



Spatiotemporal integration in somatosensory perception: effects of sensory saltation on pointing at perceived positions on the body surface

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In the past, sensory saltation phenomena (Geldard and Sherrick, 1972) have been used repeatedly to analyze the spatiotemporal integration capacity of somatosensory and other sensory mechanisms by means of their psychophysical characteristic. The core phenomenon consists in a systematic mislocalization of one tactile stimulus (the attractee) toward another successive tactile stimulus (the attractant) presented at another location, increasing with shorter intervals. In a series of four experiments, sensory saltation characteristics were studied at the forearm and the abdomen. Participants reported the perceived positions of attractees, attractants, and reference stimuli by pointing. In general, saltation characteristics compared well to those reported in previous studies, but we were able to gain several new insights regarding this phenomenon: (a) the attractee-attractant interval did not exclusively affect the perceived attractee position, but also the perceived attractant position; (b) saltation characteristics were very similar at different body sites and orientations, but did show differences suggesting anisotropy (direction-dependency) in the underlying integration processes; (c) sensory saltation could be elicited with stimulation patterns crossing the body midline on the abdomen. In addition to the saltation-specific results, our experiments demonstrate that pointing reports of perceived positions on the body surface generally show pronounced systematic biases compared to veridical positions, moderate intraindividual consistency, and a high degree of inter-individual variability. Finally, we address methodological and terminological controversies concerning the sensory saltation paradigm and discuss its possible neurophysiological basis.

Keywords: illusion, somatosensory perception, spatiotemporal integration

INTRODUCTION

THE SENSORY SALTATION PHENOMENON

Cutaneous perception relies on spatial and temporal integration mechanisms, which are limited to particular stimulation characteristics. Stimulation patterns not meeting these specifications may give rise to illusions and other paradoxical perceptions. Sensory saltation is one of these illusions, consisting of systematic distortions in the spatial perception of spatiotemporal stimulus patterns: if two stimuli are presented at two different positions with a short delay, the perceived position of the first stimulus is mislocalized toward the position of the second stimulus and this mislocalization increases with decreasing delays between the two stimuli. This phenomenon was first systematically evaluated by Frank A. Geldard and colleagues, originally introduced as cutaneous rabbit effect (Geldard and Sherrick, 1972); but Geldard later proposed sensory saltation as a more formal term (Geldard, 1973).

Saltation is not restricted to the tactile domain, but has also been demonstrated for cutaneous heat-pain stimuli (Trojan et al., 2006), auditory (Bressner et al., 1977; Hari, 1995; Shore et al., 1998; Phillips and Hall, 2001; Boecker and Phillips, 2005; Getzmann, 2009) and visual spatial perception (Lockhead et al., 1980) as well as auditory pitch perception (Getzmann, 2007). These findings suggest that sal-

tation at the perceptual level reflects general spatiotemporal processing features of the sensory system. In line with an earlier suggestion by Geldard and Sherrick (1983), Wiener et al. (2000) argued that the saltation phenomenon may be the perceptual correlate of the dynamic behavior of sensory maps in the brain, more specifically, the primary somatosensory cortex. This assumption is supported by neurobiological studies, which demonstrate that the topography of activations found in the primary somatosensory cortex is a function of the spatial and temporal input statistics (Clark et al., 1988; Braun et al., 2006). In addition, a recent neuroimaging study demonstrated that activation in the primary somatosensory cortex indeed related to the perceived "illusory" position of saltatory stimuli (Blankenburg et al., 2006). It is conceivable that phenomena like the tau illusion (Helson and King, 1931; Lechelt and Borchert, 1977) or the ventriloquist effect (e.g., Alais and Burr, 2004; Soto-Faraco et al., 2004) may have similar neurophysiological bases.

