxony. In addition, the Psychotechnical Equipment Collection in Dresden is urgently seeking new premises.

As an example, I will present the biography of the German-Peruvian psychotechnician Walter Blumenfeld (1882-1967). Blumenfeld is one of the pioneers in the field of industrial and organizational psychology. The son of a merchant initially studied electrical engineering and worked as an engineer in Berlin. He completed a second degree in psychology and philosophy in 1913. After World War I, he was a private lecturer in general and experimental psychology at the Technical University of Dresden. Appointed associate professor in 1924, he was instrumental in establishing the new Psychotechnical Institute. He was concerned with work organization ("Blumenfeld effect") and developed methods for aptitude diagnostics ("Blumenfeld cube"). Dismissed as a Jew after the National Socialists came to power, he emigrated to Peru in 1935. In Lima he received a professorship in psychology and education. His works, written in Spanish, achieved a high degree of circulation in South America. Walter Blumenfeld, who was awarded after World War II honorary membership of the German Psychological Society, died in Lima shortly before his 85th birthday.

PERCEPTUAL BIASES IN AMBIGUOUS DOT LATTICES: THE ROLE OF COGNITIVE VS. PERCEPTUAL LOAD

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Abstract

Perceptual processes are influenced not only by the physical properties of stimuli, but also by the perceptual biases of the observer. A reliable method for studying these processes is observing how stimuli are grouped together based on their proximity (Koffka, 1935; Kubovy and Wagemans, 1995). In a perceptual judgment task, we measure how proximity grouping in ambiguous dot lattices depends on the aspect ratio (AR) affects a perceptual bias for cardinal orientations (such as vertical or horizontal). Additionally, we investigated whether cognitive load and visual working memory load contribute separately to online perception. We used a continuous n-back tasks (1-back, 2-back) to manipulate cognitive load, and a flanker paradigm to manipulate perceptual load. Our ongoing experiment aims to investigate a double dissociation – whether cognitive and perceptual memory loads have independent effects on perceptual biases. Overall, our study may offer further insights into how cognitive and perceptual processes interact to shape visual perception.

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BINARY DECISIONS INFORMATION ACCRUAL MODELS: TOOL & EXAMPLE

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Abstract

A demonstration using the statistical software ‘R’ of how one can estimate information accrual parameters for people performing a binary decision task with N trials, and several categorical predictive factors. The input file comprises columns for: trial number, participant id, levels of predictive factors 1 - K, stimulus, response, and reaction time. An output file, Results 1, is generated using R package DstarM (van den Bergh et al., 2020) with the following parameters for each participant in each condition: information accrual rate (mean **v**, standard deviation, $\mathbf{s_v}$), start point (mean **z,** standard deviation $\mathbf{s_z}$**)**, barrier separation **A**, non-decision time (mean, **t0**), goodness of fit, chi-square. Results 1 may then be used as input to any ANOVA package to estimate the effect of the predictive factors, in a file Results 2, with accompanying Tables and Figures. The demonstration uses data from Dutilh et al. 2019, with predictive factor 1 = caution (speed, accuracy) and predictive factor 2 = difficulty (hard, easy). The effects of these factors on **v, z, A** are already known; and generally, the speed conditions have lower **t0** than the accuracy conditions, although theoretical reasons remain to be explored. We investigate the addition of a new factor 3 = previous trial accuracy (correct, error). Our previous analyses, (Kornbrot and Georgiou, 2022), suggest that in no feedback tasks like Dutilh et al. an error decreases performance on subsequent trials. We explore this sequential effect on **A, v**, **z. t0.** We plan to make a tool (possibly a Shiny app), the advantages of which will be illustrated., There will be opportunities for people with relevant binary data, especially in applied areas (which almost always use raw summaries rather than model-based parameters) to use the tool. This work has been generously supported by ISP, the UK Experimental Psychology Society, and the University of Hertfordshire.

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TEMPORAL AND SPATIAL UNCERTAINTY IMPROVES THE DISTRIBUTION OF VISUAL ATTENTION AND THE AVAILABILITY OF SENSORY INFORMATION FOR CONSCIOUS REPORT

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Abstract

Picking-up and exploiting spatial and temporal regularities in the occurrence of sensory events is important for goal-directed behaviour. According to the "Predictive Coding Hypothesis" (Friston, 2005), these regularities are used to generate top-down predictions that are constantly compared with actual sensory events. However, it is untested whether cumulated predictive knowledge about consciously seen stimuli improves the access to awareness of stimuli that usually go unseen. To explore this issue, we exploited the Attentional Blink (AB) task, where conscious processing of a first visual target (T1) hinders detection of early following targets (T2). We report that timing uncertainty and low expectancy about the occurrence of consciously seen T2s presented outside the AB period, improve detection (d') of early and otherwise often unseen T2s presented inside the AB. Recording of high-resolution Event Related Potentials (ERPs) and the study of their intracranial sources showed that the brain achieves this improvement by initially amplifying and extending the pre-conscious storage of T2s' traces signalled by the N2 wave originating in the extra-striate cortex. This enhancement in the N2 wave is followed by specific changes in the latency and amplitude of later components P3a and P3, signalling access of the sensory trace to the network of parietal and frontal areas modulating conscious processing.

In a second experiment, we tested whether variations in the probabilistic cueing of the position of a primary T1 visual target in a 4 × 4 letter array, modulate the retention of memory traces evoked by secondary letter targets (T2) that were presented in other positions of the array. Most important, in each trial, the identity of T2 was specified to participants upon disappearance of the array. We show that high probabilistic cueing facilitates T1 detection and improves the corresponding sensitivity index (d'). In contrast, retention and conscious report of secondary targets (T2) improves when the probabilistic cueing of T1 position is poor.

Taken together, these findings suggests that that the interaction between conscious and unconscious processing changes adaptively as a function of the probabilistic properties of the sensory environment and the combination of an active attentional state with loose temporal and spatial expectancies on forthcoming appearance of primary targets improves the possibility that traces of secondary targets gain full access to conscious processing. This likely provides an insight on the attentional conditions that predispose an active observer to unexpected "serendipitous" findings.

THE EMOTIONAL STROOP EFFECT IN HEARING: EVIDENCE FOR DRAMATIC DIFFERENCES BETWEEN THE EFFECT IN VISION AND THE EFFECT IN HEARING

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Abstract

A large body of experiments show that when presented with words printed in color, observers report the ink color slower if the carrier word is a negative threat word rather than a non-emotion neutral one, the emotional Stroop effect (ESE). However, virtually all existing ESE studies have been conducted in the visual modality. Does an ESE arise when the stimuli are heard rather than viewed? This important question about modality was surprisingly unaddressed in a systematic fashion. In 2 experiments, we tested for the presence and characteristics of an auditory ESE. The findings reveal radical differences between the senses: The classic ESE recorded in vision vanishes and even reverses in hearing. Observers typically react swifter, and certainly not slower, to threats delivered through the ears as compared with neutral stimuli. Too, the approach-avoidance distinction, so impactful in vision, loses its influence in hearing. Collectively, the results challenge traditional explanations offered for the visual ESE.

A popular assay of selective attention to emotion laden stimuli is the Emotional Stroop Effect (ESE). In the canonical setup, words printed in color are presented singly for view, and the task is to name, while timed, their ink color. The carrier words are drawn from two categories: (a) emotionally charged negative words and (b) neutral words. The ESE is the slowdown observed in naming the ink color of the emotion words compared with that of neutral words (Ben-Haim et al., 2016). Our main goal in this study was examining the purview of the ESE with respect to modality. Virtually all ESE research to date engaged the visual modality, where threats naturally appear in front of the eyes, i.e., in front of the participant. That is not the case in hearing, where threats can be heard from the entire space surrounding the person. Does the ESE exist in hearing or is it limited to vision? If it does, are the same mechanisms underlie the phenomenon in audition and vision?

There are several conceptual problems plaguing the ESE. One of the most significant refers to an inconsistency between everyday life and the laboratory in the response to threat (Chajut, Mama, Levy, & Algom, 2010). In everyday life, the response to a threat stimulus is speedy (e.g., Karekla, Forsyth, & Kelly, 2004;). In the laboratory, by contrast, the response to a feature of a threat stimulus is sluggish (=ESE). How does one resolve this conundrum? The hypothesis offered by Chajut et al (2010) implicates the counterinstinctual responses imposed in the laboratory: People instinctual response to threat is avoidance, yet they are denied this option in the typical ESE study. In the laboratory, the participant is asked to respond to threat by pressing a key – an *approach* response – violating the natural reflexive tendency of avoidance (Wentura, Rothermund, & Bak, 2000). The counternatural response is conductive in turn to the slowdown observed in the lab. To test their response-bias hypothesis, Chajut et al (2010) included avoidance as well as approaching in the set of permissible responses. The results showed the typical ESE with approaching, but the reverse ESE with avoidance (see also, Schouppe & De Houwer, 2012). For avoidance, the participants responded *faster*, not slower, to the color of a threat word than to that of a neutral word.

Given these results, the approach-avoidance distinction plays clearly a prominent role in generating and reversing the ESE. The fundamental hedonistic principle (Higgins, 1997) elucidates that role. The principle documents the timeless human tendency of approaching positive stimuli (food, partner) and avoiding negative stimuli (poison, predators). This time-honed skill is vital for adaptation and survival. It helps in averting danger or death, on the one hand, and in enabling reproduction and health, on the other hand. Bargh (Chen & Bargh, 1999) posits that all incoming stimuli are first subjected to instantaneous affective evaluation (good vs. bad), which is accomplished before full semantic processing of the stimulus. Behavioral approaching or retreating is the motor or muscular embodiment of that evaluation in accordance with the hedonistic principle. Due to the danger posed to survival, responses to negative stimuli are especially speedy. A large literature documents the sundry ramifications of approaching and avoiding in the regulation people's emotions and well-being (e.g., Chen & Bargh, 1999). When tested in the secure confines of the laboratory, safety or survival is irrelevant of course, but a modicum of the evolutionary tendency to avoid threat suffices to produce the standard ESE (Algom et al., 2004; Chajut et al., 2005).

The great majority of approach-avoidance studies, has been done in the visual realm. The very term, approach-avoidance, acquires psychological meaning due to the placement of the human eyes in a frontal position in the head. The situation is different in hearing. Due to the lateral placement of the ears, people have panoramic sensitivity to all concurrent sounds in the environment. For that reason, the approach-avoidance distinction loses much of its force in hearing. The question arises regarding the presence of an auditory ESE. Does the ESE present in hearing? If it does, it is subject to modulation by the specific motor response (e.g., stepping forward or backward) or by the spatial location of the threat (front vs. back)? These questions were pursued in the current study.

In 2 experiments, the participant decided, while timed, the gender of the speaker of words sounded via a loudspeaker. The spoken words were emotion words and neutral words. In Experiment 1 the loudspeaker was placed in front of the participant, and in Experiment 2 behind the back of the participant, and the responses included approaching or avoiding the sound stimulus (Fig. 1). If there is an auditory ESE, the latencies should differ across negative and neutral words. However, if the approach-avoidance distinction no longer constrains behavior in audition, the responses to threat stimuli should be faster than those to neutral stimuli, emulating real life, regardless of the type of response (approach-avoidance) and the spatial location of the threat (front-back). Therefore, we expected to find a reverse ESE in all conditions – at variance with the typical result obtained with visual ESE.

Experiment 1

The testing was done in vivo, following the movement of the entire body in realistic conditions. The participant was standing in the middle of the room. The words were sounded from a loudspeaker facing the participant at one end. A random half of the participants was asked to respond to a female's voice by stepping forward, thereby approaching the loudspeaker. They were stepping backward when the voice was that of a male, thereby avoiding the source of the sound. The remaining half of the participants reacted through the reverse regime.

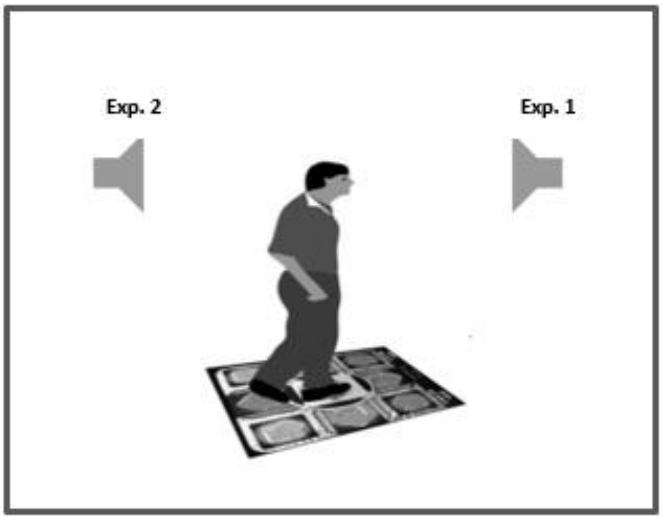

Fig. 1. The setup of Experiments 1 and 2: The participant stepped forward or backward in response to the gender of the speaker of emotion or neutral words. In Experiment 1 the loudspeaker was facing the participants. In Experiment 2 the loudspeaker was placed behind the participants

Apparatus & Stimuli

The spoken items were 5 emotional words (the Hebrew words for suffering, doom, pain, worry, grief) and 5 neutral words (trolley, centre, branch, note, delivery), borrowed from the ESE study of Chajut et al (2010). The tone of the spoken words was neutral (Ben-David et al., 2016). These stimuli were shown to produce the ESE (in vision) under the current conditions. The words were recorded in a sound-treated booth (Tel-Aviv University, Speech Therapy Lab). An AT892CW–TH microphone was hooked up with a Microset audiotechnica program, with external sound card Sound forge 7, using line 6 Tone Port aux 2.

For responding, we used a commercial mat for an electric platform (110 cm x 90 cm, Dance-Dance-Revolution Super Deluxe Pad). The pad was connected to a Dell Pentium computer through its game port with synchronization (and all other event timing) governed by a directRT Precision Timing Software (Version 2008.1.0.11). Time resolution of this system was 8 ms, on average (on a par with the typical resolution for standard key pressing).

Design

The participants stood with both feet on the marked central position of the pad, with the loudspeaker facing their eyes from a distance of 80 cm. The loudspeaker was located at the edge of shorter side of the rectangular mat. The loudspeaker was mounted at the participant's eye level. The participant responded to the gender of the speaker by stepping forward or backward.

Procedure

A random half of the participants responded to the voice of a male speaker by walking forward and to the voice of a female speaker by moving backward. The remaining half followed the reverse regime. The main dependent variable was the time elapsing between stimulus outset and completion of the participant's stepping. For the next trial, the participant then returned to the starting position, and after 1s a new voice was sounded. Note that in the present setting, stepping back signifies avoidance and stepping forward approaching.

Results

Figure 2 Panel A gives the results of Experiment 1. Salient to visual inspection is the swifter reactions to the emotional words heard – regardless of approaching or retreating. The participants responded, stepping forward or backward, to emotion words 1323 ms, on average, but to neutral words 1415 ms, on average. This reverse ESE of 92 ms was not statistically significant. Yet the absence of an interaction between response type (approach, avoid) and stimulus valence (emotional, neutral) [F<1] supports the numerical presence of a reverse ESE in audition, which is indifferent to the mode of responding.

Discussion

The findings of Experiment 1 document the absence of the typical ESE in hearing. Numerically, they confer ecological validity on the putative presence of a reverse ESE in hearing. Our participants behaved in the lab the same way as do in real life upon hearing a threatening stimulus – they walked swiftly with the direction determined by the specific circumstances (instructions). The lack of a statistically significant reverse ESE probably derives from the very long RTs. The next and last experiment was planned to further support our conclusions on the omnipresence of a reverse ESE in hearing – using walking once again but placing the loudspeaker behind the back of the participant.

Experiment 2

The singular feature of Experiment 2 was its modality-specific setting – with the source of the sounds coming from behind. This arrangement is impossible in vision. A related notable feature is the reversal of the usual classification of movements. In the typical visual setting, walking forward means approaching the stimulus, whereas walking backward means retreating from the stimulus. In the present auditory setting, walking forward means avoiding the stimulus, whereas walking backward means approaching the stimulus.

Method

Participants

A new group of 24 participants from the same pool as Experiment 1 participated in this experiment.

Apparatus & Stimuli

They were the same as in Experiment 1.

Design

The same as in Experiment 1 with a single notable change: The loudspeaker was placed behind the participant, 80 cm from the edge of the mat. The responses were those of Experiment 1, i.e., stepping forward or backward on the mat in response to the gender of the speaker.

Procedure

A random half of the participants responded to the voice of a male speaker by stepping forward and to the voice of a female speaker by stepping backward. The remaining half responded by the complementary regime: stepping backward to a male voice and stepping forward to a female voice. Because the words were heard from behind, the designation of approach and avoidance. In the current setting, stepping backward means approaching and moving forward means avoiding.

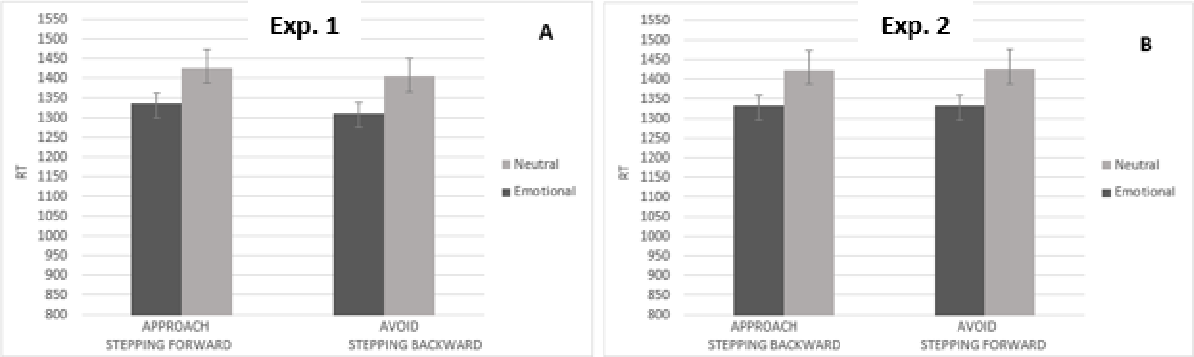

Fig. 2. *Panel A*: The results of Experiment 1. Mean reaction times for stepping forward (approach) or backward (avoidance) in response to the gender of the speaker for emotion and neutral items. The bars signify one standard error around the mean. *Panel B*: The results of Experiment 2. Mean reaction times for stepping forward or backward in response to the gender of the speaker for emotion and neutral items. Because the words were heard from behind, stepping backward means approaching and forward means avoiding. The bars signify one standard error around the mean.

Results

Figure 2 Panel B gives the results. Walking was faster when hearing emotion words (mean of 1333 ms) than when hearing neutral words (mean of 1426 ms), documenting a reverse ESE of 93 ms. This difference was not significant statistically. Notably, the numerical advantage in responding to emotion words held regardless of the direction of walking as the absence of a direction (approach, avoidance) x valence (emotion, neutral) confirmed [F(1,23)=0.022, p<0.88].

Discussion

The radical change in sound localization with the attendant change in the meaning of the motor movements did not affect the recurrent pattern observed in hearing: The absence in hearing of the standard ESE obtained in vision, with a likely reversal by which responses to threat stimuli are faster (rather than slower) than those to neutral stimuli under all contexts.

General Discussion

Virtually all ESE studies to date have been conducted within the visual modality, i.e., with the stimuli presented in front of (the eyes of) the participant. A further constant feature of existing research has been a certain curtailment of the possible reactions by the participants. They have not been provided with the option of backing off or withdrawing from the stimulus even when the stimulus is threatening. Under these conditions and with words in color as the stimuli, the common outcome is slower color naming for negative words than for neutral words. The traditional explanation holds that menacing stimuli (e.g., threat words, snakes, spiders) are afforded early preferential processing, which, in turn, exacts a toll on the task of color naming. This cost is known as the ESE.

In this early foray into hearing, we departed from both routine characteristics of standard ESE studies. First, we did not use vision as the sensory channel for stimulus delivery. Second, we afforded the participants with liberal response options: They could approach *or* avoid the (menacing) stimulus. The results revealed dramatic differences between visual ESE and auditory ESE. The sluggish performance with negative stimuli recorded in vision all but vanished in hearing. When the threat is heard rather than seen, reaction is instantaneous. In hearing the ESE reverses, i.e., the responses are faster rather than slower to threat, and in any case, there is no slowing in response to threat in comparison with neutral stimuli.

The current results reinforce the non-natural condition of laboratory ESE research, first noted by Chajut et al (2010). In real life, people usually react in a swift fashion to nearby threats. And they typically react by retreating, an option denied in the laboratory. When the option is provided, lab and real life produce the same reactions. Simultaneously, the present outcome challenges the traditional explanation offered for the visual ESE. Enhanced processing is present when retreating to the same extent that in approaching, and it supposedly is present in hearing as much as in vision – yet the standard ESE is missing under realistic conditions. The modified test of ESE with avoidance permitted probably reflects the deep seated tendency not to remain in contact with negative anxiety arousing stimuli.

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SENSORY PERCEPTION IS A HOLISTIC INFERENCE PROCESS

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Abstract

Sensory perception is widely considered a Bayesian inference process where the percept reflects an optimal estimate of a stimulus feature. We challenge this reductionist view and propose that perception is rather a *holistic process* that operates not only at the feature but at all levels of the representational hierarchy. We test this hypothesis in the context of a commonly used psychophysical matching task in which subjects are asked to estimate the orientation of a test stimulus by adjusting a probe stimulus (method-of-adjustment). We introduce a holistic matching model that assumes that subjects' responses reflect an optimal match between the test and probe stimulus, considering not only the stimulus feature (orientation) but also higher-level representations (orientation categories). Validation against several existing datasets demonstrates that our model accurately and comprehensively predicts subjects' response behavior, and outperforms previous models both quantitatively and qualitatively. Moreover, the model generalizes to other feature domains and offers an alternative account for categorical perception in color matching. Our results suggest that categorical effects in sensory perception are ubiquitous and can be parsimoniously explained as optimal behavior based on holistic sensory representations.

DANCING THE BODY, CARDINAL DIRECTIONS IN SPACE AND EMBODIED CONCEPTS

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Abstract

Space is not only a fundamental dimension of our physical experience of the world, but also an organizing principle that helps structuring mental contents. In fact, different theories suggest that spatial representations are involved in various cognitive domains (e.g., attribution of emotional valence and time) and can be used to describe states of consciousness from a neurophenomenological perspective, as suggested for example by the Sphere Model of Consciousness (SMC). We develop our sense of space through moving our body in a tridimensional environment and we attribute meanings to it through bodily experience. Dance is a communicative act based on body movements that is thought to strengthen the connection between spatial, emotional, and conceptual dimensions. In the current study, we explored the differences in bodily awareness, direction-concepts associations, and spatial affordances between dancers (N = 25) and non-dancers (N = 26). Dancers showed greater attentional, emotional, and awareness-related aspects of interoceptive sensitivity. The spatial representations of concepts were explored through associations of SMC derived concepts with cardinal directions. Both groups provided similar robust direction-concept associations for what concern *forward-future*, *backward-past*, *up-spirit/positive emotion*, while a clear difference emerged as non-dancers predominantly associated *down* with *negative emotion* while dancers associated it with both *negative emotions* and *body*. Finally, we asked participants to rate different rooms with varying levels of crowdedness (number of furniture) on different movement-related dimensions and pleasantness. We found that the practice of dance was associated with greater scores in pleasantness of rooms and ease of imaging a choreography, both regardless the crowdedness of the room, but it did not affect the ability to imaging moving in the rooms. Results indicate that practice of a body-centered activity like dance can affect different experiential domains related to bodily awareness, space-concepts associations and some aspects of spatial perception.

IMMERSION IN OVO PERCEPTUAL DEPRIVATION CHAMBER ALLOWS EMERSION OF ABSTRACT MEANINGS: ERP EVIDENCE FROM ABSTRACT AND CONCRETE SPOKEN WORDS PROCESSING

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Abstract

Abstract and Concrete concepts (AC and CC) are thought to be processed differently according to their different underlying experiences. While CC are thought to be mostly experienced through their “external” sensorimotor components, AC are experienced through “internal” experiences in terms of linguistic, emotional, and interoceptive dimensions. At the electrophysiological level, CC have been observed to elicit stronger N400 and N700 compared to AC (concreteness effect), with the N400 being associated with integration of sensorimotor features and the N700 to long-term memory retrieval and imagery processes. We hypothesized that being immersed in a specifically-structured perceptual deprivation OVO chamber would increase saliency of internal states and suppress external sensory inputs, resulting in aa reduced concreteness effect on N400 and N700 in the OVO when compared to a control white room. This reduction would reflect an increased saliency of internal states that would facilitate the processing of AC. To address this hypothesis, 20 participants volunteered to the study. EEG activity was recorded during the performance of a lexical decision task adopting 32 meaningful words (nogo trial; ~75%; 16 abstract, 16 concrete) and 4 pseudowords (go trial; ~15%) in two environmental conditions: the OVO perceptual deprivation room and a white squared room. We found that the typical concreteness effect was found in the white room in the N400 time-window (CC > AC in the frontocentral region), but it disappeared in the OVO chamber. Moreover, we identified a reverse concreteness effect in a late N700-like time-window (AC > CC in the frontocentral region). These results suggest that increasing the saliency of internal states would reduce the integration of sensorimotor components required for CC processing while contextually facilitating retrieval of situated and multisensory experiences associated with AC processing. These results highlight the importance of bodily states during language processing and open new windows on their interplay.

CULTURAL DIFFERENCES IN THE TEMPORAL PERCEPTION OF FACES EXPRESSING EMOTIONS

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Abstract

The aim of the present study was to investigate the influence of facial emotions and cultural differences in the perception of the duration of stimuli marking 0.4- to 1.6-s intervals. The stimuli were female and male faces from three different groups (Black, White, and Latino/a people) expressing joy, anger, or no emotion. There were 20 participants in each of the four groups, coming from either: 1) North America, 2) Latin America, 3) Central, North, or West Africa, and 4) Western Europe. The results reveal that participants from Latin America estimate that the presentation of faces is long more often than participants from all other cultural groups in the study. Moreover, Latin Americans responded "long" more often when a male face was presented compared to a female face. Finally, the results also indicate that participants respond "long" more often when joy is expressed by a male face than by a female face, no matter the cultural group.

The aim of the present study is to test whether cultural origin will influence judgments about duration during the presentation of faces expressing emotions. The impact on perceived duration will be tested with faces expressing anger and joy, two emotions reported to lead to an overestimation of time (Droit-Volet et al., 2004; Effron et al., 2006; Grondin et al., 2015; Tipples, 2008). We posit that faces expressing anger and joy will be more often judged long than faces with a neutral expression.

We know that the race (Black or White) of the people whose faces are being presented can affect perceived duration (Moskovitz et al., 2017). We would like to know if the cultural origin of the observers will also have an impact on the perceived duration of the presented photos. Participants from countries of Western Europe and North America, who are characterized by a faster pace of life and a higher importance given to punctuality (Levine, 2008), are expected to overestimate time more than participants from Central, North and West Africa, and South and Central America.

Method

Participants

Eighty participants aged between 18 and 55 years old were recruited and assigned into one of four groups according to the geographic region they are from (see Table 1). They were residents of Quebec, able to speak English or French, and had no uncorrected visual or cognitive impairments. For each geographic region, two or three countries were targeted, as was the case in Levine's study (2008). The countries chosen within a group shared similar characteristics regarding the pace of life of the habitants, the economic level, and the type of society (individualist or collectivist).

For the recruitment of participants, associations of foreign students from Université Laval (UL) were contacted to invite their members to be part of the study. The language school of UL authorized the research team to invite foreign students of government programs in francization or French courses offered by UL. Finally, an announcement of recruitment was shared by the organisation Quebec International for its employees in Quebec City.

Table 1.
Distribution of participants into the four different groups

Group 1	Group 2	Group 3	Group 4
10 women and 10 men from North America.	11 women and 9 men from Latin America.	15 women and 5 men from Central, North, and West Africa.	12 women and 8 men from Western Europe.
	Countries		
Canada and the United States.	Brazil, Colombia, Ecuador, and Mexico.	Cameroon, Ivory Coast, Mali, and Tunisia	France, Germany, and Switzerland.

Material

The study was carried out in a room free from any visual or auditory distraction at UL. The room was dimly lit by a small desk lamp so that participants could clearly see the computer screen. The E-Prime 3.0 software was used to present the stimuli and record the participant's responses. The experiment was under control of a Fractal Design computer with a diagonal 25-inch Alienware screen with a 240-Hz refresh cycle.

Images were used as visual stimuli to delineate the different durations in the temporal bisection task. The images were female and male faces from three different racial groups, Black, White and Latino/a. The faces, obtained from the Montreal Set of Facial Displays of Emotion (MSFEDE: Beaupré et al., 2000), expressed either joy, anger, or were neutral (no emotional expression).

Task

This study consisted of an experimental session of 45 minutes. During the session, participants did a temporal bisection task and, before performing the task, participants were informed that they should not use any counting strategy during the experiment. At the beginning of the temporal bisection task, a neutral face of a woman was presented 10 times for 400 ms (shortest stimulus) and then 10 times for 1600 ms (longest stimulus); these stimuli were the standard intervals. There was a 500-ms delay between each presentation.

The participants were conducted into four experimental blocks of 126 trials each, for a total of 504 trials in a session. Before each block, the standard intervals were presented only once. On each trial, participants saw images of faces expressing either joy, anger, or no emotion for 400, 600, 800, 1000, 1200, 1400, or 1600 ms. Immediately after each presentation, they had to report whether the duration of the image presentation was closer to the short (400 ms) or to the long standard (1600 ms) by pressing the "1" or "3" keys, respectively.

The pictures also showed female and male faces from three different racial groups: Black, White, and Latino/a. Within each block, there were four repetitions of each of the 2 sexes presented× 3 types of emotions presented × 3 racial groups presented × 7 comparison intervals. Emotion, comparison intervals, and sex represented in the images was counterbalanced for each racial group within each block.

Results

For each experimental condition, an individual 7-point psychometric function was drawn, plotting the probability of responding long on the *y* axis as a function of the comparison intervals on the *x* axis (Grondin, 2008). The cumulative normal distribution was fitted to the resulting curves. The dependent variable of interest was the point of subjective equality (PSE). The PSE can be defined as the *x* value corresponding to the 0.50 probability of "longer" responses on the *y*-axis. The smaller a PSE is, the more often the duration is perceived to be longer.

A 2 (sex presented) × 3 (racial group presented) × 3 (emotion presented) × 4 (cultural origin of the participant) ANOVA with repeated measures on the first 3 factors was conducted on the point of subjective equality (PSE). Post hoc analyses were conducted with a series of one-way ANOVAs and single-effect analyses with Bonferroni corrections. Also, for each individual psychometric function in each experimental condition, the goodness-of-fit was assessed, with R^2 values above 0.90 for 70% of the conditions and the smallest value being $R^2 = 0.57$.

Repeated-measures ANOVA on the PSE results showed that participants were significantly more likely to have a PSE smaller than the mean time interval when male faces were presented than when female faces were presented, $F(1, 76) = 3.98$, $p = 0.05$, $\eta^2_p = 0.05$. There was also a significant cultural group effect (see Figure 1), $F(3, 76) = 5.68$, $p = 0.001$, $\eta^2_p = 0.183$. Latin Americans responded much more often "long" in comparison with other cultural origins. The other two main effects, emotions and racial group were not significant ($p > .18$).

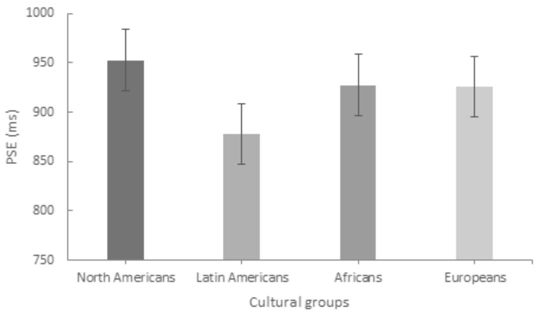

Fig. 1. Mean point of subjective equality (PSE) in each cultural group. Error bars represent 95% confidence intervals.

There was a significant Sex of faces × Emotion interaction, $F(2, 152) = 5.460$, $p = 0.005$, $\eta^2_p = 0.067$. There is a significant difference between male and female faces when joy is presented ($p = 0.05$), but not when anger ($p = 0.55$) or a neutral expression ($p = 0.10$) are presented (Figure 2). When a male face expressing joy was presented, participants were more likely to respond long ($M = 902$ ms) than when it was a female face expressing joy ($M = 930$ ms).

A repeated-measures ANOVA on the PSE results also showed a significant interaction between the Sex of faces × Cultural origin $F(3, 76) = 4.459$, $p = 0.006$, $\eta^2_p = 0.150$. It is important to note the marginally significant interaction of Sex of faces × Cultural origin × Racial group of the images, $F(6, 152) = 2.090$, $p = 0.057$, $\eta^2_p = 0.075$. Other interaction effects: $p > .159$.

There is a significant difference between the sex of faces when the participants are Latino Americans ($p < 0.001$). However, when the participants are North Americans ($p = 0.42$), Central, North or West Africans ($p = 0.70$), or Western Europeans ($p = 0.22$), there is not a significant difference. As illustrated in Figure 3, when a male face was presented to Latin American participants, they were significantly more likely to respond long (*M* = 837 ms) than when a female face (*M* = 919 ms) was presented.

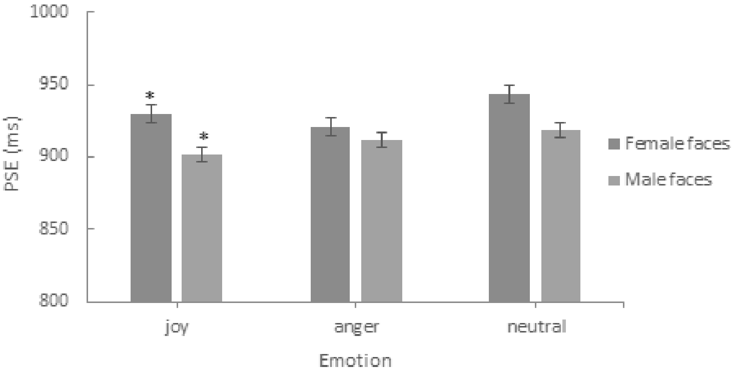

Fig. 2. Mean PSE for each emotion when female and male faces are presented. Error bars represent the standard error between groups; *$*p \leq 0.05$.*

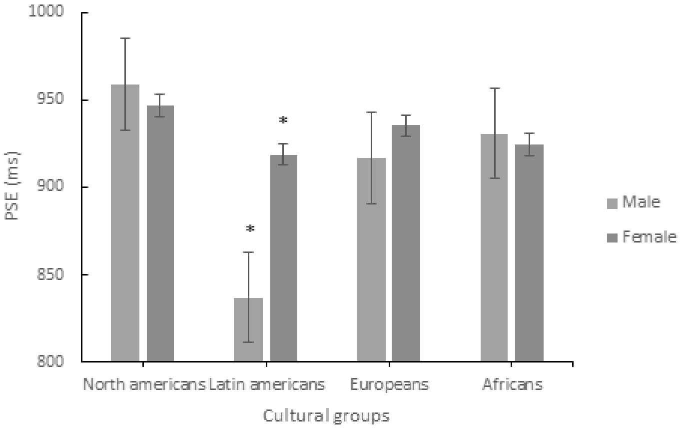

Fig. 3. Mean point of subjective equality (PSE) for each cultural group of participants as a function of the sex of faces. Error bars represent the standard error between groups, *$p < 0.001$.

Discussion

The main objective of the study was to compare the effect on interval discrimination of the presentation of emotional (joy and anger) and neutral faces, in accordance with the cultural origin of the participants. There were significant effects for the cultural group of participants and for the sex of the faces, and also significant interactions between the sex of the faces and the cultural origin of participants, and between the sex of the faces and the emotions expressed by the faces.

Two hypotheses were considered: the intervals delimited by faces expressing anger and joy should be overestimated compared to those delimited by neutral faces, and participants coming from the countries of Western Europe and North America should overestimate time more than participants from Africa and Latin America. As for the first hypothesis, participants tended to respond short more often when neutral expressions were presented, but the main effect of Emotion was not significant. However, the emotion interacted with the sex of the faces presented. Faces expressing joy were reported to be long more often when a male face was presented than when a female face was presented. There was no such sex difference with angry faces.

The results concerning the sex of the presented faces exhibit a significant probability to respond long more often when observing male faces than female ones. These results are consistent with those reported by Mioni et al., (2018) who found that presenting words with a male voice led to an overestimation of the duration, compared to presenting words with a female voice. There is a statistically significant interaction between the sex of faces and the cultural origin of the participant in the present study. When the image showed a male face, Latin Americans were significantly more likely to overestimate time in comparison to the other groups. Moreover, there was a significant difference in the PSE between images of female and male faces expressing joy. Latin Americans were significantly more likely to overestimate time when the male face expressing joy was presented. This result is in accordance with the literature, where it is mentioned that faces expressing anger and joy should be overestimated compared to those delimited by neutral faces (Droit-Volet et al., 2004; Effron et al., 2006; Tipples, 2008). However, a significant statistical difference was not found for angry faces. A tentative explanation may be that the effect of the angry faces was not strong enough to find a main effect because of the different cultural interpretations given to angry images. In fact, as the images had three different racial groups that would not always correspond with the cultural origin of the participant, cultures can differ in the contents of their meaning and information systems. Therefore, some aspects of anger expressions are not recognized the same way because they are culturally influenced (Matsumoto et al., 2010). No studies that could explain the interaction between the sex and the emotions were found. Yet, as mentioned earlier, with a male voice stimulus, an overestimation of the duration was observed, compared to words presented with a female voice (Mioni et al., 2018).

It is also possible that the neutral images were considered as angry faces for some participants. That would explain, in part, why no difference was found between joy, anger, and neutral emotions. Indeed, it seems that to consider a male face as being neutral, the facial expression must be closer to joy than anger (Harris et al., 2016). In the present study, neutral faces could have been closer to angry faces than joyful expressions.

Concerning the second hypothesis, the four cultural origin groups responded long more often than short, but it was the Latin Americans who overestimated duration the most often. This finding is surprising given the existing literature on psychological time. Matsumoto (1991) reports that members of cultures in which collectivism prevails, as is the case for Latin Americans, can express their emotions easily with people from their closest environment and create a strong link with members from their own culture. Crowne and Marlowe (1960) suggest that people tend to answer to situations according to the socially desirable answers expected by their cultures. When a situation activates cultural perceptions of desirability or undesirability, the behavior of the person can be affected. For every Latin American participant, the main researcher, being from the same cultural background, explained the experiment instructions in Spanish; there was likely a different interaction between Latin American participants and the main researcher compared to participants from other backgrounds. Latin American participants may have invested themselves more into the task out of desirability, which would change their perception of the task in general. So, participants would be more concerned about time (more attention invested in the task) due to a stronger feeling of affiliation with the main researcher (Johnson & Van de Vijver, 2003). This stronger feeling of affiliation from Latin American participants may have induced more concerns about their performance in the task (Crowne & Marlowe, 1960). These concerns may have caused a state of greater arousal for Latin American participants than for participants from the other groups. It is this higher arousal that may have led to more long responses.

Another possible explanation is that time judgments from Latin American participants were closer to the geometric mean of the standard intervals (800 ms) than the other cultural groups, who were closer to the arithmetic mean (1000 ms). Their higher tendency to respond long would then be caused by a different representation of the standards. This could be interpreted as a bias for Latin Americans in this study. As observed by Kopec and Brody (2010), the larger the span between interval (long standard/short standard) between reference durations, the higher was the tendency of the subjects to bisect near the arithmetic mean. Under a ratio of 1:2 (ex.: 400 and 800 ms) between reference intervals, subjects tended to bisect near the geometric mean. In this study, Latin Americans seem to have a representation of a smaller span between the reference intervals than the other groups. They would thus tend to bisect near the geometric mean and respond "long" more often, considering that the geometric mean is smaller than the arithmetic mean.

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ROTATIONAL MOTION AFTEREFFECT INDUCED BY ILLUSORY ROTATION OF A SQUARE: EFFECT OF TEST STIMULUS SHAPE

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Abstract

After viewing a moving stimulus in one direction (adaptation stimulus), an observer perceives a stationary stimulus (test stimulus) as moving in the opposite direction to the motion of the adaptation stimulus. This phenomenon is known as the “motion aftereffect” (MAE). Research has reported that static Gabor patches arranged to form a square, for which the carrier drifts horizontally or vertically at different speeds, give rise to the perception of a rotating square. Using this illusory rotation of a square as an adaptation stimulus, we previously reported the rotational MAE of the test stimulus (i.e., solid black square). The main purpose of the current study was to reinforce the previous findings by manipulating the shapes of the test stimulus. In two experiments, participants viewed Gabor patches forming a square (except for the vertices) for 30 seconds, followed by the presentation of the test stimulus. The test stimulus was a solid black square, octagon (Experiment 1), or hexagon (Experiment 2). We manipulated the position of the vertex of the test stimulus in such a way that some of its edges were far from the adapted area in the adaptation stimulus. The participants pressed and held a button whenever they perceived the rotational MAE of the test stimulus. The results of Experiments 1 and 2 showed that the duration of the rotational MAE became shorter, as the edge of the test stimulus was farther from the adapted area by Gabor patches in the adaptation stimulus. We will discuss the present results in the context of the neural mechanisms of motion processing.

PHONEMIC RESTORATION AND ENERGETIC MASKING WITH CHECKERBOARD SPEECH STIMULI: EFFECTS OF NOISE-FILLING ON INTELLIGIBILITY

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Abstract

To explore how listeners integrate spectrotemporally scattered speech cues, the intelligibility of checkerboard speech stimuli (interrupted periodically in frequency and time) has been investigated. Although both checkerboard speech stimuli and temporally interrupted speech stimuli consist of half of the original speech signal, it has been shown that their intelligibility differs significantly. On the other hand, whereas the intelligibility of temporally interrupted speech stimuli improves by filling the silent gaps with strong noise, the effects of noise-filling on the intelligibility of checkerboard speech stimuli have been largely unknown. Here we show noise-filling resulted in both gains and losses in the intelligibility of checkerboard speech stimuli, depending on the combination of the number of frequency bands and segment duration ($N = 20$). The effects of noise levels also depended on the combination. The intelligibility of 2- and 4-band checkerboard speech stimuli generally improved by noise-filling, irrespective of noise levels. The maximum intelligibility improvement of 40% was observed with noise-filling of -6 dB at the 80-ms segment duration. By contrast, noise-filling tended to reduce the intelligibility of 8- and 16-band checkerboard speech stimuli. The largest intelligibility reduction, 70%, was observed at the 80-ms segment duration with the 6-dB noise-filling. The results suggest that noise-filling induces both energetic masking and phonemic restoration; their balance may determine the intelligibility for checkerboard speech stimuli.

TEMPORAL PROXIMITY BETWEEN SOUND EDGES IS VITAL FOR THE GAP TRANSFER ILLUSION

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Abstract

The gap transfer illusion is an auditory illusion in which a temporal gap in the middle of a longer tone glide is perceived as if it were in a physically continuous shorter glide crossing at the center of this gap. A typical stimulus in which two glides of 5 and 0.5 s and the same slope of ~0.8 oct/s cross one another was taken up as an archetype to cause this illusion. It was examined whether lengthening the distance between the gap and the onset and offset of the shorter glide in time and/or in frequency would hamper the occurrence of the illusion. Lengthening the distance in time suppressed the illusion: It turned out that the onset-offset proximity in time is vital for the occurrence of the illusion. This presentation is based on three psychophysical experiments in which 33 participants in a combined total judged whether each stimulus was perceived as a crossing or bouncing pattern, and subsequently rated the continuity/discontinuity of each trajectory in the percept. The gap transfer illusion in the present paradigm was explained quite well by assuming that the onset of a glide and the offset, after that, of another glide are connected perceptually in a compelling manner if they are within a temporal proximity of ~0.2 s. The implication of the data is examined in this presentation with demonstrations of a few stimuli.

The gap transfer illusion gives us insight into the perceptual mechanism of auditory event formation (Nakajima et al., 2000; Kanafuka et al., 2007). In a typical stimulus, a longer ascending/descending tone glide of 1.5-5 s and a shorter descending/ascending glide shorter than 1 s cross one another at their central points in time. The longer glide has a temporal gap of 0.02-0.25 s—mostly 0.1 s—at the crossing point, and the shorter glide is continuous. The gap is stably perceived as if it were in the shorter glide and not in the longer glide, if the stimulus condition is selected properly.

Nakajima et al. (2022) conducted three psychophysical experiments, and some of their stimuli will be played in this presentation in order to examine the reliability and implication of their findings. Demo 1, which is based on one of Kanafuka et al.'s (2007) stimuli, indicates the archetype stimulus that should stably cause the gap transfer illusion. Demo 1a is a longer descending glide of 5 s from 3981.1 to 251.2 Hz with a slope (speed) of ~0.8 oct/s (exactly 0.24 1/s on the common logarithmic scale of frequency), and it has a 0.1-s gap in its temporal middle. All rise and fall times on temporal edges are 0.02 s and cosine-shaped in this presentation. Demo 1b is a shorter ascending glide of 0.5 s with the same slope from 871.0 to 1148.2 Hz, and it is continuous. These glides cross one another in Demo 1c at their central points in time (Figure 1, left). If this stimulus is presented, the gap in the longer glide now transfers to the shorter glide perceptually, that is, the gap transfer illusion takes place (Figure 1, right).

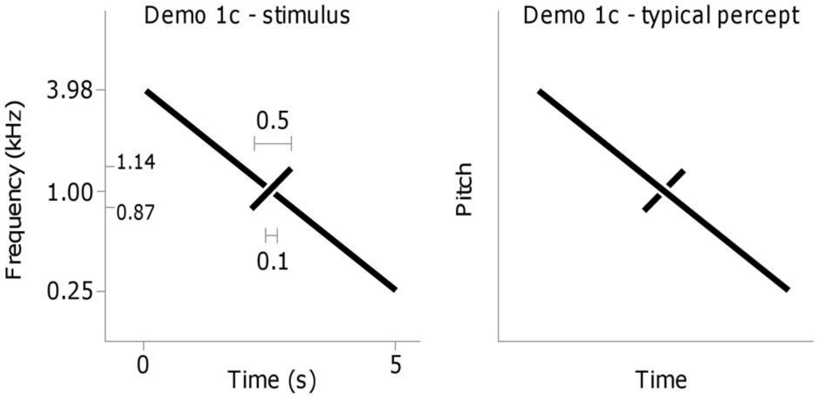

Figure 1. Schematic depiction of a gap transfer stimulus (Demo 1c, left) and the typical gap transfer percept (right)

How Auditory Grammar works

Nakajima et al. (2014) proposed a theoretical framework called *Auditory Grammar* to explain the gap transfer illusion and other related auditory phenomena. According to their heuristic model, an auditory stream is a linear concatenation of perceptual elements, *auditory subevents*, which are often smaller than auditory events. It is widely accepted, as a rough description of auditory organization, that a linear concatenation of auditory events makes an auditory stream (Handel, 1989; Bregman, 1990), and our model modifies this idea that there can be silences as perceptual elements between auditory events, and that an auditory event can be divided into two or three auditory subevents. The following types of auditory subevents appear in Auditory Grammar: *onsets*, *offsets*, *fillings*, and *silences*.

In Demo 1c, the onset of the shorter glide and the offset of the first portion of the longer glide to begin the gap are close to one another in time and in frequency, and thus they are likely to be connected to one another obeying the proximity principle, one of the gestalt principles. Since there is sound energy distribution between the onset and the offset that can work as a filling between them, the auditory system can construct an auditory event as ‘onset, filling, offset’, which should be followed immediately by a silence in Auditory Grammar—the other grammatical patterns of auditory events are ‘onset, filling’ followed by another onset, and ‘onset’ followed by a silence. Since the onset and the offset belong to different physical glides, this auditory event does not correspond to a physical tone—it is illusory. The onset of the second portion of the longer glide and the offset of the shorter glide are also close to one another in time and in frequency, and they make another illusory auditory event. The offset of the first portion and the onset of the second portion of the longer glide are also close to one another, but they do not make an auditory event, because an auditory event beginning with an offset would be ungrammatical.

In Demo 2, the above proximity in time and in frequency is loosened. Demo 2a is the same descending glide as Demo 1a. Demo 2b is a continuously ascending shorter glide. It is longer in time than the glide in Demo 1b, and the slope remains the same: It covers 1.5 s from 660.7 to 1513.6 Hz. In Demo 2c (Figure 2, left), in which these glides cross one another, the gap transfer illusion is almost lost. The crossing percept is not dominant, and the gap is not as clear as in Demo 1c if it is perceived at all. Given that the gap transfer illusion occurs in Demo 1c, but disappears in Demo 2c, it is clear that the proximity between an onset and an offset works to connect these sound edges perceptually to construct an auditory event. From Demos

1c and 2c, however, we are not able to determine whether the proximity in time, in frequency, or both is important.

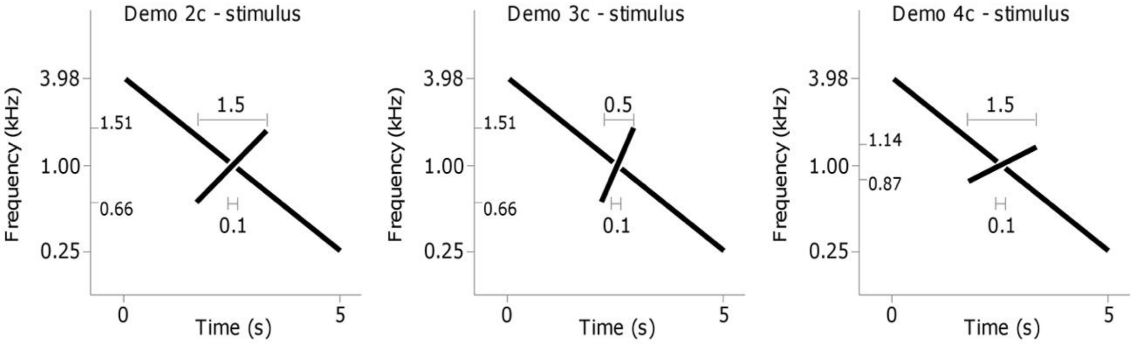

Figure 2. Schematic depiction of Demo 2c (left), Demo 3c (middle), and Demo 4c (right). Typical gap transfer is perceived only when listening to Demo 3c.

Proximity in time, in frequency, or both?

We can modify Demo 2c so that the shorter glide is as short as in Demo 1c in time—0.5 s—again, while keeping the frequency range as is covered in Demo 2c—from 660.7 to 1513.6 Hz. The sounds can be heard in Demo 3. The longer glide, Demo 3a, and the shorter glide, Demo 3b, are put together in Demo 3c (Figure 2, middle), and now the gap transfer illusion takes place stably. Although temporal proximity and frequency proximity were not distinguished in Nakajima et al.'s (2014) explanation of the illusion, it has been indicated that the *temporal* proximity is exclusively important for the occurrence of the illusion.

For a more solid argument, we can make another variation of Demo 2, in which the duration of the shorter glide was kept at 1.5 s, but its frequency range is reduced to the same range as in Demo 1c—from 871.0 to 1148.2 Hz. The longer glide, Demo 4a, and the shorter glide, Demo 4b, are put together in Demo 4c (Figure 2, right). No illusion takes place.

About the illusory continuity of the longer glide

In Demo 1c, the longer glide, which is physically discontinuous, is perceived as continuous, and this is a part of the illusion. This is often considered a kind of illusory auditory continuity in which a gap is restored with peripheral excitation of the auditory system caused by sound energy of a different sound (as described in Bregman, 1990). We are not inclined to take this view at the present stage because the gap transfer illusion can take place even when the level of the shorter glide is 9 dB below the level of the longer glide (Kuroda et al., 2010).

In the context of Auditory Grammar, we assume that an onset cue or an offset cue is interpreted by the auditory system just once if there is no particular reason to interpret it twice or more. What we called onsets and offsets of stimulus sounds so far should be called onset cues or offset cues in exact terminology because an onset or an offset can be determined only with a sound it belongs to, and to define a sound is ultimately a perceptual issue. The gap transfer illusion seems to be caused by the inclination of the auditory system to interpret all clear subevent cues to construct a grammatical auditory stream or streams, but only once.

Proximity in time before or after the gap

Keeping the duration (1.5 s), the slope (~0.8 oct) of the shorter glide, as well as the crossing frequency (1000 Hz) as in Demo 2c, the shorter glide is shifted backward/forward by 0.5 s in Demo 5/6. The temporal proximity of ~0.2 s after/before the gap is kept as in Demo 1c. The longer glide, Demo 5a/6a, and the shorter glide, Demo 5b/6b, are put together in Demo 5c/6c (Figure 3). The crossing percept is not dominant, but once it appears, the shorter glide is more likely to be perceived with a gap: The gap transfer illusion in a weaker sense takes place. The fact that the shorter glide is as long as 1.5 s as in Demo 2c does not necessarily suppress the occurrence of the illusion.

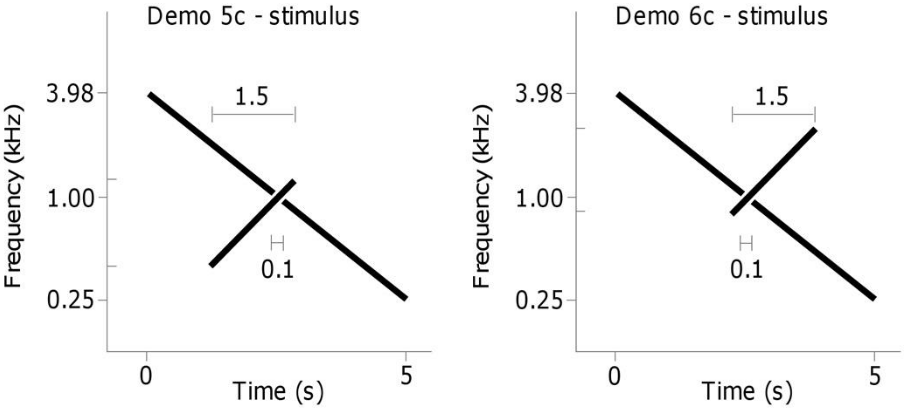

Figure 3. Schematic depiction of Demo 5c (left) and Demo 6c (right). The stimuli are often not heard as crossing, but when crossing takes place, the gap is typically perceived in the shorter glide.

In the context of Auditory Grammar, the proximity in time either before or after the gap should facilitate the construction of a short tone there by combining the proximate onset and offset (Nakajima et al., 2014; see also Remijn & Nakajima, 2005). Once crossing is perceived, the shorter glide as an auditory stream should include this illusorily constructed short tone before or after the gap; the shorter glide cannot be a single continuous tone. This explains the illusion. However, we need further research on how the crossing percept appears, including the phenomenological nature of the discontinuity.

Conclusions

By assuming that an onset and an offset within a temporal proximity of ~0.2 s are connected to one another in a compelling manner if there is a sound energy distribution to be interpreted as a filling between them, we are able to understand the perception of acoustic patterns related to the gap transfer illusion. The proximity range to cause such compelling perceptual connection should be investigated in different conditions. The present experiments and demonstrations leave it open whether such onset-offset connection is facilitated when the temporal proximity is between ~0.2 and ~0.7 s. (The audience is invited to share the audio files used in this presentation.)

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Gert ten Hoopen, Takayuki Sasaki, and Kazuo Ueda worked with us for a long time to construct the present theoretical framework. Shunsuke Tanaka and Tsuyoshi Kuroda gave us important suggestions. We thank all of them as well as our students who worked for this topic with us.

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HOW IS A TEMPORAL GAP IN A LONGER GLIDE PERCEIVED IF A LONGER AND A SHORTER TONE GLIDE CROSSING ONE ANOTHER ARE HEARD AS TWO BOUNCING TRAJECTORIES?

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Abstract

A specific aspect of one of Nakajima et al.'s (2023) experiments (Experiment 3) was analyzed. The experiment was originally designed in order to elaborate our explanation (Nakajima et al., 2014) of the gap transfer illusion, which takes place when a longer tone glide with a temporal gap and a shorter glide without a gap cross one another. In this experiment, a longer glide of 5 s and a shorter glide of 0.5-1.5 s crossed one another. We only took up the conditions in which the longer glide had a 0.1-s gap in the temporal middle, while leaving the shorter glide continuous. The shorter glide passed through the temporal center of this gap at 1000 Hz in such a way that one or both of the overlaps of these glides, before and after the gap, were as short as 0.2 s. The slope of the longer glide was ~0.8 oct/s, and that of the shorter glide was varied from ~0.27-~2.39 oct/s. The present analysis focused on the "bouncing percept" often heard in some of such stimuli, consisting of an ascending-descending lower pitch trajectory and a descending-ascending higher trajectory, occurring at the same time. We were particularly interested in how the physical gap in the longer glide would be interpreted by the auditory system in a bouncing percept.

There were 240 judgments by eight listeners for the above stimulus conditions. Among these judgments, 84 cases indicated perceptual bouncing, and 78 of these cases indicated perfect or partial discontinuity of at least one of the (lower and higher) bouncing trajectories. Mostly, i.e., in 62 cases, discontinuity was perceived only in the *shorter* trajectory. This can be understood by assuming that an onset and an offset within a temporal window of ~0.2 s are connected to one another with high priority. Together with the occurrence of the gap transfer illusion in crossing percepts, the experimental results as a whole indicate that temporal proximity of sound edges plays a vital role in auditory event formation.

Nakajima et al.'s (2023) Figure 3 showing Demos 5c and 6c indicates typical stimulus conditions in which both crossing and bouncing can take place. The gap transfer illusion, in a weaker sense, occurred once crossing took place in such conditions, while the present analysis indicates that the gap is likely to transfer to the shorter trajectory if bouncing takes place. The gap in the long glide of the stimulus is thus likely to transfer to the shorter trajectory, regardless of whether the percept is crossing or bouncing. However, we first have to accumulate more data on the bouncing percept.

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RATIOS VS. INTERVALS: A SCALING LESSON, C/O FAGOT ET AL.

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Abstract

ISP members cite Fagot, Stewart, and Kleinknecht (1975) for their model of sensation ratios as ratios of sensation intervals incorporating judgment-bias parameters. Fagot et al. fit respective equations to subjects' judgments of ratios (or intervals) of the brightness of disks of white light. The fitted judgment-bias parameters show unusual similarities and differences, not acknowledged by Fagot et al. The idiosyncrasies prove to be inherent; the model is circular. Ratios of intervals can only be meaningful (i.e., comparable) when taken from a ratio scale.

Professor R.F. Fagot has contributed often to the theory of scaling. Fagot, Stewart, and Kleinknecht (1975) stands out, offering a novel approach to psychophysical judgments, namely, imagining sensation ratios as sensation intervals. The work is later cited not only by Fagot and colleagues but also by members of the International Society for Psychophysics, amongst others (see Schneider & Bissett, 1988; Schneider & Cohen, 1997; Masin, 2022a, 2022b). Hence, revisiting Fagot et al. (1975) is timely. We examine its three parts: the model, including equations; supporting empirical judgments; and relation of model to data.

Fagot et al. (1975): synopsis of the theory

Modelling interval judgments as "sectioning"

For a true rendition of Fagot et al. (1975), we quote from their text; we also preserve their equation numbers, expediting cross-checking. They introduce their motives and methods, so:

> Empirical studies reveal the presence of systematic errors in ratio estimation judgments, and suggest strongly that the simple model that accepts subjects' responses at face value must be abandoned. One method of accounting for the apparent bias is to introduce additional parameters into the numerical representations… in this paper, a theory based on biased numerical judgments of both ratios and intervals will be considered. In the section on theory, an interval model incorporating a bias parameter is presented. A special feature of this model is that it accounts for both interval and ratio judgments. (Fagot et al., p. 309)

Figure 1 compares a practical interval scale to a practical ratio scale.

Fagot et al. (p. 310) explain their model: "In bisection. the subject is presented with two stimuli, a and b, and his task is to perform an *operation* that produces a stimulus (aob) that bisects the interval between a and b" (original italics). Of course, it is the *sensation interval* (denoted ψ_{a} to ψ_{b}) that the experimental subject bisects. In yet another confusion, Fagot et al. (p. 310) now use "a" to represent "a response bias parameter", in "A numerical representation for bisection",

$$\psi_{\mathrm{aob}} = a\psi_{\mathrm{a}} + (1-a)\psi_{\mathrm{b}}\,, \qquad 0 < a < 1 \quad (1)$$

This representation piques ongoing interest (see Masin & Toffalini, 2009, and citations therein). Perfect bisection, i.e., $\psi_{\mathrm{aob}} = (1/2)(\psi_{\mathrm{a}} + \psi_{\mathrm{b}})$, occurs for $a = 1/2$, *if* $\psi_{\mathrm{a}}, \psi_{\mathrm{b}} > 0$. The latter “if” would seem needless, but, oddly, Fagot et al. only state (p. 310) that sensations ψ are “real-valued”, potentially allowing sub-zero sensations, a puzzling notion.

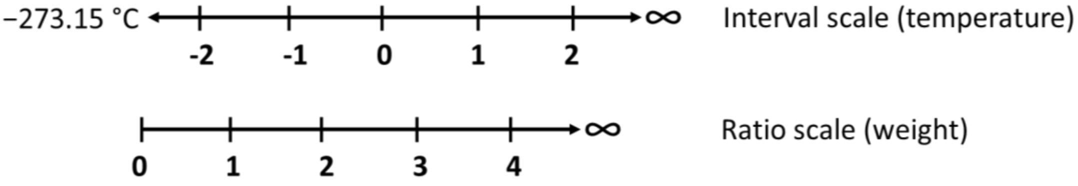

Fig.1. An interval scale vs. a ratio scale. (Upper) An interval scale (degrees Celsius). Equal intervals (e.g., $[1-(-1)]$, $[2-0]$) have equal meaning, but any ratios (i.e., $(-2/1)$, $2/1$, $(2/-1), 1/3$) are not meaningful. (Lower) A ratio scale (weight due to gravitational acceleration of mass). Here, ratios and intervals are both meaningful (see Torgerson, 1960).

Fagot et al. (p. 310) now offer “A generalization of the bisection numerical representation for ϱ-section operations”, for ϱ, “the degree of the sectioning operation”:

$$\psi_{\mathrm{ao}_\varrho\mathrm{b}} = \delta(1-\varrho)\psi_{\mathrm{a}} + [1-\delta(1-\varrho)]\psi_{\mathrm{b}} \quad (2)$$

where $a = \delta(1-\varrho)$ for a bias parameter denoted δ. Fagot et al. (p. 310) elaborate:

> For the ϱ-section operation method, the experimenter fixes ϱ, and the subject’s task would be to perform an operation that produces a stimulus [indexed as] $(\mathrm{ao}_\varrho\mathrm{b})$ that partitions the total [sensation] interval $\psi_{\mathrm{b}} - \psi_{\mathrm{a}}$ into two intervals $\psi_{\mathrm{b}} - \psi_{\mathrm{ao}_\varrho\mathrm{b}}$ and $\psi_{\mathrm{ao}_\varrho\mathrm{b}} - \psi_{\mathrm{a}}$. The constant ϱ is a function of the ratio of the *lower* interval [i.e., $\psi_{\mathrm{ao}_\varrho\mathrm{b}} - \psi_{\mathrm{a}}$] to the total interval (ϱ equals this ratio in the absence of bias). If the smaller interval is taken as a unit, then the larger of the two intervals is equal to $(1-\varrho)/\varrho$. For example, if the experimenter sets $\varrho = 1/3$, the subject produces two intervals such that the smaller interval (which is the bottom interval) is $1/2$ the magnitude of the larger interval and $1/3$ the magnitude of the total interval. (Square-bracketed terms added.)

Fagot et al. equate “lower” to “bottom”. They also use ratios to compare intervals. Figure 2 shows sectioning of an interval. Actual task instructions given to subjects appear farther below.

Sectioning as creating ratios

Fagot et al. (p. 310) operationally distinguish “ratio scaling” from “interval scaling”, viz.: “With numerical response methods [ratio scaling by magnitude estimation], the subject does not perform an operation [of ϱ-sectioning an interval $\psi_{\mathrm{b}} - \psi_{\mathrm{a}}$], but instead assigns a number directly to a stimulus” (square-bracketed terms added). Fagot et al. (p. 310) return to intervals, to quantify ϱ:

> Let $\phi_i < \phi_j < \phi_k$ be physical scale values for three stimuli with corresponding psychological scale values $\psi_i < \psi_j < \psi_k$; and let ϱ_{ijk} denote the subject's theoretical numerical response. Then solving Equation 2 for ϱ and making the appropriate notational changes results in
>
> $$\varrho_{ijk} = \frac{1}{\delta}\left(\frac{\psi_j - \psi_i}{\psi_k - \psi_i}\right) + \left(1 - \frac{1}{\delta}\right) \quad (3)$$

Fagot et al. omit some steps. Note first that ϱ_{ijk} is "the degree of the sectioning operation", e.g., $1/2$ or $1/3$, which is the ratio of the bottom interval to the total interval, given $\phi_i < \phi_j < \phi_k$. In "For the ϱ-section operation method" (above), $\psi_j - \psi_i$ is the bottom interval in the range ψ_i to ψ_k. Finally, in Eq. (2), substitute $\psi_j = \psi_{ao_\varrho b}$, $\psi_i = \psi_a$, $\psi_k = \psi_b$, and $\varrho = \varrho_{ijk}$.

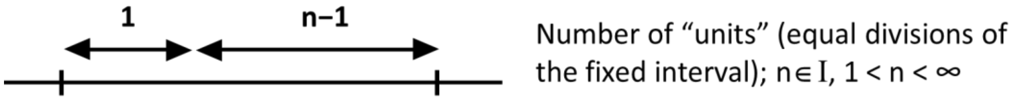

Fig.2. Sectioning the interval, in the absence of bias (i.e., $\delta = 1$; see text). Here, we let $\varrho = 1/\mathrm{n}$, so that $[(1-\varrho)/\varrho] = \mathrm{n} - 1$. For bisection, $\mathrm{n} = 2$; for trisection, $\mathrm{n} = 3$; etc.

Fagot et al. (p. 310) now join practice to theory: "In an appropriate scaling experiment, the subject's task would be to rate the middle stimulus (ψ_j) relative to the two standards (ψ_i and ψ_k)". To understand "rate", note that the experimenter sets ϕ_i, ϕ_j, and ϕ_k, and that "the subject would report an estimate – denoted r_{ijk} – of the ratio of the lower interval to the total interval: i.e., an estimate of ϱ_{ijk}" (Fagot et al., p. 310). Once again, *sectioning an interval* provides a ratio. Fagot et al. (p. 310) explain that "Given estimates of ϱ_{ijk} based on the observations r_{ijk}, the scale values and the parameter δ would be estimated". The scale values are ψ_i, ψ_j, and ψ_k.

Judged ratios as judged intervals

Fagot et al. (p. 310) now interpret classic Stevensian ratio judgments, viz.:

> A numerical representation for ratio judgments (i.e., ratios of magnitudes). in which the subject's responses are taken at face value (assumed to be unbiased), is given by Equation 5:
>
> $$\varrho_{ij} = \frac{\psi_i}{\psi_j} \quad (5)$$
>
> … In ratio estimation experiments, ψ_i (the comparison or variable stimulus) and ψ_j (the standard stimulus) would be the presentation pair. ϱ_{ij} would be a theoretical numerical response, and r_{ij} would denote the subject's estimate of ϱ_{ij}.

This is textbook material. But Fagot et al. (p. 310) innovate: "The numerical representation for the interval model (Equation 3) can be applied to ratio judgments by assuming that ψ_i partitions the interval between the *threshold* t and ψ_j into two intervals, $\psi_j - \psi_i$ and $\psi_i - \psi_t = \psi_i$ (since $\psi_t = 0$), and hence that a ratio judgment can be interpreted as an interval judgment" (original italics). Again: *a ratio judgment can be interpreted as an interval judgment*. Note that $\psi_t = 0$ is an *assumption*; the literature has implied for some time that $\psi_t \neq 0$ (reviewed in Nizami, 2011, 2015, 2020). Regardless, sensation ψ_i is no longer the lower limit of the interval of Eq. (3); now it is in the middle, emulating the term formerly denoted ψ_j. Also, the bottom of the interval is now $\psi_t = 0$. Effectively, Fagot et al. rewrite Eq. (3), redesignating ψ_i as ψ_t, ψ_j as ψ_i, and ψ_k as ψ_j. Then, "By application of Equation 3 to ratio judgments" (Fagot et al., p. 310),

$$\varrho_{ij} = \frac{1}{\delta_R}\frac{\psi_i}{\psi_j} + \left(1 - \frac{1}{\delta_R}\right) \quad (6)$$

Here δ_R replaces δ, because "the bias is not necessarily the same for a presentation pair (ratio task) as for a presentation triple (interval task)" (Fagot et al., p. 310). Further (p. 310):

> A numerical representation for the ratio bias mode, the multiplicative ratio model – MR model – is given by
>
> $$\varrho_{ij} = \beta\frac{\psi_i}{\psi_j} \quad (8)$$
>
> In the absence of bias, $\beta = \delta_R = 1$, and the representations given by Equations 6 and 8 reduce to the C [= *classical*] model (Equation 5)." (Square-bracketed term added.)

Otherwise, β need not equal δ_R or $1/\delta_R$. No bounds are given for β, δ_R, ϱ, or δ; but $0 < a < 1$ and $a = \delta(1 - \varrho)$ (above). The bounds $0 < \varrho_{ijk}, \varrho_{ij} < 1$ are implied. Thus, $0 < \delta, \delta_R, \beta < 1$.

Fagot et al. (1975): synopsis of the experiments and the relevant data analysis

Fagot et al. (1975) collect empirical judgments to compare to their model. The stimuli are equal-sized disks of white light, arrayed horizontally, viewed by dark-adapted subjects. Three discs are used for interval judgments, two for ratio judgments. Subjects are told:

> (Interval task) The light on the left will always be the dimmest of the three, the light on the extreme right will always be the brightest of the three, and the middle light will be intermediate in brightness, so the three lights will increase in brightness from left to right. You will be asked to make your judgments in terms of intervals of brightness, by rating the middle light as a percentage of the distance in brightness between the two outer stimuli. (Fagot et al., p. 312)
>
> (Ratio task) You will be presented with two lights which will vary from trial to trial. The light on the right will always be the brighter of the two, and will be called the standard. Your task will be to judge the brightness of the dimmer light on the left in relation to the standard … You should report the brightness of the dim light as a percentage of the brightness of the standard. … you may use any percent greater than 0 and less than 100 … (Fagot et al., p. 312)

This ratio task is not quite Stevensian magnitude estimation; the scale is capped, all judgments being less than 100 (actually used by Ekman et al., 1968).

Fagot et al. (p. 314) analyze their data, viz.: “Each of the three bias models [Eqs. (3), (6), and (8)] was compared with its appropriate no-bias model to test for possible significant improvement in fit due to the addition of the appropriate bias parameter” (square-bracketed term added). That is, for subjects’ empirical responses r_{ijk} (interval task) or r_{ij} (ratio task), Fagot et al. minimize:

$$\sum_{i,j,k}\left[r_{\mathrm{ijk}} - \varrho_{\mathrm{ijk}}\left(\psi_{\mathrm{i}},\psi_{\mathrm{j}},\psi_{\mathrm{k}},\delta\right)\right]^2 \quad \mathit{where}\ \varrho_{\mathrm{ijk}}\left(\psi_{\mathrm{i}},\psi_{\mathrm{j}},\psi_{\mathrm{k}},\delta\right)\ \mathit{is\ given\ by\ Eq.}(3)$$

$$\mathit{or} \quad \sum_{i,j}\left[r_{\mathrm{ij}} - \varrho_{\mathrm{ij}}\left(\psi_{\mathrm{i}},\psi_{\mathrm{j}},\delta_{\mathrm{R}}\right)\right]^2 \quad \mathit{where}\ \varrho_{ij}\left(\psi_i,\psi_j,\delta_R\right)\ \mathit{is\ given\ by\ Eq.}(6)$$

subject-by-subject for two sets of regressions, one in which δ and δ_R are set equal to 1, and one in which they vary. Regressions were also done for Eq. (8) in place of Eq. (6), exchanging β for δ_{R}. Each subject who judged intervals yielded 180 r_{ijk} values to fit, and each subject who judged ratios yielded 135 r_{ij} values to fit, populations sufficient for robust fits to Eq. (3) (four unknowns for each ϱ_{ijk}: one free parameter δ, and three variables, $\{\psi_{\mathrm{i}},\psi_{\mathrm{j}},\psi_{\mathrm{k}}\}$) and Eqs. (6) and (8) (three unknowns for each ϱ_{ij}: one free parameter (δ_{R} or β), and two variables, $\{\psi_{\mathrm{i}},\psi_{\mathrm{j}}\}$).

Critical analysis of Fagot et al. (1975)

Fagot et al. tabulate (Tables 1 and 2, p. 314) the fitted values of δ (Eq. (3)), δ_{R} (Eq. (6)) and β (Eq. (8)) for individual subjects, along with the respective sums-of-squares-of-residuals. When including δ in the respective equation, the sum-of-squares can decrease by as much 43.7%; when including δ_{R}, by 69.8%; and when including β, by 52.5%. Some improvements, however, are <10%, varying idiosyncratically across-subjects. Clearly, the addition of a bias parameter δ or δ_{R} or β *can* improve the fit; however, the fit should hypothetically *always* improve, unless the additional parameter is redundant. Is there redundancy, then? The across-subjects-average value of δ is 0.9881 (standard deviation [SD] = 0.1021). Perhaps the regressions, if done for an infinite number of subjects or an infinite number of judgments for any one subject, would give $\delta = 1$. But letting $\delta = 1$ removes it from the model. The same caution applies to β (average = 1.0957, SD = 0.0787). Nonetheless, thanks to the narrow SDs, the averages for δ and β are only equal at $p = 0.00329$ (*t*-test). In contrast, the fitted δ_{R}’s average 0.7121 (SD = 0.2422), equaling the averages of δ and β only at $p = 0.000668$ and $p = 0.0000202$, respectively. Notably, δ_{R} exceeded 1 for only 1 of 15 subjects, making δ_{R} the only bias parameter that largely obeys its inferred upper bound of 1; whereas $\delta > 1$ for 9 of 15 subjects, and $\beta > 1$ for 12 of 15. In sum: δ and β seem redundant. Yet, they decrease the sums-of-squares. This implies incomplete regressions or poor judgments, hence the low p of equality of the averages of δ and β.

Equation (6) derives from Eq. (3), and yet we see a schism between the mean values (and SDs) of their respective bias parameters, δ_{R} and δ. Indeed, Eq. (6) represents ratio judgments, whereas Eq. (3) represents interval judgments, which involve different instructions to subjects (see above). Theory-wise, the subject’s interval response ϱ_{ijk} should approach zero as the stimulus intensity ϕ_{j} drops towards ϕ_{i} (recall that $\phi_{\mathrm{i}} < \phi_{\mathrm{j}} < \phi_{\mathrm{k}}$). Correspondingly $\psi_{\mathrm{j}} \rightarrow \psi_{\mathrm{i}}$, mandating $\left(1-(1/\delta)\right) \rightarrow 0$, assured if $\delta = 1$; hence, regression-fitted δ’s cluster near 1. Consider now Eq. (8). Like Eq. (6), it represents ratio judgments, but unlike Eq. (6), it does not derive from Eq. (3). Yet β of Eq. (8) regresses towards the same value, 1, as δ of Eq.

(3). In Eq. (8), when $\psi_i = \psi_j$ then $\varrho_{ij} = \varrho_{ii} = \varrho_{jj} = 1$. Indeed, the *average* of the judgments r_{jj} must tend towards 1 when comparing a stimulus to itself, forcing $\beta \rightarrow 1$. Finally, consider Eq. (6) as $\psi_i \rightarrow \psi_j$; now $\varrho_{ij} \rightarrow 1$, but without restrictions on δ_R besides the implied limits $0 < \delta_R < 1$ (above).

Why the redundancies, $\delta, \beta \rightarrow 1$? Fagot et al.'s fundamental relation, Eq. (1), inherently assumes $\psi_a, \psi_b > 0$, i.e., measurement from a zero-point upwards. But to Fagot et al., $\psi = 0$ at the absolute detection threshold, call it ϕ_t; $\psi_t = 0$. Hence, Fagot et al.'s stipulations of $\phi_i < \phi_j < \phi_k$ and "two intervals, $\psi_j - \psi_i$ and $\psi_i - \psi_t = \psi_i$ (since $\psi_t = 0$)" are only mutually compatible if $\phi_i = \phi_t$. (Recall that Fagot et al. change notation, renaming the top of the interval as ψ_j (formerly ψ_k) and renaming the sectioning intensity as ψ_i (formerly ψ_j).) In sum: Fagot et al. argue in circles.

Summary and Conclusions

Fagot, Stewart, and Kleinknecht (1975) provide a novel model of ratio judgments as interval judgments involving "bias parameters". Three judgment equations emerge, each with its own bias parameter. Fagot et al. collect empirical judgments of intervals and ratios, and regression-fit their equations to them, gaining bias-parameter values subject-by-subject. But Fagot et al. fail to grant that two of the three bias parameters converge toward a value that makes them redundant. The redundancy reflects circular reasoning about the scales; fatal, but avoidable.

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HARD AND SOFT THRESHOLDS. PART 1: CONCEPTS

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Abstract

Stimulus-detection thresholds are inferred from psychometric functions. Such functions quantify only how often a stimulus is perceived, versus its intensity, not the exposure-to-exposure evoked sensations. But for "near-threshold" intensities, sensations fade in and out of consciousness across exposures; sensation strength must affect judgment of stimulus presence, and should therefore be explicit in models of threshold. Here, we study auditory sensation. We find a threshold conundrum; how does loudness approach zero both at a detection threshold and at $-\infty$ *decibels? Swets, working from Signal Detection Theory, claims that the two limits are one. However, his arguments prove unconvincing. Physiology mandates finite detection thresholds. Seeking resolution, we imagine loudness as a Gaussian-distributed random variable within Signal Detection Theory interpretations of threshold. The stimulus-evoked loudness is "signal" and a subconscious comparison-loudness is "noise". As intensity drops, a "soft threshold" emerges, having non-zero average loudness (as found empirically); further intensity decline produces a "hard" threshold, below which nothing is heard. The threshold conundrum is resolved.*

This paper offers a resolution of a classical limits problem in sensation. Audition is emphasized here, because the amplitude of the physical sound wave can be precisely controlled from instant-to-instant (pure tones and their combinations), or on the average (so-called "colored" noise). That is, we ignore natural fluctuations in the stimulus intensity, which have been implicated as crucial to the detection threshold of light (Hecht et al., 1941) and to auditory detection/discrimination by "ideal detectors" (Green & Swets, 1966/1988, Ch. 6-8). Nonetheless, precedent obliges us to use the words "noise" and "signal" (Green & Swets, 1966/1988, Ch. 2-3), not in reference to phenomena outside the body (Green & Swets, Ch. 6-8) but rather to phenomena inside the body (Green & Swets, Ch. 2-3).

Stimulus-detection "threshold" in terms of "loudness"

What physical value has been obtained more often in psychophysics than the "detection threshold" for a stimulus? And yet, specifying the physical intensity that is "threshold" has been *conceptually* frustrating. Hence, *operational* specifications have ruled. Here, we offer no new measurements; the literature is full. Rather, we adapt a well-known model in a novel way, to offer a conceptualization of a phenomenon that many readers find non-intuitive: non-zero sensation at stimulus-detection threshold.

We concentrate here on the field best-known to the first author, audition. We begin by defining "near threshold". A near-threshold stimulus intensity is one for which, in practice, a stimulus of fixed acoustic waveform (but change-able amplitude) will be heard some (but not all) of the times that it is presented to the listener in a threshold-determining psychophysical procedure. Such procedures are Yes/No and two-alternative two-interval forced-choice (2AIFC). They offer the details needed to build roughly-S-shaped psychometric functions, which show the proportion of stimulus exposures on which the stimulus is heard, expressed as percentage-correct plotted versus stimulus intensity. Some criterion percentage-correct is taken to signify “threshold” intensity. For Yes/No, any percentage-correct from 0 to 100 (but, in practice, ≥ 50) can be declared to indicate the intensity called “threshold”. For 2AIFC, the percentages-correct tend to vary from 50 to 100, and again, some percentage in that range is chosen as signifying threshold. Swets (1961, p. 168) explains Yes/No in a famous paper: “Plots of the ‘psychometric function’ – the proportion of ‘yes’ responses as a function of the stimulus energy – were in the form of ogives, which suggested an underlying bell-shaped *distribution of threshold intensities*. Abundant evidence for continuous physiological change in large numbers of receptive and nervous elements in the various sensory systems made this picture eminently reasonable. Thus, the threshold value of a stimulus had to be specified in statistical terms” (italics supplied). And indeed, repeated psychometric functions for a chosen ear will differ, yielding different estimates of threshold.

Note well: Swets infers a bell-shaped (i.e., Gaussian, called “normal”) distribution of threshold intensities – based upon psychometric functions, for which stimulus intensity is the abscissa – but no mention of the distribution of the resulting *loudnesses*. Again: threshold is classically defined by *how often* the listener hears the stimulus, not by *how loud* it seems when heard. As Swets (1961) notes, the psychometric function is imagined most conveniently as being sigmoidal; a vertical axis through the unique point on the curve, its midpoint, is often taken to indicate the stimulus intensity deemed threshold. That stimulus (or any other), when repeated, will not evoke the exact same neuronal response from any peripheral auditory receptor cell (reviewed for the ear in Nizami & Schneider, 1997; Nizami, 2002, 2005a, 2005b), nor will “higher” (more central) neuronal activity be constant (Ehret & Romand, 1997). For these reasons alone, we would expect variation in the experiential correlate of neuronal activity, namely, loudness. A “near-threshold” stimulus’ loudness would fade in and out of consciousness from exposure to exposure (ignoring any “adaptational” fading within the brief exposure; citations omitted). And psychophysics and neurophysiology suggest that we cannot expect any two ears to work identically.

Altogether, loudness is not fixed for any stimulus of given intensity that is used to infer detection threshold; we can only speak of the “average loudness” for any given stimulus intensity and for any chosen ear. Contrary to some customary interpretations, loudness is not *a priori* zero “at [stimulus-detection] threshold”. We start with the principle, therefore, that “near-threshold” stimuli are those that are more likely to be perceived with increase in intensity, given that perceived stimulus-presence and stimulus loudness are not operationally separated in psychophysical threshold-determination runs.

The threshold conundrum

Let us denote loudness as L, and denote physical waveform amplitude, in root-mean-square Newtons per meter squared, as I. Diminishing the intensity of a heard stimulus monotonically to threshold, denoted I_{th}, is customarily presumed to reduce loudness monotonically to zero: $L \rightarrow 0$ as $I \rightarrow I_{th}$ from $I > I_{th}$. However, by the very definition of loudness as a stimulus-evoked sensation, loudness is zero when stimuli are absent: $L \rightarrow 0$ as $I \rightarrow 0$ from $I > 0$. Of course, decibel scales are favored when discussing auditory stimuli. They are especially useful when constructing psychometric functions; they allow the function to have long tails as identification of the stimulus’ presence empirically slowly approaches chance performance with decreasing waveform amplitude. The particular location of 0 decibels on a decibel scale (whether dB SPL, or other decibel measure) is not of concern, because $-\infty$ remains $-\infty$.

Altogether, then, zero loudness is approached in two different intensity limits:

$$L \rightarrow 0 \ as \ I \rightarrow I_{th} \ (1) \quad for \ all \ I > I_{th} \qquad and \qquad L \rightarrow 0 \ as \ I \rightarrow 0 \ (2) \quad for \ all \ I > 0$$

Remarkably, this threshold conundrum seems unmentioned in the literature. But it deserves mention, because it confounds any attempts to express loudness as an equation of intensity (e.g., Nizami & Schneider, 1997; Nizami, 2002, 2003, 2005a, 2005b, 2011, 2014; see others' attempts cited within). This, in turn, causes circular arguments in the derived ANSI loudness standard (Nizami, 2015).

Is threshold (in decibels) infinitely low?

When choosing an intensity at which loudness falls to zero, which intensity is to be used? And what relation is that intensity to "threshold"? The limit $L \to 0$ as $I \to I_{th}$ begs the definition of I_{th}. The problem disappears if we arbitrarily set $I_{th} = 0$, that is, threshold $= -\infty$ decibels. This notion is widely accepted, and is attributed to Swets (1961). But as Wever and Zener (1928, p. 491) note, "we could not take seriously a measure of sensitivity at infinity". Would a stimulus of, say, -200 dB SPL ever be detected by a human listener?

Let us re-examine Swets' (1961) idea of an infinitely-low-decibel stimulus-detection threshold. He attributes it to Signal Detection Theory (SDT), a broadly-applied model. But skepticism of Swets (1961) proves easy. SDT concerns optimal decision-making, and has often been applied to the interpretation of psychophysical detection and discrimination thresholds, especially those obtained through Yes/No or 2AIFC trials. SDT assumes that stimulus intensities, or the resulting evoked sensations, are random variables, distributed as Gaussians which, like all Gaussians, have infinitely-long tails. When intensities are expressed in decibels, infinitely-long tails allow infinitely-low-decibel stimulus-detection thresholds. Swets (1961) reviewed the application of SDT to data from several kinds of psychophysical procedures: Yes/No, "second-choice" and rating experiments, in the context of what SDT's usefulness meant for five threshold models, which were not SDT models, "concerning the processes underlying these data" (Swets, p. 175). After a laborious and arcane analysis, Swets reached strangely equivocal conclusions. Of the examined models, one fitted none of the data; two fitted *some* of the data; another could not be evaluated at all (with the particular data); and finally, one model fitted *all* of the data, as did SDT. Swets (p. 176) concluded: "The outcome is that, as far as we know, there *may* be a sensory threshold" (italics added). However, he then stated that "On the other hand, the existence of a sensory threshold has not been demonstrated". In sum: Swets (1961) fails to convince the reader of an infinitely-low-decibel stimulus-detection threshold. An infinitely-sensitive ear is certainly not compatible with primary afferent neuronal firing (reviewed in Nizami & Schneider, 1997; Nizami, 2002, 2005a, 2005b).

There is other work that offers reasons for rejection of an infinitely-low-decibel stimulus-detection threshold. Denk and Webb (1992) review evidence that, for detection of a stimulus to occur, the hair bundle of the auditory inner hair cell must deflect sufficiently for ion channels on the cell to open, causing a flow of transduction current. Denk and Webb (p. 99) note that "there exists no threshold for *bundle deflections* to lead to a change in the transduction current. Whether a stimulus can be detected or not depends therefore only on whether it can be distinguished from noise" (italics added). Here, "noise" refers to spontaneous fluctuations at the auditory periphery, fluctuations that are not caused by the stimulus, and that reduce the impact of the stimulus. One kind of noise is the spontaneous movement of the hair bundle due to random thermal ("Brownian") motion of the fluid that surrounds the hair cells (e.g., Denk & Webb, 1989; Denk et al., 1989; Denk & Webb, 1992). In theory, however, Brownian motion is too weak for this (Bialek & Schweitzer, 1986). Empirically, the electrical fluctuations caused by the random opening and closing of ion channels actually obscures the electrical fluctuations caused by thermal motion (Denk & Webb, 1992). Thus, although the hair bundle's Brownian motion "is, in some sense, unavoidable and so defines the fundamental physical limit to detection" (Denk & Webb, 1992, p. 99), a higher limit is imposed by ion-channel noise.

The same year that Swets implied an infinitely low threshold, Hellman and Zwislocki (1961, p. 687) offered the contrary view that "The threshold of audibility is a natural boundary condition which cannot be eliminated". We are obliged to agree, given the evidence reviewed above. The present model therefore proceeds on the assumption that threshold is *not* infinitely low, that is, that $I_{th} \neq 0$, and that there is some "hard threshold" below which loudness is always zero ($L = 0$).

Loudness near and above threshold

An internal scale of sensory events

We turn to the "textbook" of SDT, Green and Swets (1966/1988). SDT deals with distributed quantities, i.e., random variables. Early on, Green and Swets (pp. 31, 45, 58) describe those random variables as *sensory events*, not as *external* events such as stimulus intensities. Likewise, we presently assume an internal scale of sensory events, envisioned as a number line labeled "x" and called "response". (We realize that y is the usual notation for a stimulus-dependent variable, but here we follow the Green & Swets notation, for continuity with their work.) A "negative" response appears to be meaningless, but we also assume, after Green and Swets, that random variables on x have distributions expressed by Gaussian *probability density functions* (pdfs); as they note (p. 58), "this assumption allows one to derive results that would be difficult or impossible to derive under other assumptions". Of course, to assume Gaussians (or other well-known pdfs) is to assume infinitely long tails. Let us therefore defy orthodoxy, by assuming (for sheer convenience) that $-\infty < x < \infty$. Note well that this is *not* a confirmation of an infinitely low threshold in decibels, as will be explained.

Of course, if x is to be an ordinal scale (Stevens, 1946), one on which entities can be characterized by magnitude, it cannot *in this case* also be a ratio scale, whose lowest value is zero and on which ratios of quantities are meaningful. Rather, it can at best be an *interval* scale, whose lowest value is not zero, and, on which, ratios of x's are not meaningful but equal intervals have equal meaning.

The random responses called noise and signal

We now assume a random variable "on x" called "noise". "Noise" represents organismal limitations on the threshold of hearing, limitations best explained by others (see above). Additionally, we assume that the mean and variance of the noise distribution are stationary, that is, they do not drift over time, at least, not over the course of a typical threshold-determining procedure such as a run of Yes/No or 2AIFC trials. Such procedures will be integrated into the present model in Part 2 of this duo of papers.

"Responses" x are also evoked by auditory stimuli. The response to a given stimulus is assumed to be distributed: the evoked responses will differ from exposure to exposure, no matter how carefully the stimulus is reproduced. However, the mean of the stimulus-evoked responses is assumed to rise monotonically with the stimulus' intensity, I. All of this parallels the peripheral physiological response; the firing rate of voltage spikes increases monotonically *on average* with increase in stimulus intensity, in single afferents (e.g., Nizami, 2002, 2005a, 2014) and, consequently, in the massed firing of the auditory nerve (e.g., Nizami & Schneider, 1997; Nizami, 2011). Monotonicity thus also occurs in mean values of potentials that represent massed peripheral firing (e.g., the peripheral N_1; Nizami, 2005b).

Remarkably, it is not clear whether stimulus-evoked physiological activity represents "inclusion" of any internal noise, no matter how "internal noise" is defined. Does stimulus-evoked activity nullify internal noise, or merely add to it? We therefore refer to the stimulus-evoked response as "signal". We denote the signal's presence by s and its absence (i.e., nothing but noise) by n. The mean of noise is denoted m_n and the mean of signal is denoted m_s. By stipulation, $m_s \geq m_n$. We denote the noise variance by σ_n^2 and the signal variance by σ_s^2, and we initially take the most general stance, $\sigma_n^2 \neq \sigma_s^2$. The respective Gaussian pdfs of noise, $f(x|n)$, and of signal, $f(x|s)$, are

$$f(x|n) = \frac{1}{\sqrt{2\pi\sigma_n^2}} exp\left(-\frac{(x-m_n)^2}{2\sigma_n^2}\right) \quad (3) \qquad f(x|s) = \frac{1}{\sqrt{2\pi\sigma_s^2}} exp\left(-\frac{(x-m_s)^2}{2\sigma_s^2}\right) \quad (4)$$

Figure 1 shows the imagined pdfs of noise and of signal. We postulate that as intensity declines, the pdf of signal approaches that of noise; signal and noise eventually become indistinguishable. Figure 2 illustrates this relation. For the sake of simplifying the subsequent algebra (see Part 2 of this duo), both pdfs are henceforth assumed to have the same variance, denoted σ^2.

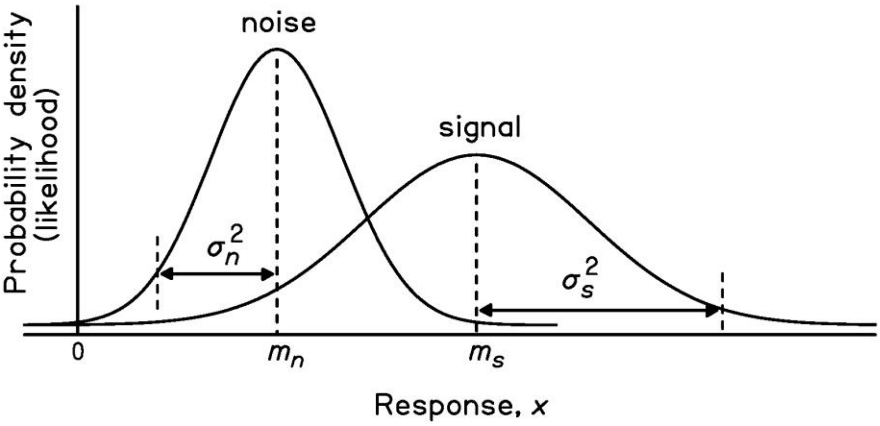

Figure 1. Hypothetical probability density functions (pdfs) of responses x deemed noise and signal.

Loudness as the response

We now postulate that the response scale x is loudness, rather than, say, a firing rate or an electrical potential. Noise and signal are loudnesses. Each loudness appears (from experience and experiment) to monotonically correspond to some most-likely stimulus intensity (citations too numerous to mention). The mean of the noise pdf, m_n, will hypothetically correspond to an unknown stimulus intensity $I_{min} > 0$ that we deem a *hard threshold.* Any stimulus for which $I < I_{min}$ is unheard, as if absent. The signal pdf has become the noise pdf; and the noise is subconscious.

Hypothetically, above the hard threshold I_{min}, there is a "threshold zone" within which loudness evoked by repeating a particular stimulus will fade in and out of consciousness from exposure to exposure, obeying a pdf on x. Those differing loudnesses will be captured in any Yes/No or 2AIFC procedure that produces a psychometric function. From that function a stimulus-detection threshold intensity, I_{th} will be declared at which the loudness will *on average* exceed zero, as concluded empirically (Buus et al., 1998; Buus & Florentine, 2001), as long as that threshold corresponds to some reliably above-chance identifiability. We call I_{th} the *soft threshold.*

Recall now the limits problem that provoked this investigation: there were two contradictory limits for zero loudness, $L \to 0$ as $I \to I_{th}$ and $L \to 0$ as $I \to 0$. Both of those limits can now be recognized as misunderstandings; if nothing is heard, trial-after-trial, then $m_S = m_n$, corresponding to a single, new limit for zero loudness: $L \to 0$ as $I \to I_{min}$, where $0 < I_{min} < I_{th}$.

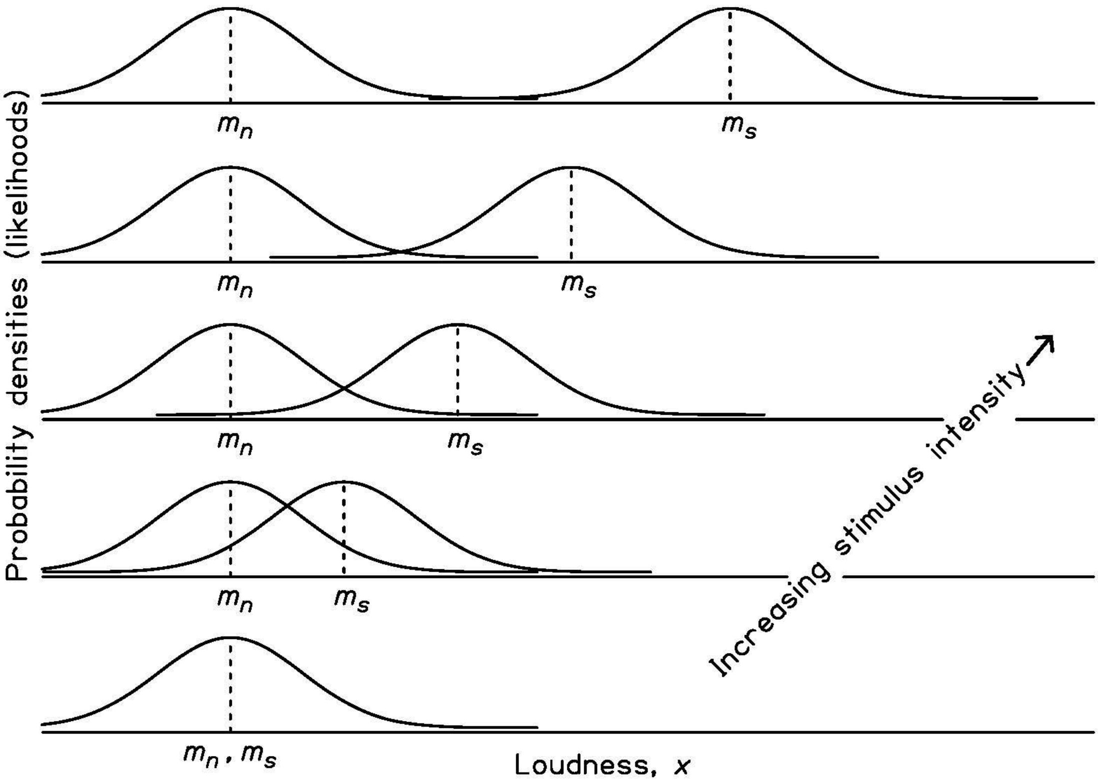

Figure 2. Hypothetical pdfs of noise and signal as stimulus intensity, and hence average loudness, increases from bottom panel to top panel.

Summary and Conclusions

Stimulus-evoked sensation is customarily presumed to decline monotonically to zero as the stimulus intensity deemed “threshold” is approached. But this mimics the complete absence of the stimulus. What intensity, therefore, constitutes “threshold”? This is a conundrum. For audition, the conundrum disappears if threshold is deemed to be $-\infty$ decibels (intensity = zero). Established psychophysical threshold-determination procedures produce psychometric functions of correct stimulus identification plotted as a function of intensity, allowing inference of threshold intensity. Those thresholds, in decibels, are not infinitely low; indeed, such would defy physiological limits. Here, we recognize that threshold-determining procedures depend upon comparisons of loudnesses, and that a stimulus’ near-threshold loudness varies from presentation to presentation. We therefore imagine that any particular stimulus, when repeated, evokes a signal on a loudness number line, a signal assumed to be Gaussian-distributed. That distribution’s terminal form is a Gaussian of subconscious “noise”, representing the physiological limitations. Stimulus detection thus consists of discrimination of signal from noise. The threshold conundrum is resolved; threshold corresponds to non-zero loudness, as suggested by empirical studies.

All these notions can be integrated into traditional Signal Detection Theory models of established psychophysical threshold-determining procedures. This is done in Part 2 of this duo.

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HARD AND SOFT THRESHOLDS. PART 2: DECISION VARIABLES

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Abstract

This is the second of a duo of papers concerning stimulus-detection thresholds. In the first paper, we noted that the specification of threshold involves an unresolved (and apparently unrecognized) conundrum. We then proposed a novel conceptual solution inspired by Signal Detection Theory, involving a near-threshold intensity range that includes a lowest (hard) threshold of zero sensation and a higher (soft) threshold of non-zero (but variable) sensation. Signal Detection involves distributed quantities; we chose loudness (rather than intensity as in the literature) to develop hypothetical loudness-based Signal Detection decision variables to be used in customary one-interval (Yes/No) or two-interval forced-choice threshold-determination procedures.

This paper is the second of a duo. The first justified the ideas of "hard" and "soft" thresholds; the present paper integrates those concepts into the Signal Detection Theory of threshold-determination procedures.

Earlier, we offered a conceptual resolution of a non-intuitive phenomenon: non-zero sensation at stimulus-detection threshold. We concentrated upon audition, because the amplitude profile of a physical sound wave can be precisely reproduced in the laboratory from exposure to exposure. We began by defining a "near-threshold" stimulus intensity as one for which a stimulus of fixed acoustic waveform (but change-able amplitude) will be heard some (but not all) of the times that it is presented in a psychophysical threshold-determining procedure such as two-alternative one-interval forced-choice (Yes/No) or two-alternative two-interval forced-choice (2AIFC). That is, "near-threshold" stimuli are those that are more likely to be perceived with increasing stimulus intensity; as intensity rises, so does the percentage of times that the stimulus' presence is correctly identified, plotted as the roughly-S-shaped *psychometric function*. Some criterion percentage-correct on that function is taken to signify "threshold" intensity. Note again: threshold is defined by *how often* the listener hears the stimulus, not by *how loud* it seems when heard. But a "near-threshold" stimulus' loudness will actually fade in and out of consciousness from exposure to exposure (even ignoring adaptation); phenomenologically, repeating the stimulus will not evoke the same neuronal response each time. A waveform of a given profile evokes no unique loudness, only a unique *average loudness*. *Threshold-determination does not differentiate mere presence from loudness*.

Contrary to some traditional interpretations, then, loudness cannot be zero at stimulus-detection threshold. This poses a conundrum, one that is scrupulously ignored in the literature: at what intensity does loudness actually fall to zero, and how does that intensity relate to "threshold"? That is, using L for loudness and I for stimulus intensity, the limit $L \rightarrow 0$ as $I \rightarrow I_{th}$ begs the definition of I_{th}. The problem disappears if we set $I_{th} = 0$ Newtons/m^2 ($-\infty$ decibels), a widely-accepted notion credited to Swets (1961). Hence, we re-examined Swets (1961), and found his arguments wanting. Further, there is strong physiological evidence of a non-zero limit to detectable auditory intensities. We therefore assumed that $I_{th} \neq 0$ Newtons/m^2; there must be a "hard threshold" below which loudness is always zero ($L = 0$).

Swets (1961) attributed the notion of an infinitely-low-decibel threshold to Signal Detection Theory (SDT). SDT assumes that either stimulus intensities or the resulting evoked sensations are random variables, having distributions expressed by Gaussian *probability density functions* (pdfs), which have infinitely-long tails. Notwithstanding Swets' (1961) interpretations of threshold, SDT remains a useful model because it has especially been focused on the interpretation of psychophysical detection and discrimination thresholds, particularly those obtained through Yes/No or 2AIFC. We therefore turn to the "textbook" of SDT, Green and Swets (1966/1988). Early on, Green and Swets (pp. 31, 45, 58) denote *sensory events* as their random variables of interest, rather than *external* events such as stimuli. Likewise, in the first paper of this duo we imagined an internal scale of sensory events, a number line "x" called "response". We assumed, after Green and Swets, that random variables on x are Gaussian-distributed. To accommodate Gaussians, we assumed that $-\infty < x < \infty$. Note well that this is *not* a confirmation of an infinitely low threshold in decibels.

A model of loudness near and above threshold

We used the words "noise" and "signal", not in reference to extra-corporeal phenomena (acoustic stimuli such as tones or "colored" noise; Green & Swets, Ch. 6-8) but rather to intra-corporeal phenomena (internal "responses"; Green & Swets, Ch. 2-3). We assumed "noise" to be a random variable "on x", reflecting physiological restrictions on auditory stimulus-detection thresholds. The mean and variance of noise were assumed to remain stationary over the course of a Yes/No or 2AIFC threshold-determining run. A distribution having a distinct mean and variance was also assumed to characterize the repeated evoked response x to any particular auditory stimulus, although its mean was assumed to rise monotonically with the stimulus' intensity, I, reflecting known physiology. We then asked whether stimulus-evoked activity nullifies internal noise, or merely adds to it. We found no firm answer, so we proposed our own interpretation, as follows. We called the stimulus-evoked response "signal", its presence denoted by s and its absence (i.e., nothing but noise) by n. Noise mean was called m_n; signal mean was called m_s. We stipulated that $m_s \geq m_n$, and we proposed that as $I \to 0$ the pdf of signal approaches that of noise until the two pdfs become indistinguishable. For algebraic convenience those pdfs were assumed to have the same variance, σ^2. The pdfs of noise, $f(x|n)$, and of signal, $f(x|s)$, were

$$f(x|n) = \frac{1}{\sqrt{2\pi\sigma^2}} exp\left(-\frac{(x-m_n)^2}{2\sigma^2}\right) \quad (1) \qquad f(x|s)$$

$$= \frac{1}{\sqrt{2\pi\sigma^2}} exp\left(-\frac{(x-m_s)^2}{2\sigma^2}\right) \quad (2)$$

or, symbolically, $x \sim \mathcal{N}(m_n, \sigma^2)$ and $x \sim \mathcal{N}(m_s, \sigma^2)$, where $\mathcal{N} = "normal"$. Figure 1 shows the pdfs.

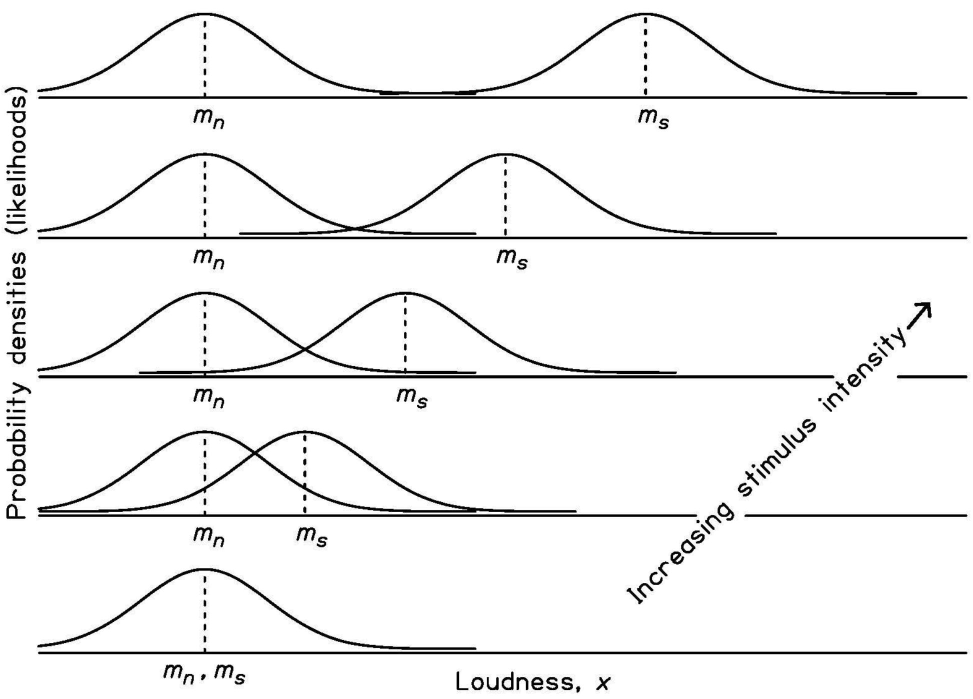

Figure 1. The hypothetical probability density functions (pdfs) of noise and signal, as stimulus intensity, and hence average loudness, increases from bottom panel to top panel.

We then boldly postulated that the response x is loudness, not some stimulus property or respective known neuronal activity. Noise and signal are now loudnesses. The mean of the noise pdf, m_n, then corresponds to some unknown stimulus intensity $I_{min} > 0$, which we called a *hard threshold*. As $I \to I_{min}$, $m_S \to m_n$ and $L \to 0$. Stimuli $I < I_{min}$ are unheard; the signal pdf has become the noise pdf, and the noise is subconscious. Conversely, above I_{min} there is a "threshold zone" within which the loudness evoked by any particular stimulus will fade in and out of consciousness with stimulus repetition, obeying the pdf of loudnesses x. That pdf will underly any Yes/No or 2AIFC procedure that produces a psychometric function, from which some reliably above-chance stimulus identifiability will be chosen, corresponding to an intensity I_{th} where $0 < I_{min} < I_{th}$. *On average*, $L(I_{th}) > 0$, agreeing with intuition and with Buus et al. (1998) and Buus and Florentine (2001). I_{th} is the *soft threshold.*

Operational use of loudness in psychophysical determination of threshold

In our view, operational specification of a stimulus-detection threshold lies in the trial-by-psychophysical-trial differentiation of response evoked by stimulus from response that is spontaneous (noise), where "response" is (once again) sensory response, not choices made by the listener. Old arguments about whether detection differs from discrimination (citations omitted) become redundant. We propose the counterintuitive notion that whatever comparisons are made in a Yes/No or 2AIFC trial, what is compared are loudnesses or manipulations of loudnesses, *even if some of the respective loudnesses are not consciously heard.* Of course, the listener will always employ *memory*. On each trial of Yes/No the loudness experienced in a listening interval is compared to the memories of loudnesses in previous intervals; the same is assumed for each interval of 2AIFC, but inevitably the loudness experienced in the 2nd listening interval will be compared to the memory of the loudness experienced in the 1st listening interval. (We will presently ignore the possibility of further sequential effects, as found [for example] in magnitude estimation [citations omitted].) We emphasize again that the distributions on x represented by Eqs. (1) and (2) are sensory responses (loudnesses) that precede any *judgment*.

Yes/No and 2AIFC threshold-determining procedures can be interpreted in terms of the model of Fig.1 and Eqs. (1) and (2) within the context of Signal Detection Theory, as follows.

The applicability of Signal Detection Theory

Green and Swets (1966/1988) explicate SDT as follows. SDT is a *decision theory*. Decisions are forced choices; a single trial of a forced-choice task such as Yes/No or 2AIFC is a *decision cycle* involving forced *identifications* (signal present or not? which interval has the signal?). It is usually assumed that a listener who is assigned a sequence of forced identifications will try to maximize the number of *correct* identifications. That is, the listener presumably adopts the *decision rule* that is optimal *on average*. That optimal decision rule can be determined if the decision *sequence* can be ignored, as we will assume.

The likelihood ratio

Equations (1) and (2) each express probability densities, that is, *likelihoods*, each corresponding to some x. A ratio of two likelihoods, from the same pdf or from different pdfs, is a *likelihood ratio*. For example, the likelihood ratio for Eqs. (1) and (2) is $\ell(x) = f(x|s)/f(x|n)$ (Green & Swets, p. 37). Choosing a *likelihood ratio* that equals or exceeds some constant, β, called the *decision criterion*, constitutes the decision rule that maximizes the probability of correct identification of one of two possible conditions (Yes or No? Interval 1 or Interval 2?) (Green & Swets, 1966/1988, pp. 14-23).

As Green and Swets (p. 50) note, "In much psychophysical research the level of the signal is systematically changed in the course of the experiment. Changing the signal level would change the signal distribution, since a stronger signal should, on the average, lead to larger values of likelihood ratio than a weaker signal". Green and Swets (1966/1988) note that, in dealing with Gaussian pdfs, taking the natural logarithm removes the exponent "*e*", easing the derivation of likelihood ratios ℓ. If a quantity increases monotonically, then so does its natural logarithm. Thus, if the log(likelihood ratio), $ln\,\ell(x)$, is monotonic with x, then so is the likelihood ratio $\ell(x)$. As x is a random variable, so are $\ell(x)$ and $ln\,\ell(x)$.

The likelihood ratio and decision variable for Yes/No

Solving for $ln\,\ell(x)$ for Yes/No yields a polynomial in x^2, one that need not be monotonic with x. Therefore, Green and Swets (1966/1988, pp. 59, 67) assure monotonicity by letting the variance of the noise pdf equal the variance of the signal pdf: $\sigma_s^2 = \sigma_n^2$ (= σ^2 in Eqs. (1) and (2)), producing a Gaussian-distributed linear function of x. Recall our assumption that when stimuli are absent, there remains noise; $x \sim \mathcal{N}(m_n, \sigma^2)$, hence $ln\,\ell(x)$ obeys a Gaussian pdf, deemed $[ln\,\ell(x)]_n$. But when stimuli are present, i.e., $x \sim \mathcal{N}(m_s, \sigma^2)$, then $ln\,\ell(x)$ obeys a Gaussian pdf deemed $[ln\,\ell(x)]_s$. Figure 2 shows these pdfs.

The difference $[ln\,\ell(x)]_s - [ln\,\ell(x)]_n$ is a Gaussian random variable that can hypothetically be compared to some decision criterion to choose optimally whether the signal was present or not. However, the variance of $[ln\,\ell(x)]_s - [ln\,\ell(x)]_n$ is not constant. We can make it constant, by dividing $[ln\,\ell(x)]_s - [ln\,\ell(x)]_n$ by the square root of its original variance. This produces a random variable whose variance is unity, and whose mean is the original mean divided by the square root of the original variance. Figure 3 shows the pdf of that putative *decision variable*.

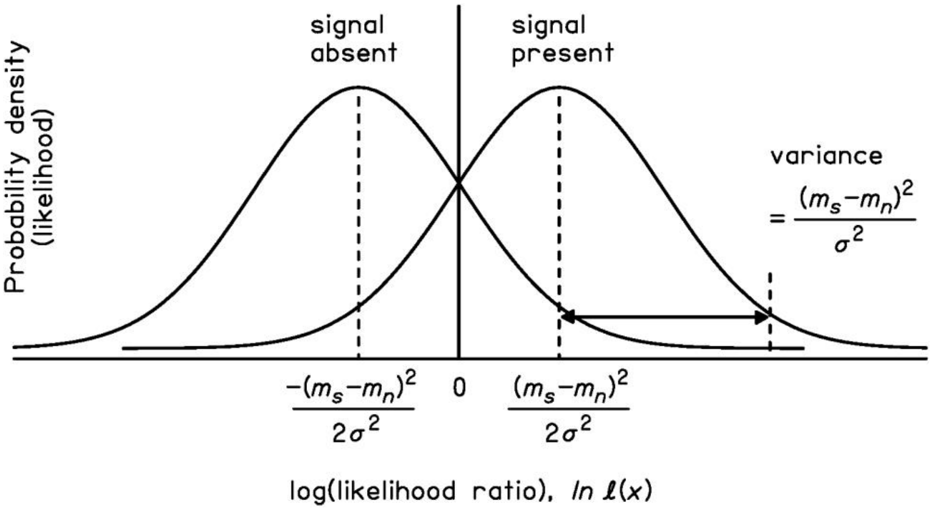

Figure 2. The pdf of the log(likelihood ratio) in the Yes/No task, for the signal absent or present.

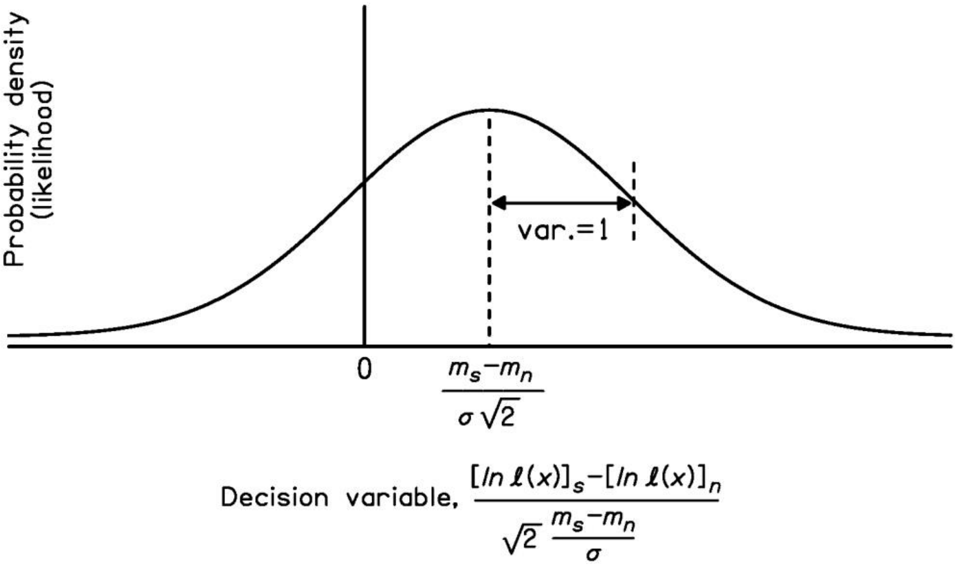

Figure 3. The pdf of the decision variable for the Yes/No task.

The likelihood ratio and decision variable for 2AIFC

The reasoning for 2AIFC is more complicated. 2AIFC involves two possible physical events per trial, namely, the appearance of signal in Interval 1 and not in Interval 2, or vice versa. It is hence necessary to mathematically separate the two listening intervals, done by letting the response be denoted x_1 during the 1st listening interval and x_2 during the 2nd listening interval. Each x_1 and x_2 has its own likelihood ratio, $\ell(x_i) = f(x_i|s)/f(x_i|n)\,, i = 1\ or\ 2$ (Green & Swets, pp. 45-46). But each of these is merely the likelihood ratio for a Yes/No choice (Yes, the signal is present, or No, it is not). The likelihood ratio for 2AIFC is then $\ell(x_1, x_2) = \ell(x_1)/\ell(x_2)$. Its logarithm, the log(likelihood ratio) $ln\,\ell(x_1, x_2)$, transpires to be a polynomial in the terms $(x_2 - x_1)$ and $(x_1 + x_2)$, which are functions of random variables and therefore random variables. To simplify, Green and Swets (p. 67) assume once again that $\sigma_S^2 = \sigma_n^2$ $(= \sigma^2)$, altogether allowing a linear function of $(x_2 - x_1)$. That function has two possible pdfs: one for when the signal appears in the 1st interval, $[ln\,\ell(x_1, x_2)]_{S1}$, and one for signal appearing in the 2nd interval, $[ln\,\ell(x_1, x_2)]_{S2}$. Figure 4 illustrates these pdfs. An optimal choice by the listener corresponds to $([ln\,\ell(x_1, x_2)]_{S1} - [ln\,\ell(x_1, x_2)]_{S2}) > \beta$. The pdf of $[ln\,\ell(x_1, x_2)]_{S1} - [ln\,\ell(x_1, x_2)]_{S2}$ has a non-constant variance, but it can be stabilized as for Yes/No. Figure 5 illustrates the resulting pdf.

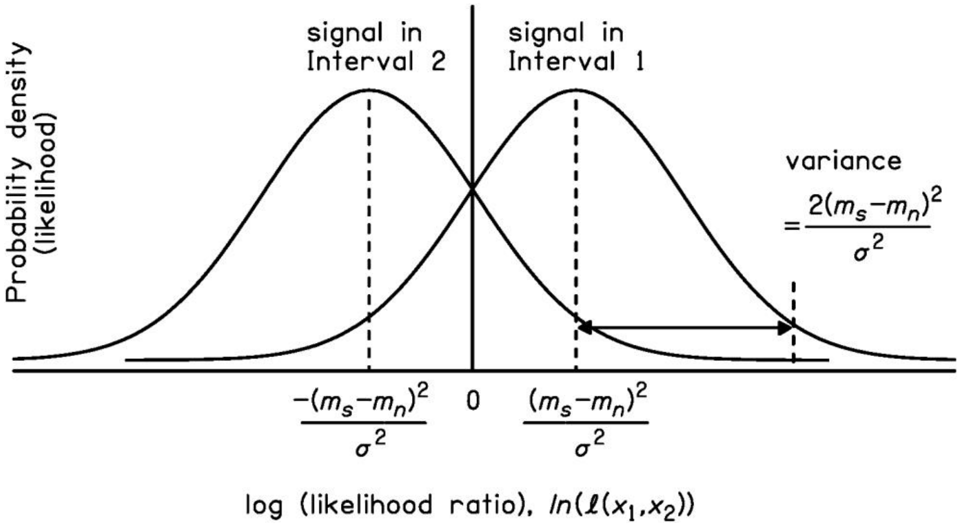

Figure 4. The pdf of the log (likelihood ratio) for 2AIFC, for the signal in Interval 1 or in Interval 2.

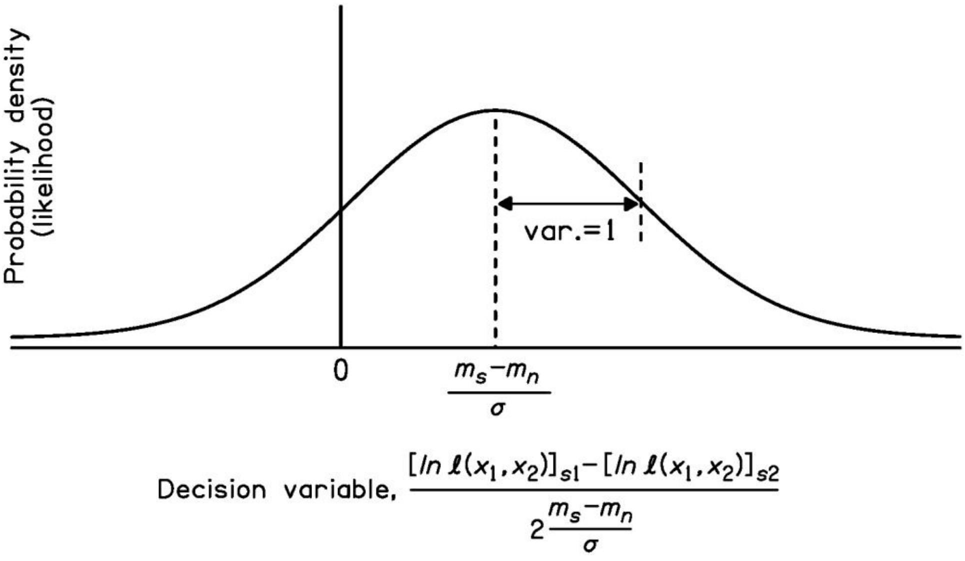

Figure 5. The probability density of the decision variable for the 2AIFC task.

The decision

As stimulus intensity increases, the pdf for signal will shift monotonically rightwards (Fig. 1). So does the pdf of the decision variable for Yes/No or for 2AIFC. Figure 6 shows the shift. On the x-axis there is a criterion β; the listener indicates “signal absent!” for $x < \beta$ and “signal present!” for $x \geq \beta$.

Summary and Conclusions

This is the second paper of a duo concerning sensation at stimulus-detection threshold. The first paper proposed that, contrary to some beliefs, the auditory threshold cannot be $-\infty$ decibels. We further advanced the counter-intuitive (but empirically-supported) notion that average loudness at threshold is non-zero; after all, the near-threshold loudness of a stimulus wavers from presentation to presentation. We presumed (after Signal Detection Theory) that a repeated stimulus would evoke a Gaussian-distributed *signal* on an internal scale of sensory events, taken to be a number line of loudness. As the stimulus intensity drops, the Gaussian for loudness slides leftwards towards lower values, eventually reaching a limiting form, the distributed *noise*. Here in the second paper we incorporate the assumed Gaussians for signal and noise into the Signal Detection Theory of optimal decision-making in Yes/No or two-alternative two-interval forced choice (2AIFC) threshold-determination tasks. We thus determine the *decision variables* hypothetically used by the listener, which are Gaussian-distributed, and are loudness-dependent as expected for comparison-based threshold-determination tasks.

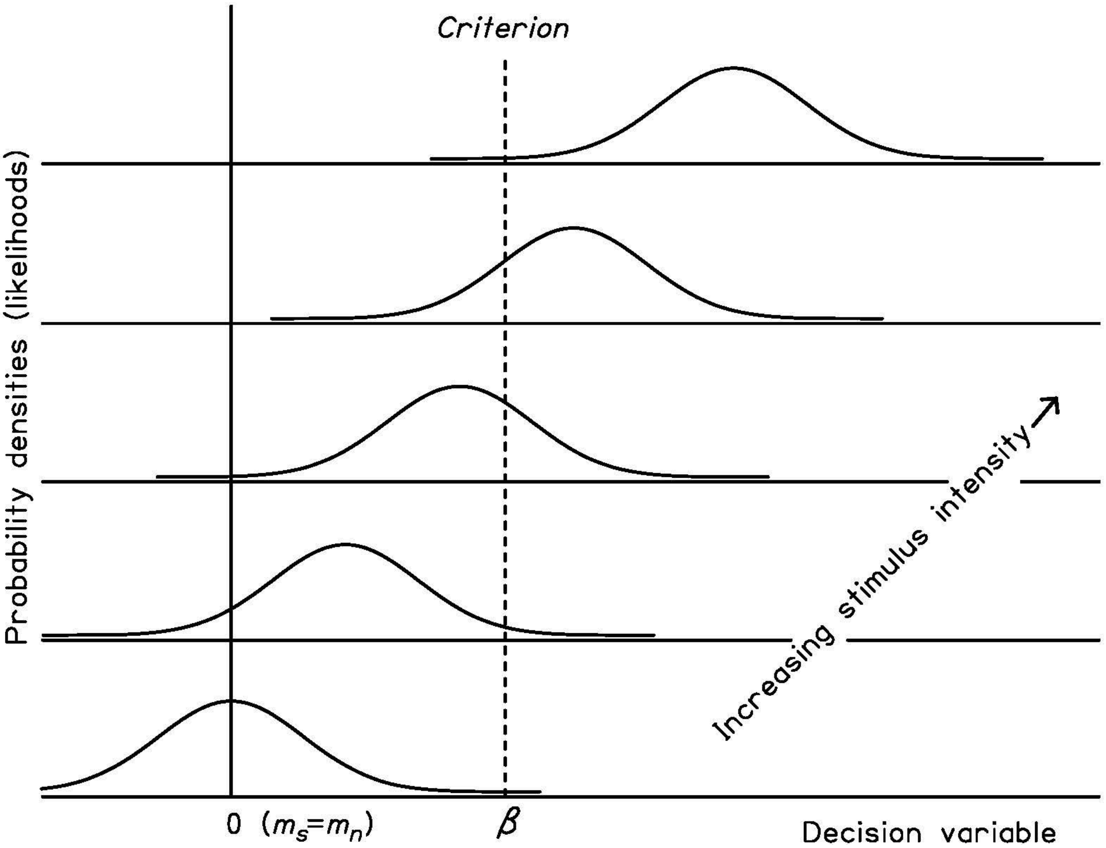

Figure 6. The intensity-dependence of the decision variable (in Fig. 3 for Yes/No procedures and in Fig. 5 for 2AIFC procedures). When the signal mean m_S equals the noise mean m_n (bottom-most panel), the signal pdf has become the noise pdf (Fig. 1); no stimulus is heard.

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MUSEUM- AND ART-BASED INTERVENTIONS IN ALZHEIMER PATIENTS: A SYSTEMATIC REVIEW AND THE AIDA PROJECT

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Abstract

Alzheimer’s Disease (AD) is the main cause of dementia worldwide and one of the most significant health issues in aged individuals. The impact of AD in terms of people affected is estimated to multiplicate in the next years given the increasingly aging population. For this reason, is important to find ways to improve the quality of life and health of the people affected.

Neuroaesthetics, neuropsychology and psychophysics seem to indicate that arts and other aesthetic sensory experiences can elicit positive outcomes in terms of increased subjective psychological wellbeing. But often art-based and museum-based interventions may suffer from experimental flaws due to participants with mixed types of dementia and from constraints in experimental design due to the delicate nature of participants. Our first objective is to systematically assess the efficacy and outcomes of Museum- and Art-based interventions aimed at improving quality of life, memory and well-being in people with AD through PRISMA guidelines and to provide an updated overview of the available literature on this topic in the last ten years. The outcome of this systematic review is orienting and guiding our second objective, the European project called Alzheimer patients Interaction through Digital and Art (AIDA). The aim of AIDA is to create, starting from good practices in different fields of research and interventions, a novel procedure to help people with AD. In particular, people with AD and their caregiver will be involved in a series of art-making and art-viewing sessions in museal and/or cultural environments in which we will promote their communication, self-efficacy and self-esteem in a group setting, testing after the project their perceived well-being and quality of life. Further studies may investigate not only affective improvements but also effects on perception and cognition of these types of interventions.

THE OVO-WBPD CHAMBER: RESTING STATE EEG EVIDENCE

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Abstract

The OVO-Whole Body Perceptual Deprivation chamber (OVO) is a specifically designed room in the shape of a human sized egg built with the aim of facilitating an immersive experience and an increased state of presence. The OVO-WBPD has been previously shown to create a state of absorption and alter time perception (Ben-Soussan et al., 2019; Glicksohn et al., 2017).

The aim of the present work was to investigate the effect of OVO-WBPD on participants in a state of wakeful rest. In this preliminary work (n=15) we recorded the resting state EEG of participants for three minutes with eyes open in two different environmental conditions: 1) the OVO chamber and 2) an empty white room as a control condition. We analyzed across the 180 seconds of recording, the relative power of main EEG frequency bands.

Results highlighted how, in the OVO-WBPD, participants showed increased relative Gamma activity compared to the white room. Increased Gamma power is not unusual in some meditative/absorption states, especially in states related to higher states of consciousness with fullness of content (Lehmann et al., 2001; Beauregard et al., 2009) and for its central role in brain mechanisms underlying information processing (Başar et al., 2001; Fries, 2015) and in meditation-induced neural plasticity (Fell et al., 2010). Moreover, the possibility of increased conscious content in the OVO compared to an "empty" condition may have been the cause of these results. We plan to continue this work by expanding the sample and by analyzing participants' subjective reports collected during the experiment to expand our knowledge on the neurophenomenological effects of this environment. Finally, we are also collecting data from a neuropsychological task to further explore the effect of this environment on internally directed attention processes of participants.

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VISUAL GLOBAL AND LOCAL PROCESSING AND ITS RELATIONSHIP TO AUTISTIC-LIKE TRAITS IN NON-CLINICAL INDIVIDUALS

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Abstract

For decades, research has investigated how we visually perceive our environment which consists of global structures and its local parts. On the one hand, a general global advantage was observed, with individuals being biased to react faster to the global compared to the local level. On the other hand, a local processing bias was observed for individuals with high levels of autistic-like traits, with faster but no less accurate reactions to the local level compared to age-matched peers with lower levels of autistic-like traits. However, previous research does not agree on which specific subset of autistic-like traits relates to this local processing bias. Moreover, many different tasks have been developed to investigate visual global and local processing and previous studies vary vastly in their usage, therefore complicating the comparability of their findings.

Thus, we will investigate the visual global and local processing in neurotypical adults (18-35 years) by assessing and comparing their performance on three frequently used tasks; a task with Navon's compound stimuli, the Embedded Figures Test (EFT), and the Compound Figure Test (CFT). The participants' autistic-like traits will be quantified with the Autism-Spectrum Quotient (AQ). We will analyze the visual processing and the relationship to the autistic-like traits by assessing the correlation coefficients of the task performance and the AQ scores. We expect a positive correlation between local processing bias and AQ scores. These findings would suggest that the performance on the visual processing tasks relates to autistic-like traits in a non-clinical sample with more traits being associated with a higher bias for local processing. Results and discussion will be presented at the conference.

PAIN PERCETION IN TODDLERS BORN WITH ZIKA VIRUS

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Abstract

The pain perception evaluation of non-verbal patients, who also may have intellectual disabilities, poses a challenge to the pain management in daily care units. Moreover, the sequels of ZIKA virus in infants/toddlers and its impact on pain reactivity are yet to be clarified and this study advances in exploring their responses in a controlled investigation setting. This study used skin conductance activity to investigate the pain reaction to invasive procedures in this population compared to a control group. We found that toddlers with ZIKA virus with subcortical alterations and under different medications had the lowest stress response for amplitude of the skin conductance marker altering their pain response to different nociceptive stimuli

Zika virus (ZIKV) is a virus of the family Flaviviridae, the same as dengue and yellow fever. The virus was first isolated in 1947 in the Zika Forest of Uganda, which gave the name to the disease now called Zika fever. Among the neurological sequelae found in fetuses affected by Zika virus are anomalies that include cerebral atrophy with extensive calcifications involving the white matter of the frontal lobes, the caudate nucleus, the slow-acting vessels, and the cerebellum.

Dysgenesis of the corpus callosum and vermis and enlargement of the great cistern were observed. These malformations are associated with memory impairment, learning and psychomotor development. Ventricuolomegaly was added to this symptom group where the head circumference is normal, but its cerebral ventricles are enlarged because they are filled with fluid and have various types of brain changes leading to the concept of congenital Zika syndrome. (Agumadu & Ramphul, 2018; Bhardwaj, Pandey, Rastogi, & Singh, 2021; Grant et al., 2021; Montandon, Ribeiro, Lobo, Montandon Júnior, & Teixeira, 2003; Oliveira Melo et al., 2016; Sousa et al., 2020; Vos et al., 2017).

How much these neurological changes alter the perception and response of young children to nociceptive stimuli remains to be clarified. Hitherto, no study investigated the pain reaction profile of this population. This observational study in a convenience sample of a dental outpatient clinic sought to analyze the physiological response to nociceptive stimuli by skin conductance.

Method

This study evaluated 20 toddlers born with ZIKV with a case control group age-paired, age mean of 36,6 months (+-6.06), 61.1% males, during a dentist procedure divided into 6 stages: 1) baseline, 2) saliva collection with a suction probe, 3) mouth examination, 4) opener mouth bite-blocker positioning, 5) tartar and plate cleaning with excavator, and 6) recovery period.

The Research Ethics Committee of the University of Ceará, Brazil, approved all study procedures.

The stress to invasive or nociceptive stimuli was recorded by Skin conductance activity (SCA) – SCA was assessed by the SCMS® System (Medstorm Innovation, Norway), which translates the SCA by variables: number of peaks (NP) and amplitude (A) showing the intensity of perceived pain at 15 seconds before, during and after events. Both groups were evaluated by Bayley Scales for Infant Development -III (BIDS-III) for measuring the cognitive, language and psychomotor development. Participants of the ZIKV group differed in medication use of Phenobarbital, Vigabatrin (Sabril), Clobazam, Valproic Acid and Levetiraceram). They also differed in brain areas alterations observed in Magnetic Resonance Exam.

Results

T-test with equal variance assumed detected that the groups differed significantly for Amplitude at baseline (.043) and excavator use at stage 5 (p=.000) having the ZIKV group the lowest amplitude level at baseline: CG= 1.465µS x ZIKV= .571µS; and at Stage 5: CG= 4.650µS x ZIKV= .487µS. Groups also differed in all skills by BSID-III (p< .004), but for cognitive development (p= .063), though none of the development markers had impact over stress reaction.

Repeated-measures-ANOVA (Greenhouse-Geiser correction) determined that pain or stress reaction differed through time for SCA- Amplitude and differed by group (p<.002) being the ZIKV group with poorer reaction. Medication had no effect over pain response but affected brain area had and toddlers of ZIKV group with subcortical calcifications (F=4.530, p=.019) and with diffuse subcortical atrophy (F=2.869 p=.021) presented the lowest values in SCA Amplitude.

Discussion and Conclusion

The electrodermal stress marker was sensible to change in response from baseline and reaction to invasive/nociceptive stimulation for six differing conditions, meaning toddles born with ZIKV and control group were able to discriminate among different stages of a dentist examination and cleaning tartar session. In general, ZIKV children had poorer response in skin conductance. Groups differed in development in general with ZIKV group with lowers development indexes, but also with greater variability. Participants of the ZIKV group differed in use of medication and affected areas by the virus infection. Among all factors, toddlers with subcortical alterations had the lowest stress response for amplitude of the skin conductance marker.

Acknowledgements

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PERCEPTION OF EMOTIONS IN SPEECH: THE EFFECT OF SPEAKER'S AGE

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Abstract

The ability to identify emotions in spoken language is essential for effective communication. It requires understanding both the semantics (meaning of words) and prosody (tone of speech) of an utterance and their interaction. Evidence in the literature suggests that older adults perceive emotions in speech differently compared to young adults. While young adults tend to show a bias towards the prosody of speech, older adults demonstrate a more balanced weighting of both speech channels (Ben-David et al., 2019). However, the mechanisms underlying these age-related differences remain unclear. Various sensory, cognitive, and affective factors have been suggested, as well as socio-cultural influences such as social context and age-based stereotype threat. To test the later factor, we adapted the Test for Rating of Emotions in Speech (T-RES), designed to assess the interplay of prosody and semantics in spoken language (Ben-David et al., 2016). In the adapted version, the same emotionally semantic sentences as used by Ben-David and his colleagues (2019) were recorded in three emotional categories: Anger, Happiness, Sadness, and a Neutral category. An acoustic analysis, comparing the adapted version and the original versions of the T-RES, shows differences in the acoustic features between the older and younger speakers. To validate the adapted tool, we compared the performance of young and older adults on both versions of the T-RES. Our results highlight differences and similarities between the two groups and the two versions of the tool, giving a glimpse of the effect of the social context on emotional communication in older age. We believe that the adapted version presented here will contribute to the examination and understanding of the processes underlying age-related differences in the perception of emotions.

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WHISPERED SPEECH CAUSES DISRUPTION OF SERIAL SHORT-TERM MEMORY

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Abstract

Task-irrelevant speech is known to disrupt serial short-term memory, and this phenomenon has been explained with either interference-by-process or attentional capture. In the present experiment, these two accounts were contrasted by investigating the potentially disruptive effect of whispered speech. An attentional capture account of auditory distraction would predict whispered speech to be more disruptive due to either its enhanced relevance to the individual or the greater listening effort required to process the meaning. However, according to an interference-by-process account, whispered speech is expected to be less disruptive due to the reduced amplitude modulations and temporal fine structure conveying weaker order cues to the auditory system, thus inducing less interference with deliberate seriation processes. Ninety-four participants (62 women, ages 18-61 years) performed a serial recall task in which eight visually presented letters were to be retained while task-irrelevant steady-state or changing-state utterances were played via headphones. Crucially, half of the utterances were spoken with a whispered voice (either male or female). Recall accuracy was significantly impaired not only by the presence of changing-state sound (compared to steady-state), but also by the presence of whispered speech (compared to loud speech), and the two effects were found to be additive and independent (see Fig. 1). These results suggest that whispered speech diverts additional attention from the focal task, beyond the distraction elicited by an unpredictable sequence of changing-state speech. The results are less compatible with a unitary interference-by-process account.

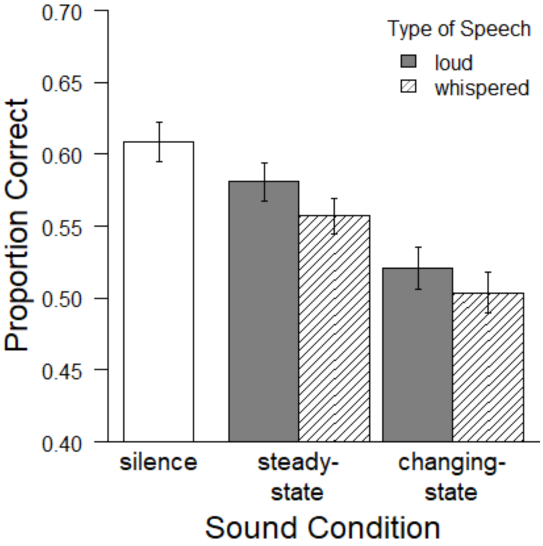

Fig. 1. Accuracy in the serial recall task as a function of the type of background sound, indicating detrimental effects of changing-state and whispered speech. Error bars depict standard errors of the mean.

EFFECT OF ATTENTION ON VECTION

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Abstract

The present study examined the effect of visual attentional selection on visually induced self-motion perception (vection). In an experiment, participants viewed vertically moving dots (either upward or downward) superimposed on stationary dots. In each trial, a cross or t-shaped cross (upper or lower part of the cross was removed) was presented on the center of a display. When a cross was presented, the participants were instructed to focus their attention on the stationary dots while ignoring vertically moving dots (i.e., motion unattended condition). In contrast, when a t-shaped cross was presented, they were asked to focus their attention towards the vertically moving dots while ignoring stationary dots (i.e., motion attended condition). In all the trials, the participants were required to press and hold a button whenever they experienced vection. After each trial, they were required to rate the magnitude of vection. In addition to the attentional conditions, a control condition was conducted where the participants viewed only vertically moving dots or stationary dots. The results revealed a tendency for shorter latency, longer duration, and a higher rating of vection magnitude in the motion attended condition than those in the motion unattended condition. Additionally, shorter latency, longer duration, and a higher rating of vection magnitude were observed in the control condition than those in the other conditions. These results will be discussed within the context of attentional selection and resources allocation.

EXTENDING GAME THEORETICAL FRAMEWORKS TO CYBERSECURITY

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Abstract

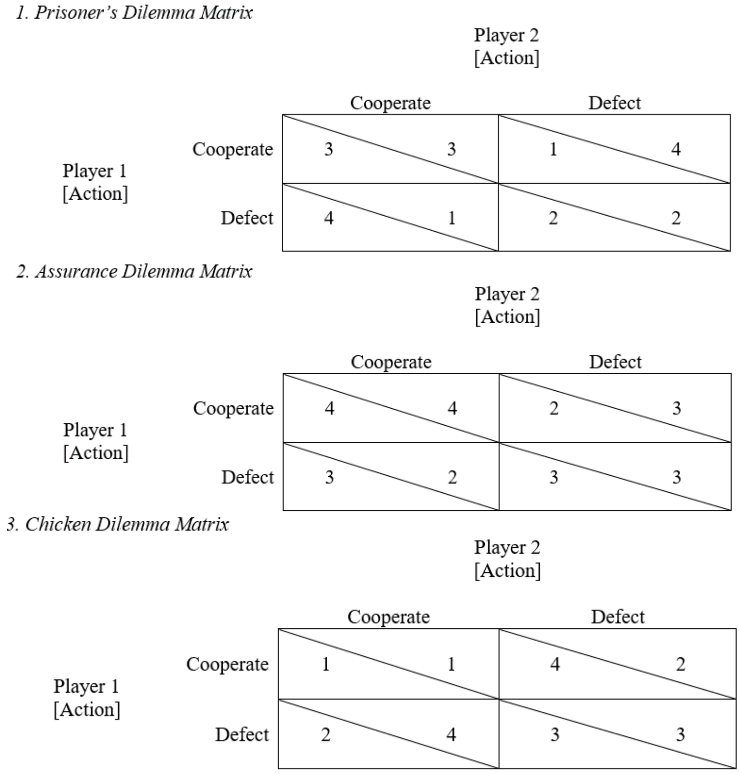
Despite its limitations, Game Theory provides a parsimonious basis for understanding human interaction. Novel domains such as cybersecurity can benefit from adopting these approaches. Cybersecurity research has typically considered only computer hardware, networks, and the technical aspects of software. Users' decision-making processes, beliefs and attitudes have only recently become the focus of cybersecurity research. In the current study, participants were presented with cybersecurity scenarios ('cyber hygiene') that defined three kinds of social dilemmas: Assurance Dilemma, Chicken Dilemma, and Prisoner's Dilemma. Within each social dilemma participants were asked if they would cooperate by performing three cybersecurity tasks: report a suspicious email, run an antivirus scan, and take a cybersecurity course. The results of the present study revealed that while social dilemma type affected cooperation rate, the cybersecurity tasks did not. We additionally found that individual differences were important mediators of the cooperation rate.

Novel domains such as cybersecurity are often seen as presenting unique problems. However, beyond the hardware and software, the behaviour of attackers and security analysts can be captured using social dilemmas (for a review, see Schoenherr & Thomson, 2020). While cybersecurity has typically been framed in terms of the Prisoner's Dilemma, this social dilemma structure only captures adversarial situations and fails to account for other possible social dilemmas that promote cooperation (Amini & Bozorgasl, 2023; Buchanan, 2016; Cavelty, 2014; Chukwudi et al., 2017; Kostyuk, 2013; Sokri, 2020). The purpose of the present study was to examine whether differences in cooperation rate in a cybersecurity task were affected by a) different social dilemmas, b) game framing, and c) task framing.

Theories of Games and Social Dilemmas

Game Theory and related theoretical approaches (e.g., Interdependence Theory) have proven to be invaluable conceptual models to understand rational choice in any social setting (Balliet, Tybur, & Van Lange, 2016; Kelley & Thibaut, 1978; Komorita & Parks, 1996; Luce & Raiffa, 1957; Rapoport & Guyer, 1966; van Dijk & Wilke, 2000). A basic assumption of early research on social dilemmas is that there is an optimal pattern of responses for each dilemma type (Mailath, 1998). According to Game Theory, if all players are rational agents, they will adopt a strategy such that no other responses would produce an optimal outcome (e.g., Nash Equilibria; Myerson, 1999; Nash, 1950; (Yin, et al., 2010). In the simplest case, game theoretical approaches have been used to model two-person, two-option games, with other studies demonstrating that these models can be generalized to other domains (for reviews, see Sally, 1995). Many social situations can be described using this model. For instance, in addition to the Prisoner's Dilemma which places individual and collective interests into competition (e.g., biasing responses toward defection), the Assurance Dilemma describes a scenario wherein individual and collective interests are complimentary (e.g., biasing responses toward cooperation; see Figure 1).

Despite its elegance, Game Theory has its limitations, with early studies demonstrating violations of rational behaviour that were not accounted for with these models (Rapoport, 1965). Subsequent studies have demonstrated that many factors can affect suboptimal responses strategies. For instance, how a social dilemma is framed can influence a person to adopt a suboptimal response strategy (Fleishman, 1988). Collectively, these discrepancies are referred to as the Description-Experience Gap (DEG; Wulff, Mergenthaler-Canseco, & Hertwig, 2018). The DEG assumes that the game is *described* using pay-off matrices in terms of gains or losses incurred by each player based on their choices. In contrast, players' prior *experience* might suggest typical response strategies (e.g., norms of cooperation and competition) which might be weighted more highly than information obtained from pay-off matrices. For instance, participants show more cooperation within the Prisoner's Dilemma if it is framed as the "Community Game" than if they are told that they are playing the "Wall Street Game" (Liberman et al., 2004).



1. Prisoner's Dilemma Matrix

Player 2 [Action]

Player 1 [Action]	Cooperate	Defect
Cooperate	3 \ 3	1 \ 4
Defect	4 \ 1	2 \ 2

2. Assurance Dilemma Matrix

Player 2 [Action]

Player 1 [Action]	Cooperate	Defect
Cooperate	4 \ 4	2 \ 3
Defect	3 \ 2	3 \ 3

3. Chicken Dilemma Matrix

Player 2 [Action]

Player 1 [Action]	Cooperate	Defect
Cooperate	1 \ 1	4 \ 2
Defect	2 \ 4	3 \ 3

Fig. 1. Pay-off matrices reflecting the Prisoner's Dilemma, Assurance Dilemma, and Chicken Game.

Present Study: The Social Dilemmas of Cybersecurity

As a field, models of cybersecurity have become increasingly aware that simply studying the hardware and software used for network defence is insufficient to ensure effective network protection. Cybersecurity analysts that have acknowledged the utility of game-theoretic approaches have focused exclusively on the Prisoner's Dilemma (PD). (Sokri, 2020; Kostyuk, 2013; Chukwudi, Udoka, & Charles, 2017; Buchanan, 2016; Cavelty, 2014) or Stackelberg competitions (von Stackelberg, 1934; Yin, Korzhyk, Kiekintveld, Contizer, & Tambe, Stackelberg vs. Nash in Security Games: interchangability, Equivalence, and Uniqueness., 2010) which model optimal distribution of limited defensive resources, assuming that defenders and attackers take turns.

The present study examines whether social dilemma theory can be applied to cybersecurity domains (Schoenherr & Thomson, 2020). Participants are presented with three ‘cybersecurity tasks’ that described three cyber hygiene behaviours (reporting an email, running an antivirus scan, or taking a course; *task-type*). Participants were either told that the task was a ‘Business Game’ or a ‘Community Game’ (*framing*) and were presented with pay-off matrices that described three kinds of social dilemmas (*dilemma type*) described in Figure 1. While we expected that participants cooperation rate should differ based on social dilemma type, we did not assume that framing or task type would alter cooperation rate.

Method

Participants

Sixty-eight Carleton University undergraduate students participated in this study. They received 0.5% toward in-course credit.

Materials

Materials consisted of demographic questionnaires, an individual differences survey, and a social dilemma task.

Individual Differences

Higgins et al.’s (2001) Regulatory Focus Questionnaire was used to assess individual differences in regulatory focus. The questionnaire has eleven items that assess prevention and promotion focus. Each item is on a 5-point Likert scale with (1) representing “never or seldom” and (5) being “very often.” Personality scales assessing facets of conscientiousness and openness of the Five-factor Model was also included. The cybersecurity questionnaire (Schoenherr & Thomson, 2021; see also, Schoenherr, 2022, in preparation;) were also included. These results were not included in the analysis.

Social Dilemmas and Payoff Matrices

Three sets of payoff matrices were provided to participants corresponding to three prominent social dilemmas (see Figure 1). The task was framed as an Employee Reward Systems (ERS) in participants' interactions with co-workers would be rewarded to varying degrees based on the ERS (pay-off matrices) used on any trial.

To reduce variability in the data set, each of the nine types of social dilemmas (3 payoff matrices x 3 difficulty levels) was presented 4 times. For each of the replications, a different employee name was used for each co-worker, i.e., Mark, Bob, Kim, and Anna. Thus, the payoff matrices, task difficulty, and the number of replications will create 36 stimuli.

*Manipulation Check***.** Two manipulation checks were included to ensure that participants understood if they were playing the Community Game or Business Game. The check asked the participants what game they were playing and gave them several choices to pick from.

Procedure

Consent was obtained through Qualtrics.com. Following completion of the informed consent, individual difference questionnaires were administered. Participants were then presented with a general set of instructions that included framing information concerning the Business Game or Community Game. Participants were also instructed to attend to the different payoff matrices they would be presented with, framed as “Employee Rewards Systems.” Each block of trials presented participants with a different pay-off matrix, where the instructions emphasized the name of the game, i.e., Community Game or Business Game.

Within a block of trials, participants were randomly presented with one of three kinds of cybers hygiene tasks: reporting a suspicious email, running an antivirus scan, and completing a cybersecurity module. The pay-off matrix remained on the screen with the options changing depending on the task. The participants were not provided with feedback about their co-worker’s decision after each task to avoid turning the replications into an Iterative Prisoner’s Dilemma.

Results and Discussion

A 2 (variable: levels) x 3 (variable: levels) x 3 (variable: levels) mixed effect repeated-measures ANCOVA was conducted using SPSS. The Community/Business Game frame are variables that were tested between-subjects, while Task Type and Social Dilemma Type were within-subjects variables. The covariate in the ANCOVA was the participant’s regulatory focus and facets of conscientiousness (orderliness and achievement/striving) and openness (intellect).

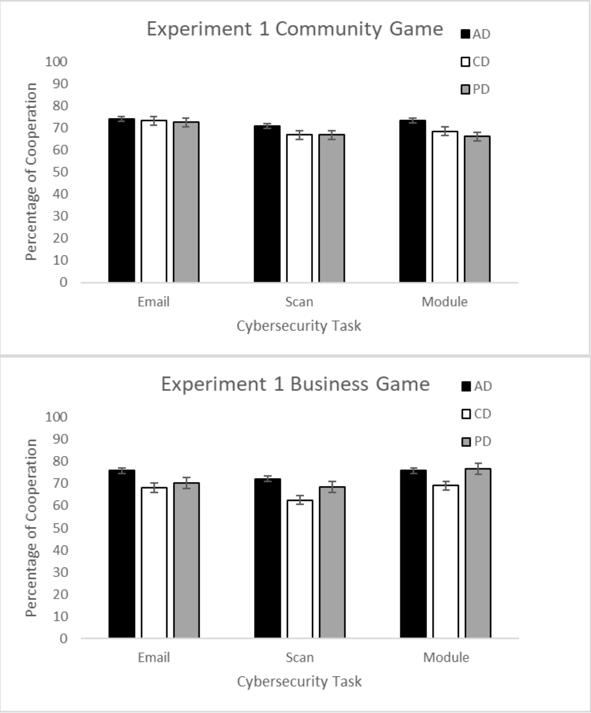


Fig. 2. Mean cooperation for cybersecurity tasks within the Prisoner’s Dilemma, the Assurance Dilemma, and the Chicken Dilemma.

Preliminary analyses assessed whether the inclusion of the covariates was necessary. Both in the absence of the inclusion of any covariate or whether regulatory focus was solely included did not yield any significant results (e.g., Sheen, 2023). The absence of significant results for social dilemma type were particularly concerning given the robustness of these patterns reported in other studies.

In a final analysis, we used the manipulation check to remove participants who did not accurately identity the framing either before or after the primary task. We additionally included individual difference measures (i.e., facets of conscientiousness and intellect, regulatory focus), and into the analysis as covariates to remove any additional extraneous variations. Only under these conditions did we final obtain significant results such that a significant interaction was obtained between Dilemma Type, Instruction, and Manipulation Checks, *F*(2, 110) = 4.33, *MSE* = .115, *p* = .017. This interaction qualifies the simple interaction of Dilemma Type and Intellect, *F*(2, 110) = 3.91, *MSE* = .115, *p* = .025, and a marginal interaction of Dilemma Type and Instruction, *F*(2, 110) = 2.69, *MSE* = .115, *p* = .076. As Figure 2 suggests, participants were the most cooperative when presented with the Assurance Dilemma and the least cooperative when presented with the Chicken Game, with the Community Game framing producing higher levels of cooperation.

Conclusion

Cybersecurity represents a social domain like any other. The present study replicated the results of previous studies suggesting that pay-off matrices are a major determinant of participants willingness to cooperate. Our study also finds evidence that overall task framing affected cooperation rate. However, these results must be heavily qualified. We only obtained them once multiple individual differences measures had been controlled and a manipulation check had been used to disqualify participants who failed to attend to task instruction. Rather than being a concern for the materials, the results are most likely attributable to the modality of experimentation (online) as well as context effects (completion during COVID-19 lockdowns). Nevertheless, even under these conditions, we failed to find differences in cooperation rates between reporting emails, running anti-virus scans, and taking cybersecurity courses. This might suggest that motivation is primarily driven by pay-off matrices rather than any specific feature of the task participants were performing.

Cooperation rates were also quite high relative to previous studies. One possibility is that either the cybersecurity questionnaire (Schoenherr & Thomson, 2021) or the task framing (Employee Reward System) might have primed cybersecurity concerns and motivated cooperation with co-workers, respectively. Regardless, the possible influence of any one of these factors suggests that game theoretical approaches must account for individual differences related to the individual and task domain.

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ACTIVATION IN SUPPLEMENTARY MOTOR AREA, ANTERIOR CINGULATE CORTEX, AND INSULA DURING PRIMING AND FLANKER TASK: A SYSTEMATIC REVIEW

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Abstract

The present systematic review aims to answer the research question which brain areas are involved in visual response priming and how these might be modulated by the stimulus onset asynchrony (SOA) between flanker/prime and target. Hence, we aimed to provide an up-to-date synthesis of the studies using functional magnetic resonance imaging (fMRI) during priming and flanker tasks. Our focus is to identify and characterize the research period from 1996 to 2022 in order to capture the cognitive processes correlated with response activation by primes and flankers, the methodological specificities, and the main outcomes in adult samples without any diagnosis of psychological and neurological disorder. The review resulted in 16 studies using visual stimuli presented in a Flanker/Erikson paradigm or a priming task based on the search of PubMed and Scopus. While activations in different areas of the brain were identified, the most often reported activated areas are the supplementary motor area (SMA), anterior cingulate cortex (ACC), frontal gyrus, and insula. Interestingly, increased brain activity in additional visuomotor areas was observed in incongruent and congruent trials at SOAs longer than 100ms as compared to SOAs shorter than 100ms, as expected from a response conflict becoming more severe as the SOA progresses. These findings suggest that the SOA length plays a crucial modulating role in the activity of different brain areas during response priming and flanker tasks.

SYMPOSIUM ON “PSYCHOLOGICAL TIMES”

To some extent, the question of time can be addressed by psychophysicists in the same way that sensory modalities are. For instance, psychophysical methods can be used to determine such things as the suitability of Weber’s law or Stevens’ law. But the question of time remains fundamentally different, primarily because it lacks a “genuine temporal stimulus”, “temporal receptors”, and even a cortical area dedicated to processing time, as is the case, for instance, with vision or audition. During this symposium, after a presentation dedicated to the place of the temporal experience in psychological science and in science at large, there will be presentations on methodological issues in the study of psychological time, followed by a presentation on the impact of altered states of consciousness on psychological time and the self.

The first presentation, by Mark Elliott, from the University of Galway (Republic of Ireland), will invite ISP members to deepen their understanding of time. He will explain in what treating time as the subject of scientific enquiry might cause problems, and how we can experience events in future time, i.e., with an event structure separated into past, present, and future.

Joseph Glicksohn, from Bar-Ilan University (Israel), in collaboration with Tal Dotan Ben-Soussan (who is hosting this meeting), will focus on the analyses of results in a classical time production task. They will show how to visually detect outliers using the power function that relates produced duration to target duration and examine 1) the negative correlation between intercept and slope values after computing the linear regression on the log-transformation data, 2) the negative correlation between the exponent and the constant after using nonlinear regression, and 3) the positive correlation between the exponent and the slope.

Simon Grondin, from Université Laval (Québec), will address the question of expertise of musicians in processing temporal information. After showing that there are reasons in the literature to raise this question, old and new data from the laboratory will provide different methodological angles to provide elements of responses regarding this expertise.

Yoshitaka Nakajima, from the Sound Corporation and Kyushu University (Japan), in collaboration with Emi Hasuo, also from Kyushu University, will show the extent of discrepancies between physical and subjective time one has to deal with when processing auditory temporal patterns. With the help of auditory demonstrations, they will explain different instances of time warp, both impressions of shrinking or lengthening of time intervals.

Finally, Marc Wittmann, from Institute for Frontier Areas of Psychology and Mental Health in Freiburg (Germany), will take us on the paths of altered states of consciousness. He will explain to what extent the experience of time and self can be distorted using a variety of techniques. These techniques are the use of a rhythm game in virtual reality, of a visual and auditory Ganzfeld, of meditation, and of a floatation-REST experience.

MURKY MENTALISM FIGHTS BACK

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Abstract

The ideas of dimensional time, i.e., time as experienced flow, and of a zero to n-dimensional space time are by no means new. Both ideas first appear in proto-European thought in the fragmented writings of Heraclitus in or around the 5th century BCE. The proximity of these ideas to concurrent Hebrew ideas of time (related ultimately, according to some, to Mosaic teachings) suggest the Greek and subsequently influential Latin ideas of time (particularly those expressed in Marcus Aurelias' Meditations) emerged from the prehistoric Egyptian mystery tradition. Ancient Egypt is known to have initiated several presocratic Greek philosophers before their return to the Hellenic world (Waterfield, 2000).

In the ancient concept of time, 'experienced time' was held to exist as a past, a present and a future within which changes or movement occur and time is experienced as a non-stationary present moment. This idea of time concerns the physical or, to us, the 'knowable' world. In addition to the knowable, there was an infinite space-time with no beginning or end, of which only a fraction becomes experientially manifest as experienced time. Hinging upon the interpretation of Aristotle who argued in Metaphysica that an infinite future time could only exist in principle and therefore not substantially (Smith and Ross, 1908), infinite space-time was preserved in Western thought as the literal metaphysics expressed in Plato's Timaeus. However, and whilst expressible, there is nevertheless no possibility for us to 'know' or to be able to measure this all-encompassing instance of time. Infinite time is consequently dimensionless but nevertheless superordinate to time as flow, which relates more directly to experience of the physical world and is inherently psychological. In addition, in early Hebrew, and in the Neoplatonic and Gnostic schools of thought, although infinite time is unknowable to us, it might be 'knowable' in different ways by sentient entities outside of our existential frame of reference (ultimately by God). Although not directly relevant to the topic as presented here, the importance of this idea lies in the acknowledgement that there is something other than the anthropocentric, existential 'I' that has 'knowledge' of time.

Our present discussion of psychological time occurs in the common scientific framework defined by physics. The entry of time into the calculus of physics could only occur post enlightenment. Nevertheless, the idea of science is ancient and the groundwork for the entry of time into physics was laid originally by Aristotle. In Physica, Aristotle explicitly identified the idea of time with movement, and in turn with the flow of event structure. Important for the present discussion is the influential interpretation of this provided by Thomas Aquinas. St. Thomas clearly interpreted the Aristotelian idea of time flow as existing only in the experience of the soul (Hardie and Gaye, 1930; Snyder, 2000. Also note the Neoplatonist, Plotinus in Enneads stated explicitly some 1,400 years earlier that 'There is for this universe no other place than the soul or mind' and 'We should not accept time outside the soul or mind', see Schopenhauer, 1851). So, by the late Middle Ages, the eternal quality of time, whilst still present in cosmological theory, had become secondary as an understanding of physical time in terms of the anthropocentric and mental experience of time flow. Given his role in reconciling Christian dogma with Aristotelian logic, the influence of St. Thomas cannot be underestimated, and by virtue of his interpretation the case is re-presented to consider time as primarily a psychological phenomenon.

For the sake of brevity, I skip past several thinkers on time from the Middle Ages to the present day. In the broader context there are thinkers on persistence through time and it is not possible to deal exhaustively with this topic in this contribution. The reader is referred to Haslanger (2003) for a review. In addition, and more specifically, are a set of ideas considered of relevance (i.e., Locke, Newton, Leibnitz, Kant, reviewed by Benjamin, 1966). These tend to concur with the idea preserved by St. Thomas that time is experienced as flow and flow concerns the mental experience of movement or change. Unfortunately, this provides us with a problem if we are to treat time as the subject of scientific enquiry.

The problem is twofold: first modern theoretical physics defines experienced time as illusory because it is essentially dimensionless. This is because 4-dimensional space time specifies that all events possess the same ontological status and are inseparable into past, present, or future (see, Poincaré 1900; Einstein, 1905). In addition, this effective absence of dimensionality for experienced time is physical and not metaphysical. Consequently, experienced time cannot be an operational variable in the calculus of physics, and it can have no basis for consideration outside of physics either. Nevertheless, we still experience time as a nonstationary ‘moment now’ bridging future with past. The problem for physics is partly retrieved by assuming observations across a very small spatial scale will provide a measure of the experience of time flow as we know it. This is the reasonable compromise accepted by almost everyone. However, it is a compromise and the problem remains that the assumption of infinite space-time remains the province of theoretical physics, which, paradoxically, seems to prohibit an overarching, and strictly scientific definition of experienced time.

Secondly, the problem refers to Feynman’s complaint that analysis of experienced time depends upon “murky notions of mentalism” (Gleick, 2011, on Feynman, 1963). Experienced time generally entails that time is experienced in mind, and murky mentalism is another way of saying that mind-matter dualism is inadequate for scientific purposes. If we assume this to be a problem, it is a) not resolved by empirical observation, because the observer’s report of their experience is based upon the mental and so is non-defeasible; b) additionally, it is not resolved by correlational methods such as brain imaging, for which, brain data require a variable with a-priori validity to correlate with; in addition c) whilst models of psychological time rely upon empirical, and defeasible behavioral or event data, they still rely upon the reported experience of event structure to make sense in terms of experienced time flow.

But a great deal of psychological science relies upon murky mentalism, so much so that major psychological theories such as Gestalt theory premise on the validity of the phenomenal. It could be argued that the inherently non-physical defines a major remit of psychological science, which by Aristotle’s definition can still be referred to as science. In the present context, around 2,500 years of thought on the phenomenology of time broadly concurs on the idea that experienced time, including the non-stationary ‘now’, is valid, existent and not illusory. This tends to suggest that the most sensible solution to the problem of the scientific definition of time is to declare the criteria set by physics to be an overreach and not appropriate for the task of explaining the experience of time.

But this does not help inasmuch as it does not bridge the mind-matter divide. So here is an alternative proposition: This proposition refers to the idea that time might be experienced, and indeed the way time is processed can be measured in entities other than the existential ‘I’. Rather than appealing to God, I set my sights rather humbly to Elliott (2014), who showed that during the implicit coding of a repeating temporal sequence, a sequence presented so rapidly that its event structure was experienced but non reportable, not only was the timing of the sequence faithfully coded, but the coding mechanisms advanced in time their response to events in the sequence relative to those events. In this instance and without explicit report, or conscious experience of event structure, cognitive systems advanced their response in such a manner that event-related cognition occurred slightly ahead in time of the event to which it responded. It cannot be claimed that the observer has conscious access, that they can report anything as experienced by the ‘I’, or that their first-person experience of derivative events occur in future time. However, this evidence nevertheless shows that experience in the receiver can operate in future time, and to make this claim, one must adopt the position that in order to do so it is the system as an ‘entity’ that experiences events in future time, and consequently, event structure is separated into past, present and future. [For a related discussion based upon the role of neural oscillation in perception, the reader of referred to Communication Through Coherence (CTC) theory by Fries, 2015].

In conclusion, science need not throw out the baby with the proverbial bathwater. Instead, the variables used to define temporal experience need to be examined carefully, and broadened appropriately and not put into a conceptual frame of reference to which they do not fit. Of course, this is a problem for the strictest definition of science, but not necessarily for psychology. Psychological science might accept it occupies a position that is a challenge to this strictly reductionist scientific agenda. And this said, it might be content to define its own validity regardless. In this enterprise, there has been consistent support on what defines experienced time for a very long time.

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VISUALLY DETECTING OUTLIERS IN A TIME PRODUCTION TASK

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Abstract

We present three methods by which outliers appearing in time production may be visually identified. Given the power function relating produced duration (P) to target duration (T), on log-transforming the data and then computing the linear regression of log(P) on log(T), the intercept and slope values are negatively correlated. Outliers in this scatterplot will be readily noticed, and this is the first method employed. The second method is the identification of outliers in the data following the use of nonlinear regression to compute this power function. A negative correlation between the exponent and the constant should be found, relative to which outliers can be identified. The third method is based on the positive correlation between the exponent and the slope, relative to which outliers should also be identified.

As is well known, outliers in one's data should be identified and then removed prior to any further act of data analysis (Judd et al., 1995, pp. 453-454). Well, not always, because sometimes it is important to reflect on the location of such outliers in a visual representation of the data, such as when using multidimensional scaling (for an example of such a case, see Naor-Ziv et al., 2020, p. 35). Consequently, outliers should be extensively investigated. Thus, though specifically writing about cluster analysis, Aldenderfer and Blashfield's (1984, p. 61) comments have general relevance:

> It is important to remember that outliers are not simply aberrant cases, but may in fact be representatives of poorly sampled subgroups of cases. Therefore, the obvious solution to this problem, the discard of these cases, should not be the routine solution. Whatever their interpretation, outliers should be identified before cluster analysis is used, and each should be carefully evaluated to determine the reason it is so different from the other cases.

Nevertheless, it is standard practice to simply remove outliers, to report the criteria by which such outliers were identified, and to indicate the number or percentage of such outliers detected in one's data. Thus, for example, using a task of time production (which is the focus of the present article), Fortin and Breton (1995, p. 206) reported that "The means and standard deviations of the temporal intervals and response times were computed for each subject, and any responses more than four standard deviations from the means were discarded; 12 outliers were eliminated in the response time data set, and 19 in the temporal production data set."

And yet, as André (2022) has recently noted, such standard practice has been tweaked in a number of studies, wherein the outliers are identified, and subsequently discarded, from *particular* cells (or groups) of the experimental design, relative to such cell- (or group-) data. André (2022) has cautioned researchers to handle outliers without taking into consideration either the hypothesis under investigation, or the nature of the experimental design, because outliers should be assessed relative to the *complete* data set. A neat way of viewing how outliers might influence such a complete data set and one's findings is to consider that, for example, an A × B interaction in a standard A × B analysis of variance (ANOVA) might in fact be the resultant of the presence of such outliers (Brown, 1975), and that on removing the outliers, a simpler additive model could be fitted to the data, as Brown (1975) has demonstrated. Consider, for example, how much easier it would be to fit an additive model of, for example, stimulus congruity and S-R compatibility to performance on a Stroop-like task, if this is what is actually hypothesized (Zakay and Glicksohn, 1985), than to explore their possible interaction (see Vellan and Leth-Steensen, 2022, for a recent detailed exposition regarding such a type of investigation). Or, closer to the study of time production, consider the fit of an additive model to subjective duration data (Blankenship and Anderson, 1976).

True, the detection of a particular cell of the factorial design which becomes the locus of an ordinal interaction, is of theoretical importance (see, e.g., Glicksohn et al., 2007, for an example of this). Nevertheless, this might also suggest (in line with Brown's, 1975, analysis) the existence of outliers in that particular cell—and that option should first be ruled out. The arsenal that can be used in one's study to identify outliers include: the use of statistical procedures to screen for outliers in a distribution (e.g., van Selst & Jolicoeur, 1994); the option to gather additional observations prior to concluding that that there is an outlier in one's data (Wichmann and Hill, 2001, p. 1310); and the use of diagnostic scales to detect discrepancies in the data that will be subsequently classified as outliers (Lilienfeld et al., 2014, p. 4). In addition to these, as we shall show in the present paper, it is the *visual* detection of outliers, such as those appearing in a task of time production, that is worthy of study.

Methods and Results

Our goal is to propose three methods to identify such outliers, visually, based on linear regression (method 1) and nonlinear regression (methods 2 and 3). We employ two different data sets to this end. The first comprises an intensive study of time production, using target durations of 1, 2, 4, 8, 16, and 32 seconds. These durations were produced by pressing and then releasing the 'enter' button on a keyboard for each target duration. These were produced by a single participant, who was exposed to various combinations of visual and auditory flicker stimulation during the task. Each target duration was produced 6 times within a session; and there were a total of 48 different sessions. A detailed presentation of this study has been recently published (Glicksohn & Weisinger, 2022). Here, we look at the complete data set, comprising 288 data points, to demonstrate our first method of visually identifying outliers, based on linear regression. The second data set derives from a study of time production, completed before and after exposure to whole body perceptual deprivation (WBPD) achieved by immersion in a chamber which was flooded with red light and indigo light (these two colored-light conditions were presented in a counterbalanced order across participants). In this study, 19 participants produced target durations of 4, 8, 16, and 32 seconds, before and after immersion in the WBPD chamber. A detailed presentation of this study has been recently published (Glicksohn, Berkovich-Ohana, Mauro, & Ben-Soussan, 2017). Here, we look at the complete data set of 38 data points, to provide a further demonstration of the visual detection of outliers, based on linear regression (method 1), and complement this using two methods to visually detect such outliers, based on nonlinear regression.

Given the power function relating produced duration (P) to target duration (T) being $P = aT^{\beta}$ (e.g., DeCarlo, 2005), a standard approach has been to first log-transform the data, and then compute what is now the linear regression of $\log(P) = \log(a) + \beta\log(T) = \alpha + \beta\log(T)$, α being the intercept, and β being the slope (Glicksohn & Hadad, 2012). Of course, at this stage of the analysis, any point from a particular individual's data, which deviates from this linear regression, would be readily identified and removed, prior to computing the individual regression line and its parameters. This is standard practice. We are therefore assuming that the individual intercept and slope values can be empirically justified.

The first method builds on this linear regression, and had originally been outlined in connection with the relationship between impulsivity and time perception (Glicksohn, 2002, pp. 15-16): For any such linear regression, where $T > 1$, as here, these intercept and slope values are themselves negatively correlated (DeCarlo, 2005, p. 890; Glicksohn, 2007, p. 155; Rule, 1993, p. 441). Any data point deviating from this linearity will be readily noticed, and if this point is quite removed from the regression line, then one can identify the data point as being an outlier. In the context of that discussion (Glicksohn, 2002), such outliers could be subsequently investigated for both trait and cognitive impulsivity. This idea, however, is a general one for identifying outliers in the data. We can exemplify this by means of Figure 1, using the first data set (Glicksohn and Weisinger, 2022), which comprises a total of 288 linear regressions for the same participant, each providing both slope and intercept values. As can be clearly seen in Figure 1, the intercept and the slope values in the data set are strongly and negatively correlated [n = 287 (due to missing data), r = -.81, p < .001], their scatterplot is highly and tightly linear, and there are two data points which are clear outliers. Note the triangulation of: (1) extreme values of these two data points in the distribution of the slope, which would be readily detected using a standard statistical procedure for determining marked distance from a measure of central tendency; and (2) their marked deviation from the regression line. The negative correlation is slightly increased on removing these two points (r = -.85).

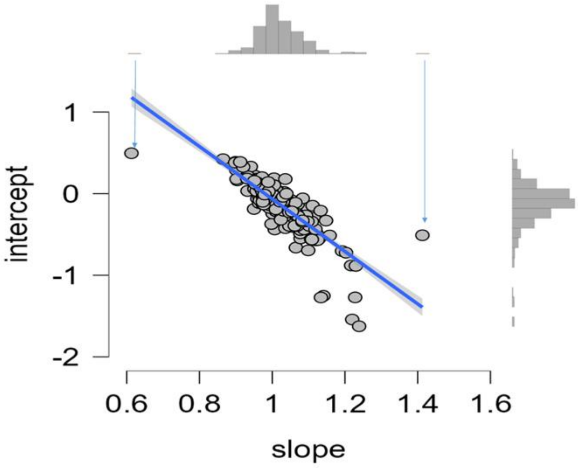

Fig. 1. Slope and intercept values of the psychophysical function for time production for one participant, each determined 288 times. Respective histograms appear in the margins.

There are a number of other data points, worthy of further investigation—and again note the triangulation of an extreme value in the distribution of the intercept, coupled with a marked distance from the regression line. Given that this is a group of outliers, in line with Aldenderfer and Blashfield's (1984) comments, cited above, this may constitute an important subgroup of cases worthy of further study. In any event, our goal in this paper is to demonstrate the feasibility of this method for visually detecting outliers in one's data. In this vein, we now turn to our second data set. Figure 2 is the scatterplot for the intercept and the slope for the data of our 19 participants, each producing the target durations pre-WBPD and post-WBPD (hence n = 38 separate regression lines). Note that this is a much sparser data set. Again, as expected, the correlation between the slope and the intercept is significantly negative (r = -.51, p = .001), the scatterplot exhibits linearity, and one data point (S3, pre-WBPD) is a clear outlier. On removing this participant from the analysis (both pre- and post-WBPD data), the correlation is greatly increased (r = -.74, p < .001). As before, there are a number of other data points, worthy of further investigation. For present purposes, the feasibility of adopting method 1 to visually detect outliers in one's data set has been demonstrated.

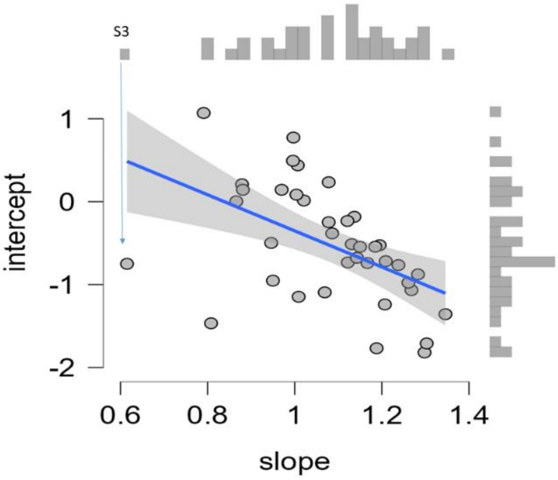

Fig. 2. Slope and intercept values of the psychophysical function for time production for 19 participants, each determined both pre- and post-WBPD. Respective histograms appear in the margins. One outlier (S3) is identified.

The second method we employ is based on the use of nonlinear regression to compute the power function relating produced duration to target duration, namely $P = aT^{\beta}$, as above. In line with Kornbrot's (2016) explication of this model, her presentation of this power function as $P = a(T-b)^{n}$, and her implementation of the initial values of $a = 1$, $b = 0$, $n = 1$, we can compute both the exponent (n) and the constant (a), using the nonlinear regression function of the Stata statistical package. Methods 2 and 3 for identifying outliers in one's data set build on these indices. Method 2 is based on the logic that for the same data, analyzed using both linear and nonlinear regression, the exponent of the power function should be positively correlated with the slope of the log-log plot, as should the constant and the intercept, respectively. Hence, we should see a negative correlation between the exponent and the constant across participants, relative to which outliers can be identified. Method 3, in turn, is based on the positive correlation between the exponent and the slope, relative to which outliers should also be identified.

Figure 3 is the scatterplot for the constant and the exponent deriving from our second data set, following this nonlinear regression. The correlation between these is significantly negative, and to the same degree ($r = -.54$, $p < .001$) as that reported above between the slope and the intercept of the linear regression. Two data points are clear outliers in this scatterplot, and these are the pre-WBPD and post-WBPD values for participant S5. On removing both this participant and S3 (in line with Figure 2), the correlation is greatly increased ($r = -.74$, $p < .001$). Figure 4 is the scatterplot for the exponent and the slope for these data, prior to removing both S3 and S5, presenting the positive correlation for these two indices ($r = .52$, $p < .001$). In this scatterplot, we indicate two of several plausible outliers (S14, post-WBPD, and S15, post-WBPD). On removing these two participants, together with S3 and S5 (in line with Figures 2 and 3), our n is now 30, and the positive correlation for these two indices is slightly increased ($r = .57$, $p < .001$). While one could continue with this procedure to identify further potential outliers in the data, one goal in this paper is to show the feasibility of Method 3, as of Methods 1 and 2. Hence, as we have shown using the second data set, we sequentially identify, visually, four individuals presenting us with outliers: S3 (identified in Figure 2); S5 (identified in Figure 3); and both S14 and S15 (identified in Figure 4).

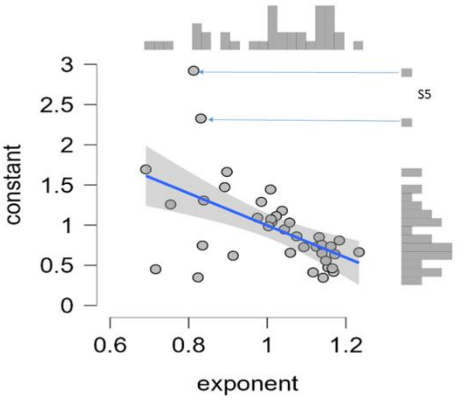

Fig. 3. Exponent and constant values of the psychophysical function for time production for 19 participants, each determined both pre- and post-WBPD. Respective histograms appear in the margins. One outlier (S5) is identified.

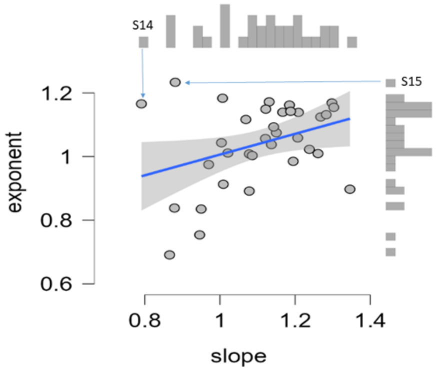

Fig. 4. Slope and exponent values of the psychophysical function for time production for 19 participants, each determined both pre- and post-WBPD. Respective histograms appear in the margins. Two outliers (S14 and S15) are identified.

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EXPERTISE ON MUSICIANS IN PROCESSING TEMPORAL INFORMATION

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Abstract

There are reasons to doubt the trainability of temporal processing capabilities, at least if training is expected to be transferred from one sensory modality to another, or from one duration range to another (Grondin et al., 2008, 2009; see Grondin, 2020). However, there are reasons to believe that people who receive extensive musical training are more apt at processing temporal information (Rammsayer and Altenmuller, 2006). This conclusion seems to apply, for instance, to the discrimination of time intervals marked by auditory or visual signals (Rammsayer et al., 2012), but maybe not to conditions implying tactile signals (Güçlü et al., 2011). Even for a tapping task, Madison et al. (2013) report that giving nonmusicians even a slight training can lead them to reach the level of musicians.

In this presentation, studies conducted at Université Laval on temporal processing in nonmusicians vs. musicians are reviewed. In these studies, a variety of methods was used. These methods include the capability to discriminate tempo variations of a musical excerpt (Grondin and Laforest, 2004) and the capability to keep track of very long intervals using a singing and a counting strategy (Grondin and Killeen, 2009). The results of more recent data are also presented. In one study, the strategy described in Grondin et al. (2015) is used and shows that the capability of musicians to maintain a stable counting pace is superior to that of non musicians, and this finding applies whether counting is aloud or not, and with an inter-count pace involving intervals below and above one second. In another recent study, this one on the discrimination of empty intervals marked by two brief signals (Auditory, Visual, or Tactile), musicians are better in the AA, VV, and TT conditions, and in most intermodal conditions; moreover, this finding applies for intervals in the 250- and in the 1250-ms range. This variety of investigations leads to the conclusion that musicians are, in most cases, much better at processing temporal information.

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INEVITABLE TIME WARP IN MUSIC PERCEPTION

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Abstract

Music perception research is often closely related to auditory perception research, helping us to understand how humans perceive and produce sounds in realistic situations. Experience of time through the auditory modality is particularly important in music, and related psychophysical data have been cumulated (Grondin et al., 2018). A few such examples on auditory temporal patterns taken up here will show systematic discrepancies between physical and subjective time marked by very short sounds or sound onsets. It is sometimes difficult to find just one physical temporal pattern that matches a music notation. Such time warp makes musicians' job difficult but gives interesting materials to psychophysicists. A few auditory demonstrations will explain this below. 1) It is impossible to divide an empty time interval as short as 200 ms to make it perceived as divided in the ratio of 1:3 or 3:1 (Nakajima, 1987; Nakajima et al., 1988; see also Cheatham and White, 1954). 2) To divide an empty time interval into the subjective ratio of 1:3 or 3:1 and to divide it into the subjective ratio of 1:1:1:1 can result in different physical duration corresponding to 1 in these ratio expressions (Nakajima, 1987). 3) Illusory underestimation of an empty time interval preceded immediately by a shorter time interval—time-shrinking (Nakajima et al., 2004)—can occur or not occur depending on whether or not this two-interval pattern begins and ends in synchrony with beat sounds (Hasuo and Arao, 2020). 4) A time interval marked by the onsets of very short (click-like) tones can be lengthened perceptually by lengthening the second tone without changing the temporal position of its onset (Hasuo et al., 2012). 5) A temporally regular pattern can cause an impression of irregularity if mixed with another regular pattern of a different tempo in the same auditory stream. If these patterns are heard in different auditory streams, their regularity recovers, and to grasp the temporal relationship between the different auditory streams is often extremely difficult (a new demonstration based on van Noorden, 1975).

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SUBJECTIVE TIME AND SELF DURING ALTERED STATES OF CONSCIOUSNESS

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Abstract

The perception of time and self are modulated in altered states of consciousness (ASC), in extreme cases leading to a joint dissolution of these experiences (Wittmann, 2018). In a series of studies with a variety of techniques we investigated how the sense of time and self are relatively down-regulated in ASC.

(1) When playing the rhythm game Thumper in virtual reality (VR: n = 50) or on a computer screen (2D: n = 50) for 25 minutes, participants who experienced deeper flow states thought less about time and felt that time had passed more quickly. Individuals in VR performed better and had a stronger feeling of presence than in 2D (Rutrecht et al. 2021).

(2) The Ganzfeld is a homogenized visual and auditory perceptual field which induces ASC. We compared the experience of 67 participants during two differently colored, 25-minute Ganzfeld sessions with ‘brown noise’ as acoustic stimulation. Participants reported that the session with the green visual field seemed to last significantly shorter than the red session. During the green session, arousal levels were significantly lower, and individuals on average felt emotionally more positive (Kübel et al. 2021).

(3) Twenty-two highly experienced meditators (average 20 years of regular practice) perceived their body boundaries during meditation less strongly, paid less attention to time, and felt time pass more quickly than during a silent reading control session (Linares et al. 2022).

(4) Floatation-REST is a technique during which a person effortlessly floats in a dark, soundproof tank filled with water that is supersaturated with Epsom salt. Fifty individuals were exposed for one hour each to Floatation-REST and a Bed-REST control condition. Aside from a stronger induction of ASC as measured with the PCI questionnaire, Floatation-REST also led to a reduction in perceived body boundaries and a stronger loss of the sense of time than bed-REST (Hruby et al. 2023).

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MAGNETOENCEPHALOGRAPHY OF CHECKERBOARD SPEECH PROCESSING

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Abstract

Checkerboard speech is a degraded speech that is interrupted in time and frequency, such that its spectrogram looks like a checkerboard pattern. Its characteristic U-shaped intelligibility curves as a function of segment duration are consistent with two temporal windows that may correspond to neural oscillatory activity in the theta and gamma bands in speech processing. However, any direct evidence supporting the connection has not yet been provided. To elucidate the mechanisms underlying the perception of checkerboard speech, we conducted a magnetoencephalography (MEG) experiment. Thirty-two participants passively listened to checkerboard, temporally-interrupted, and just-filtered speech stimuli while MEG data were acquired through a 306-channel whole-head magnetometer (Neuromag, Elekta/MEGIN). The 54-seconds long speech stimuli were diotic collage of isolated sentences, originally extracted from recordings of several novels. The checkerboard speech stimuli were generated by filtering into 4, 8, and 16 critical frequency bands and temporally segmenting into 20-, 80-, 160-, and 320-ms segments with square-root-of-cosine ramps. The interrupted speech stimuli were made by filtering and segmenting. The just-filtered speech stimuli were produced by filtering and segmenting into 320-ms segments. The empirical intelligibility obtained with the same parameters (Doan et al., 2022, Fechner Day) for the individual speech stimuli was regressed by the stimulus parameters together with an estimator of speech envelope representation. The estimator was calculated first by separating the MEG data into epochs for the individual stimuli in the theta, alpha, beta, and gamma bands and by convoluting with the envelopes of the speech stimuli, to see if the estimator made additional contribution in predicting intelligibility. The estimated strength of the envelope representation significantly contributed to intelligibility only in the theta and gamma bands for the checkerboard speech. The effects appeared as a linear term in the theta band and as an interaction with the number of frequency bands in the gamma band. The estimator was not significant in any case of the interrupted speech. Because the perception of checkerboard speech stimuli requires grouping of speech cues in the spectrotemporal space, the correlated component of the MEG signal may point to the neural correlate of the processes for grouping in the two temporal windows. The source localization of the significant MEG component must therefore overarch the two sets of windows in physiology and psychophysics. Supported by Japan Society for the Promotion of Science (JSPS) KAKENHI Grant No. JP19H00630.

THE DIFFERENTIAL DIAGNOSTIC TECHNIQUE: A TEST OF AND FOR QUANTUM PSYCHOPHYSICS

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Abstract

The Differential Diagnostic Technique (DDT) follows some patterns of quantum physics; Feynman's path integral method and the Relativistic Possibilist Transactional Interpretation Theory (Kastner, 2019). The DDT is a visual-motor projective personality test objectively assessing straight and curved line variations when copying 12 geometric figures used to diagnose personality structure and functioning. The Rorschach is a visual, language based projective test widely used for diagnostics. Both were given together during each assessment (n = 1322). The Rorschach was quantized to include all transcribed responses (fireworks, human, bear, cat, foot, texturing, etc.), yielding 171 variables to be compared with 41 DDT indices. Of 1171 significant t-tests comparing frequencies, 16 DDT indices offered for 2 dependent Rorschach variables (eyes and crest) were examined to investigate internal versus external dependency aspects of personality. Intellectual Control (1), Impulsiveness (3), Dissociation, (3) summative Loss of Control (3) and Control Index (3) scores compared internal dependency (eyes) with external dependency (crest). In addition, stress (Memory) (3) as measured by the DDT, compared an individual's performance when unpredicted experimental circumstances of loss occur without prior notice. T-tests comparing "no response" versus "one or more" responses of "eyes" or "crest" Rorschach responses yielded similar patterns for each of the Intellectual Control, Impulsivity, Dissociation, Loss of Control and Control Index scores, suggesting that internalizing what one sees (eyes) while drawing complex geometric figures and relying on the group (crest) were similarly effective. In the Memory section, however, they differed. Only those who reported "eyes" showed findings under pressure, suggesting that "eyes" on the Rorschach also measure an ability to respond under pressure as drawn from internalizations, while those showing "crest" responses did not differ from their "no response" group. The DDT is discussed as a test of quantum mechanics and a method of identifying "psychological quarks".

Table 1: T -Tests Comparing “Eyes” and “Crest” from the Rorschach with DDT Indices

Rorschach variable “eyes”						Rorschach variable “crest”					
DDT	Frequency	*M*	*SD*	*n*	*t*	DDT	Frequency	*M*	*SD*	*n*	*t*
TIC	no value >	4.45	3.00	240		TIC	no value	4.74	3.07	923	
	zero	4.99	3.09	1082	-2.47		> zero	5.25	3.10	399	-2.74
TIMP	no value >	12.36	2.91			TIMP	no value	11.90	3.22		
	zero	11.59	3.22		3.40		> zero	11.34	3.05		2.98
HIMP	no value >	8.28	3.18			HIMP	no value	7.98	3.27		
	zero	7.72	3.24		2.42		> zero	7.45	3.12		2.65
PIMP	no value >	7.20	3.06			PIMP	no value	6.94	2.97		
	zero	6.71	2.93		2.37		> zero	6.47	2.90		2.64
MIMP	no value >	10.71	2.49			MIMP	no value	No finding			
	zero	10.25	2.74		2.39		> zero				
TDIS	no value >	5.88	3.60			TDIS(u)	no value	5.42	3.44		
	zero	5.12	3.24		3.24		> zero	4.86	3.00		2.99
HDIS	no value >	3.91	2.54			HDIS(u)	no value	3.64	2.65		
	zero	3.44	2.54		2.58		> zero	3.27	2.28		2.58
PDIS	no value >	2.01	3.00			PDIS	no value	1.59	2.38		
	zero	1.40	2.10		3.00		> zero	1.31	2.10		2.07
TLC	no value >	18.25	5.52			TLC	no value	17.31	5.66		
	zero	16.69	5.39		4.04		> zero	16.21	4.91		3.38
HLC	no value >	12.18	4.68			HLC	no value	11.57	4.93		
	zero	11.12	4.78		3.14		> zero	10.71	4.34		3.00
PLC(u)	no value >	9.14	4.81			PLC	no value	8.51	4.26		
	zero	8.09	4.01		3.16		> zero	7.75	3.98		3.03
MLC	no value >	18.82	5.58			MLC	no value	No finding			
	zero	17.84	5.94		2.33		> zero				
TI	no value >	-8.26	6.97			TI	no value	-7.00	7.23		
	zero	-6.21	7.14		-4.84		> zero	-5.61	6.84		-3.26
HI	no value >	-2.86	6.45			HI	no value	2.39	6.54		
	zero	-1.86	6.40		-2.19		> zero	-1.22	6.28		-3.07
PI	no value >	.46	6.80			PI	no value	1.30	6.35		
	zero	1.83	6.28		-3.04		> zero	2.27	6.47		-2.45
MI	no value >	-11.04	6.32			MI	no value	No finding			
	zero	-10.08	7.08		-2.09		> zero				

Note. (u) = unequal variances. TIC = Total Intellectual Control, TIMP = Total Impulsiveness, HIMP = Hostility Impulsiveness, PIMP = Passivity Impulsiveness, MIMP = Memory Impulsiveness, TDIS = Total Dissociation, HDIS = Hostility Dissociation, PDIS = Passivity Dissociation, TLC = Total Loss Control Score, HLC = Hostility Loss Control, PLC = Passivity Loss Control, MLC = Memory Loss Control, TI = Total Index, PI = Passivity Index, MI = Memory Index

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EFFECTS OF ANGLES AND MOTION LINES IN PICTOGRAMS ON PERCEIVED PRESENTATION DURATION

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Abstract

The duration of a moving object can be perceived as being longer than that of a static object when the durations are physically equal to each other. Previous research revealed that the presentation duration of a running man represented by a realistic stationary figure is also perceived as being longer than that of a standing man. Our purpose was to investigate whether perceived presentation duration is also affected for pictograms made of simple components by the implied speed in the pictograms. We created a pictogram representing a running man, and varied the angle of tilt from 0 to 24 degrees in steps of 8 degrees. We assumed that with increasing tilt, the implied speed of the running man would increase. The pictograms with the four tilt angles were individually presented with a presentation duration of 300, 600, or 900 ms. Participants were asked to evaluate the motion speed implied in the stimulus by providing a number. They were also asked to reproduce the presentation duration by pressing a key, making the key press duration subjectively equal to the duration of the presented stimulus. The results of the reproduction task showed that perceived stimulus duration and participants' evaluations of the implied speed increased with the angle of the pictogram. Furthermore, we investigated the effect of additional motion lines, representing a cognitive motion, on the perceived presentation duration. We measured the perceived presentation duration for a pictogram of a running man with motion lines and without motion lines (by masking the motion lines with orthogonal lines). The results showed no significant effect on the perceived duration between the with- and the without-motion-line stimuli. Together, this indicates that perceived presentation duration is affected by implied motion speed interpreted from body posture in simplified symbolic figures.

INTERRUPTED MOSAIC SPEECH REVISITED: A CURIOUS BIPHASIC EFFECT OF STRETCHING ON INTELLIGIBILITY

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Abstract

Periodicity and temporal fine structure provide a perceptual cue to connect speech fragments when the speech is interrupted. In mosaic speech stimuli, which are noise-vocoded with stepwise amplitude and spectral envelopes, interruption drastically reduces intelligibility because of lacking the perceptual cue. Here we show that the intelligibility of mosaic speech stimuli (20 frequency bands and 20-ms segment duration) declined from 95% to 78% and 33% by interrupting with 20- and 80-ms gaps but improved to 92% and 54% (+14% and +21% gains) by stretching mosaic segments and filling silent gaps (n = 21). By contrast, the intelligibility reduced to 9% and 15% (-7% and -5% gains) by stretching at the 160- and 320-ms original gap duration. The intelligibility minimums (9%-16%) were observed at the 160-ms original gap duration irrespective of stretching ratios. The modulation unmasking hypothesis was inconsistent with the biphasic effect on intelligibility by stretching mosaic segments and filling gaps. These results provided further evidence to be considered with the integration process of the temporal windows model in which short (~30 ms) and long (~250 ms) temporal windows worked in parallel and the probability summation model by which the intelligibility minimums were predicted.

ONSET AND OFFSET OF INHIBITION FROM MOTION MASKING DURING MOTION INDUCED BLINDNESS

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Abstract

When superimposed on global motion, stationary objects vanish from awareness – a phenomenon known as Motion Induced Blindness (MIB). Luminance contrast thresholds were used across two experiments to measure the offset and onset of inhibition created by the motion mask. In Experiment 1, thresholds were measured during the presentation of the mask and after the mask was removed to measure the resulting decay of inhibition. In Experiment 2, thresholds were measured thresholds before the mask was presented, during mask presentation, and after the mask was removed to measure the growth of inhibition due to the mask. In both experiments, higher contrast thresholds were observed in the presence of the mask compared to when the mask was not present, even within the span at onset and 20 ms after offset. These results indicate a rapid onset and offset of the inhibitory effect observed throughout the duration of the mask.

Motion induced blindness (MIB) is a phenomenon wherein salient visual targets stochastically disappear and reappear when superimposed upon a globally changing pattern such as motion (Bonneh et al, 2001). In a typical MIB experiment, subjects fixate foveally on a point while attending to one or more targets in the periphery while a mask of discreet elements (e.g., the black dots in Figure 1) move.

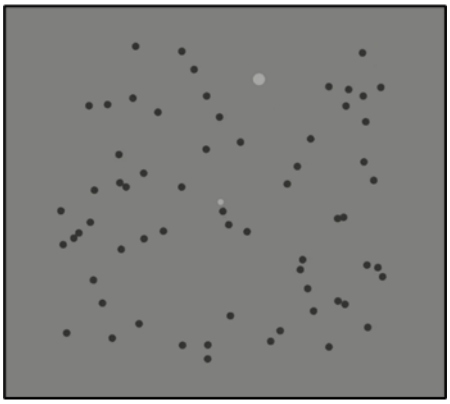

Fig.1. A typical MIB display with a motion mask (black dots) and a target (grey dot above fixation).

During an experiment investigating binocular rivalry, Grindley and Townsend (1965) serendipitously discovered MIB when they observed that a stimulus viewed by one eye vanishes upon moving a stimulus viewed by the opposing eye. In 2001, Bonneh and colleagues more formally tested and documented MIB, finding that total disappearance time is negatively related to target size and speed, and positively related to mask contrast, density, and speed. Interestingly, disappearance time is also positively related to target contrast. Although several methods of rendering stimuli perceptually invisible have been discovered, none of the factors that account for these disappearances can account for MIB. For example, perceptual disappearance also occurs in the form of Troxler fading, when a low contrast and retinally stable target with an indistinct boundary fades from view (Clarke and Belcher, 1962; Troxler, 1804). In addition to the positive relationship between target contrast and disappearance time that is unlike Troxler fading, several experiments have shown that MIB still occurs with both moving and flickering targets (Bonneh et al., 2001; New and Scholl 2008, 2018), indicating that different mechanisms must be engaging for these phenomena.

Contrast valence of MIB elements affects disappearance (Lombardo et al., 2021, Stine et al., 2017; 2022, White et al., 2020). Namely, decrement masks (negative contrast relative to the background) are more effective than increment masks (positive contrast relative to the background) at inducing disappearance of increment targets, and increment targets vanish more easily than decrement targets overall. Presumably increment elements stimulate ON-channels while decrement elements stimulate OFF-channels, resulting in the differential effects of increment and decrement elements. These findings may therefore reflect the importance of detecting decrements, given their prevalence in the environment.

Target disappearance is associated with both a drop in sensitivity to the target and an upward shift in detection criteria (Caetta et al., 2007), which can be modeled as response gain change (measured by brightness matching) combined with contrast gain changes (measured by contrast detection thresholds, Gorea and Caetta, 2009). Therefore, the contrast valence effects are to be expected if the motion mask alters contrast gain. In line with this view, the contrast threshold for increment targets increases when preceded by an increment dot in the same location as the target that is physically removed after four seconds (called an "inducer"; Lombardo 2021, Stine et al., 2022, White et al., 2020). One might expect that the mask-induced inhibition should dissipate over time, causing target contrast thresholds to decrease with inter-stimulus interval (ISI) between the removal of inducers and the onset of targets. Although Lombardo et al. (2021) found a small effect of inducer-target ISI at the smallest interval (500ms), presumably due to afterimages, Stine et al. (2022) and White et al. (2020) found no such effect of inducer-target ISI, indicating that the change in contrast gain is long lasting – once the inducers have been inhibited, that inhibition can be maintained by the motion mask.

The present study investigates the timing of the inhibition created by the motion mask. In Experiment I, luminance contrast thresholds were measured after the onset of the motion mask and after the offset to measure the decay of inhibition after removal of the motion mask. In Experiment II, luminance contrast thresholds were measured before mask onset, during the presentation of the mask, and after mask offset to measure the rise of inhibition due to the mask.

Experiment 1

Methods

Participants

Three females and two males, over the age of 18 with normal or corrected to normal vision, participated in the study. The study was approved by the University of New Hampshire Institutional Review Board.

Apparatus and Stimuli

Following Stine et al. (2022), stimuli were presented using a Dell Dimension E521 computer running Vision Works (Swift et al., 1997) in Windows XP drove an Image Systems M21L-H4101 monitor with a 120 Hz refresh rate. The monitor uses a monochrome P46 ultra-short persistence phosphor (yellow-green; CIE x = 0.427, y = 0.543), presenting 800 x 600 pixels with a pixel pitch of 120 dots per inch. Gray scale was rendered using a Vision Research Graphics Gray-Scale Expander VW16 to provide 15-bit linearized depth. A 50 cd/m2 background was continuously present. Negative contrast stimuli (decrements) were 0 cd/m2. The 21" flat-screen monitor was viewed at distance 1 m while using a chin rest.

One independent variable was manipulated, the moment of presentation of the target (0.50 s, 3.40 s, 3.45 s, 3.55 s, 3.60 s, and 8.10 s after the start of the motion mask). The target was a 16 arc-minute circular dot on a uniformly gray background. They were presented in a temporal Gaussian window (100 ms SD) for 200 ms. Both the mask and targets were decrements (negative contrast). The inducers were four deg of retinal angle from the fixation dot. The mask moved incoherently at 6.2 deg of retinal angle per s. All five subjects experienced each of the six conditions at least 20 times presented in random order.

Procedure

Sitting in a darkened room with their head stabilized by a chin rest 1 m from the monitor, each participant viewed the central fixation dot and adapted to the background luminance of the screen for five min. Following adaptation, each trial lasted 10 s during which the motion mask was visible for 3.5 s. At delays of 0.50 s, 3.40 s, 3.45 s, 3.55 s, 3.60 s, or 8.10 s after the start of the motion mask, the target was briefly flashed (250 ms) in one of four quadrant locations. After each flash an auditory beep indicated to the participant a brief response interval during which he or she could report the location of the target's flash using a keyboard. The participant received feedback after each response. The participant was instructed to maintain fixation on the centrally located fixation dot. A 12 s adaptation period followed each trial.

As a function of the time of target onset, the contrast of the target was varied following a weighted up-down adaptive psychophysical procedure (Smith, 1961; Kaernbach, 1991) to converge onto a 0.625 probability of a hit. The 3.40 s, 3.45 s, 3.55 s, 3.60 s presentation times for the target were randomly varied across trials while the 0.50 s and 8.10 s presentation times varied within trials.

Results

We fit a normal cumulative density function to the probability of a hit as a function of target log Weber percent contrast weighted by the number of presentations for each condition, which varied according to the weighted up-down procedure. The means and standard deviations from those fits served as our raw dependent variables. While analyzing these two variables independently, we chose a familywise type I error rate of 0.05 using the Šidák (1967) inequality (see Kirk, 2013, p. 183) with a Holm procedure (Kirk, 2013, p. 185-187). Only the analysis of the psychometric function means will be reported as the standard deviations did not vary systematically $(F(5, 20) = 2.33, ns)$.

We conducted a repeated measures randomized-block analysis of variance (RB-6; Kirk, 2013, Ch. 8) using SAS v9.4. Chi-Muller adjusted F ratios (Chi et al., 2012) were used for omnibus tests. All contrasts were tested using error terms calculated specifically for each contrast as sphericity was not tenable.

Preliminary analyses showed the mean log Weber percent contrasts to be normally distributed and a Tukey test for non-additivity for the design was not significant

$(F(1,\,19) = 0.08,\ ns)$. There were differences among the participants $(F(4,\,20) = 29.00,\ p < 0.001,$ partial $\hat{\rho}_I = 0.8235)$.

The time of presentation for the target influenced contrast thresholds $(F(5,\,20) = 16.45,$ $\epsilon_{CM} = 0.8819,$ adj $- p < 0.0002,$ partial $\hat{\omega}^2 = 0.8235)$. For a posteriori analyses we again used the Holm procedure to maintain a familywise type I error rate of 0.05. There was no difference between the thresholds for the first two presentations (at 0.50 s vs 3.40 s; $F(1,\,4) = 0.55,\ ns$) or the last two (at 3.60 s vs 8.10 s; $F(1,\,4) = 0.37,\ ns$). However, the drop in threshold with the removal of the mask is precipitous (at 3.40 s vs 3.60 s; $F(1,\,4) = 23.95,\ p = 0.0081,$ partial $\hat{\omega}^2 = 0.8211$).

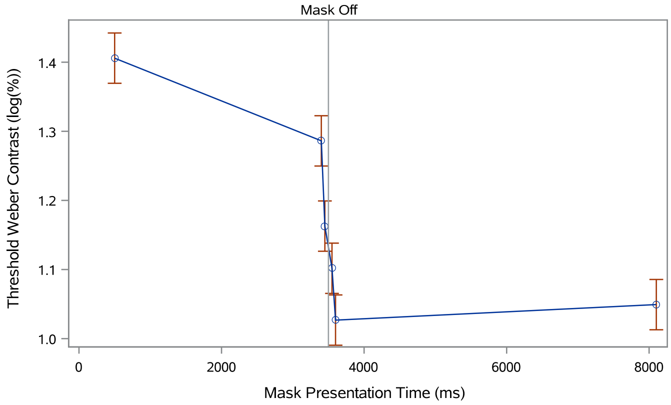

Fig. 2. Experiment I threshold contrasts as a function of time of target presentation.

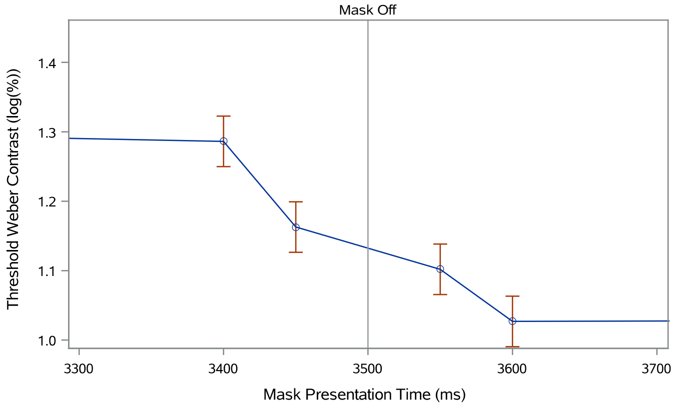

Fig. 3. Experiment I threshold contrasts as a function of time of target presentation around mask offset.

Experiment 2

Methods

Participants

Three females and two males, over the age of 18 with normal or corrected to normal vision, participated in the study. The study was approved by the University of New Hampshire Institutional Review Board.

Apparatus and Stimuli

The apparatus was the same as in Experiment I.

One independent variable was manipulated, the moment of presentation of the target (0.50 s, 4.00 s, 4.10 s, 4.25 s, 4.50 s, 5.00 s, 8.00 s, 11.00 s, and 14.00 s after the start of the trial). The targets were 16 arc-minute circular dots on a uniformly gray background. They were presented in a temporal Gaussian window (100 ms SD) for 200 ms. Both the mask and targets were decrements (negative contrast). The mask moved incoherently at 4 deg of retinal angle per s. The mask was presented at 4.00 s into the trial and extinguished at 8.00 s into the trial). All five subjects experienced each of the six conditions at least 20 times presented in random order.

Procedure

Sitting in a darkened room with their head stabilized by a chin rest 1 m from the monitor, each participant viewed the central fixation dot and adapted to the background luminance of the screen for five min. Following adaptation, each trial lasted 15 s during which the motion mask was visible for 4.00 s to 8.00 s. At delays of 0.50 s, 4.00 s, 4.10 s, 4.25 s, 4.50 s, 5.00 s, 8.00 s, 11.00 s, and 14.00 s after the start of the trial, the target was briefly flashed (200 ms) in one of four quadrant locations. After each flash an auditory beep indicated to the participant a brief response interval during which he or she could report the location of the target's flash using a keyboard. The participant received feedback after each response. The participant was instructed to maintain fixation on the centrally located fixation dot. A 15 s adaptation period followed each trial.

As a function of the time of target onset, the contrast of the target was varied following a weighted up-down adaptive psychophysical procedure (Smith, 1961; Kaernbach, 1991) to converge onto a 0.625 probability of a hit. The 4.00 s, 4.10 s, 4.25 s, 4.50 s, 5.00 s presentation times for the target were randomly varied across trials while the 0.50 s, 8.00 s, 11.00 s, and 14.00 s presentation times varied within trials.

Results

We fit a normal cumulative density function as before. Again, the means and standard deviations from those fits served as our raw dependent variables. While analyzing these two variables independently, we chose a familywise type I error rate of 0.05 using the Šidák (1967) inequality (see Kirk, 2013, p. 183) with a Holm procedure (Kirk, 2013, p. 185-187). Only the analysis of the psychometric function means will be reported as the standard deviations did not vary systematically $\left(F(8, 32) = 1.95, ns\right)$.

We conducted a repeated measures randomized-block analysis of variance (RB-9; Kirk, 2013, Ch. 8) using SAS v9.4. Chi-Muller adjusted F ratios (Chi et al., 2012) were used for omnibus tests. All contrasts were tested using error terms calculated specifically for each contrast as sphericity was not tenable.

Preliminary analyses showed the mean log Weber percent contrasts to be normally distributed and a Tukey test for non-additivity for the design was not significant $\left(F(1, 31) = 1.58, ns\right)$. There were differences among the participants $\left(F(4, 32) = 21.98, p < 0.0001, \text{partial } \hat{\rho}_I = 0.8749\right)$.

The time of presentation for the target influenced contrast thresholds $(F(8, 32) = 21.69, \epsilon_{CM} = 0.4116, \text{adj} - p < 0.0001, \text{partial } \hat{\omega}^2 = 0.7862)$. For a posteriori analyses we again used the Holm procedure to maintain a familywise type I error rate of 0.05. There was a difference between the thresholds for the first two presentations, before and coincident with mask onset ($F(1, 4) = 21.69, p = 0.0096, \text{partial} - \hat{\omega}^2 = 0.6742$). However, none of the thresholds measured in the presence of the mask differed from on another (e.g., 4.00 s vs 4.10 s; $F(1, 4) = 0.96$, ns, 4.10 s vs 4.50 s; $F(1, 4) = 0.60$, ns; 4.50 s vs 8.00 s; $F(1, 4) = 1.33$, ns). As well, thresholds measured without the mask did not differ (e.g., 0.5 s vs 11.00 s; $F(1, 4) = 0.32$, ns).

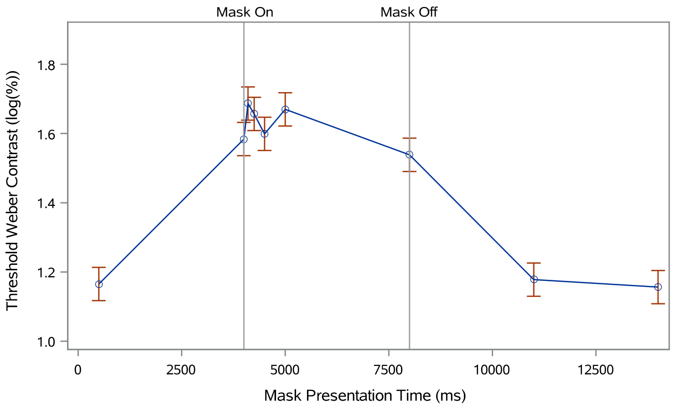

Fig. 4. Experiment II threshold contrasts as a function of time of target presentation.

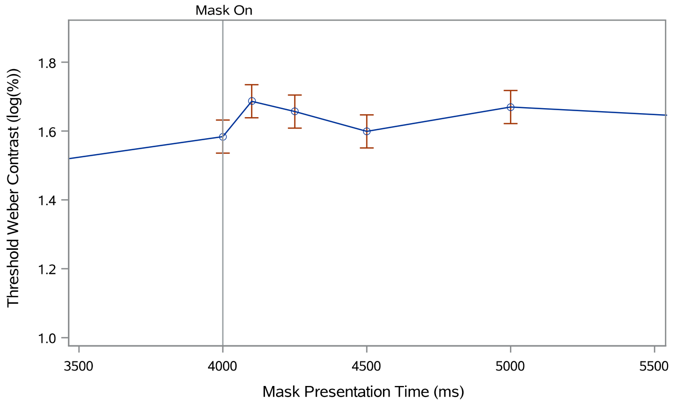

Fig. 5. Experiment II threshold contrasts as a function of time of target presentation around mask onset.

Discussion

We found that inhibition is induced rapidly at the onset of the motion mask, remains throughout the duration of the motion mask, and disappears rapidly after the offset of the motion mask. Luminance contrast thresholds at mask onset and offset were three times those measured before or after the presentation of the mask. These results are surprising considering that significant contrast gain changes should be relatively slow since they are a function of neural fatigue involved in sensory adaptation (e.g., Troxler fading) and/or overall photopigment availability (i.e., light and dark adaptation). These results are also peculiar given that previous work by Wilson and Humanski (1993) has shown that adaptation induced contrast gain changes require the stimulus be present at least 500 ms for the feedback mechanisms involved in contrast gain to propagate through the network – stimulus presence for 20 ms is not sufficient to observe an adaptation induced contrast gain change. However, it appears that we observed contrast gain changes within that time frame. Other inhibitory mechanism must therefore be at play. As a possible explanation, suppose that the onset and offset of the motion mask elicits eye movements. Such saccades result in saccadic suppression, which may block the target at mask onset and block the mask's inhibition of the target at mask offset. The timing of the inhibition from saccades as measured by Volkmann, Schick, and Riggs (1967) is in line with our observations.

Acknowledgements

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ALTERED INFORMATION PROCESSING STRATEGY AMONG PATIENTS WITH SCHIZOPHRENIA IN A LIKING TASK: AN EYE MOVEMENT STUDY

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Abstract

Eye-tracking technology provides valuable insights into how individuals perceive and interact with their environment, offering a window into the intricacies of information processing. In the realm of clinical research, eye-tracking has emerged as a powerful methodology for investigating eye movement patterns among psychiatric disorders, especially in patients with schizophrenia (SZ). Patients with SZ show substantial impairments in various cognitive processes, including attention, perception, and social cognition, all of which can be explored through precise gaze measurements. Over the past decades, clinical studies investigating visual perception presented stimuli in a controlled and passive manner (e.g., free-viewing, smooth-pursuit tasks). However, there is a growing interest in studying visual processes under more natural conditions, aiming to enhance ecological validity while maintaining the reliability of findings. In this study, participants [SZ=30, healthy control (HC)=30] were asked to evaluate the appetitive appeal of presented food images, incorporating individual food preferences and aesthetic properties (i.e., *liking* task). The task was executed under a *time-controlled* condition; hence, participants had no control over the exposure time of the presented food images. Furthermore, to ensure equal representation, each exposure duration between 1 and 8 seconds was used 5 times over 40 trials. By comparing eye-tracking data between patients with SZ and HC, impairments in visual attention and gaze patterns have been reported. Compared to HC, patients with SZ exhibit fewer fixations and lesser saccades. In addition, while HC made shorter fixations demonstrating a more efficient allocation of attention (i.e., faster attention shifts due to time constraints), the average fixation duration among patients with SZ indicated prolonged processing of visual information. Moreover, the decrease in saccade frequency suggested a more restricted scanning behavior among patients with SZ, potentially reflecting difficulties in actively exploring food images under a task with a predetermined exposure time frame. Overall, in the context of future trends in the clinical domain, further investigations are warranted to develop a thorough understanding of the distinct disparities in gaze metrics between HC and patients with SZ.

EFFECTS OF LISTENING CONTEXTS ON THE PERCEIVED CHARACTERISTICS OF MUSICAL PIECES

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Abstract

The perceived characteristics of musical pieces depend not only on their musical features but also on the listening contexts and listeners' attributes. The relation between the perceived characteristics and musical features of musical pieces has been studied extensively, whereas research on the effects of listening contexts and listeners' attributes on the perceived characteristics of musical pieces has been limited. Therefore, especially given recent advancements in music reproduction technologies and their widespread use, this study aimed to examine such effects.

This study investigated how listening contexts influence the perceived characteristics of musical pieces via a psychological experiment. The study also examined the relation between the perceived characteristics of musical pieces and listeners' attributes, such as stimulus sensitivity.

In this experiment, 24 participants (all females, mean age of 21.2 years, SD=4.07) listened to two musical pieces (a bright and lively classical piece and a tranquil and slow ambient piece) in two different contexts (listening intentionally, as foreground music, or listening while solving arithmetic problems, as background music). They rated the perceived characteristics of the musical pieces using semantic differential scales with 16 adjectives pairs. In addition, the participants' auditory sensitivity was measured using the Japanese version of Khalfa's Hyperacusis Questionnaire.

Factor analysis and analyses of variance revealed that the participants perceived different characteristics with respect to each musical piece. Furthermore, the study confirmed that listening contexts affected the perceived characteristics of musical pieces. The participants' stimulus sensitivity also partly influenced such perceived characteristics, although further data would be needed for a clearer interpretation. These results emphasized that listening contexts should be considered carefully for inducing the positive effects of music.

THE AFFECTIVE CHARACTER OF ABSTRACT SHAPES

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Abstract

This work explores the Takete/Maluma and Bouba/Kiki crossmodal correspondence. The phenomenon involves presenting participants with two abstract shapes – one characterised as curvy/roundish, and the other as angular/pointy – and two sets of meaningless words/sounds, one characterised by rounded vowels or a 'smooth' sound, the other by unrounded vowels or a 'sharp' sound. Participants tend to associate the curvy shape with the rounded vowel/smooth sounding non-word, while linking the angular shape to the unrounded vowel/sharp sounding non-word. The phenomenon is quite intriguing as it is a showcase for structural commonalities among perceptions deriving from different sensory channels. Nevertheless, there are concerns regarding the methodology used to define it. Specifically, what happens if people are given more choices in terms of shapes and non-words, will the reported correspondences hold under these expanded conditions? Additionally, the study seeks to verify whether abstract shapes possess other tertiary qualities, such as an 'affective personality'. The study was conducted by means of an online experiment involving 122 native Italian speakers. Participants were presented with 9 abstract shapes (Fig. 1) and 10 non-words: three characterised as sharp sounding (takete, kiki, and tidi), three as soft sounding (maluma, bouba, and puloma), two as mixed sounding (kalute and bouki), and two which sounds may remotely recall the name of the shapes (tigano for *triangolo*-triangle and kiquoda for *quadrato*-square). Each shape was presented singularly, and participants were asked first to choose a name for the shape among the non-words and then to select an affective characteristic that best described each shape from the following list of options: good, bad, angry, sad, scared, joyful, calm, pleasant, bored, and melancholic. Results show strong convergences among participants in assigning affective characteristics to the abstract shapes. However, it should be noticed that only certain abstract shapes show a consistent correspondence with specific non-words.

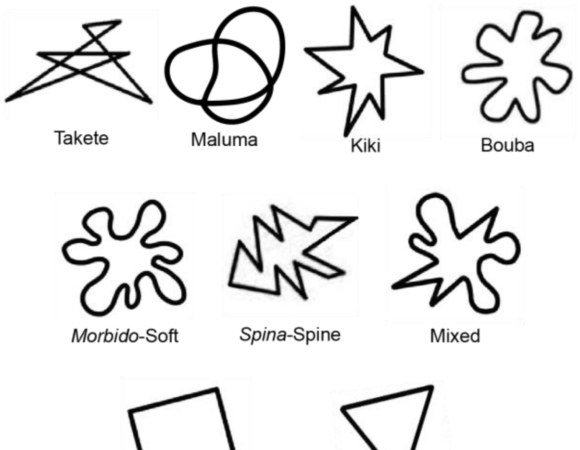

Fig. 1. The nine abstract shapes employed.

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