A number of different, sometimes quite complex stimulus patterns were used in the classic studies at Geldard's lab. However, the psychophysical characteristics of the core phenomenon are demonstrated best in the so-called *utterly reduced rabbit* and *reduced rabbit* patterns. In the *utterly reduced rabbit* pattern, only two stimuli are presented: the first stimulus is termed *attractor* and the second is

Sensory Saltation

Yoshihiko Takahashi



Sensory Saltation:

Sensory Saltation Frank Arthur Geldard, 1975

Somatosensory Research Methods Nicholas Paul

Holmes, 2023-03-28 This volume provides methods on the study of the systems of the brain Chapters are divided into four parts covering discriminative touch proprioception and kinaesthesia affective touch individual differences due to atypical development ageing illusions and sensory substitution microneurography electrophysiology brain imaging and brain stimulation In Neuromethods series style chapters include the kind of detail and key advice from the specialists needed to get successful results in your research center and clinical investigation Thorough and comprehensive Somatosensory Research Methods aims to be comprehensive guide for researchers

What is Psychology? Andrew Colman, 2016-01-28 This clear and lively introduction to psychology assumes no prior knowledge of the subject Extensively revised and updated this third edition describes psychology as it is taught at universities Examples are used throughout to illustrate fundamental ideas with a self assessment quiz focusing readers minds on a number of intriguing psychological problems The differences between psychology psychiatry and psychoanalysis are explained and the professions and careers associated with psychology are explored Suggestions for further reading and useful internet sites are included

Haptic and Audio Interaction Design

Ian Oakley, Stephen Brewster, 2007-10-25 This book constitutes the refereed proceedings of the Second International Workshop on Haptic and Audio Interaction Design HAID 2007 held in Seoul South Korea in November 2007 The 12 revised full papers presented together with two invited talks were carefully reviewed and selected for inclusion in the book The papers are organized in topical sections on tactile displays communication and games accessibility and navigation as well as design

Fundamentals of Wearable Computers and Augmented Reality Woodrow Barfield, Thomas Caudell, 2001-01-01

Fundamentals of Wearable Computers and Augmented Reality presents a broad coverage of the technologies and interface design issues associated with wearable computers and augmented reality displays both rapidly developing fields in computer science engineering and human interface design This book presents concepts related to the use and underlying technologies of augmented reality and wearable computer systems There are many application areas for this technology such as medicine manufacturing training and recreation Wearable computers will allow a much closer association of information with the user than is possible with traditional desktop computers This book addresses an important aspect of wearable computers and augmented reality either from the conceptual or from an application framework Given the wide coverage of topics on issues related to the display of computer generated images in the environment this book can be used as a text for computer science computer engineering and interface design courses

What is Psychology? Andrew M. Colman, 1999 First Published in 1999

Routledge is an imprint of Taylor Francis an informa company *Haptics: Science, Technology, and Applications* Domenico Prattichizzo, Hiroyuki Shinoda, Hong Z. Tan, Emanuele Ruffaldi, Antonio Frisoli, 2018-06-04 The two volume set LNCS 10893 and 10894 constitutes the refereed proceedings of the 11th International Conference EuroHaptics 2018 held in Pisa Italy in

June 2018 The 95 papers 40 oral presentations and 554 poster presentations presented were carefully reviewed and selected from 138 submissions These proceedings reflect the multidisciplinary nature of EuroHaptics and cover all aspects of haptics including neuroscience psychophysics perception engineering computing interaction virtual reality and arts The Auditory Cortex Jeffery A. Winer, Christoph E. Schreiner, 2010-12-02 There has been substantial progress in understanding the contributions of the auditory forebrain to hearing sound localization communication emotive behavior and cognition The Auditory Cortex covers the latest knowledge about the auditory forebrain including the auditory cortex as well as the medial geniculate body in the thalamus This book will cover all important aspects of the auditory forebrain organization and function integrating the auditory thalamus and cortex into a smooth coherent whole Volume One covers basic auditory neuroscience It complements The Auditory Cortex Volume 2 Integrative Neuroscience which takes a more applied clinical perspective A *Dictionary of Psychology* Andrew M. Colman, 2015-01-22 Including more than 11 000 definitions this authoritative and up to date dictionary covers all branches of psychology Clear concise descriptions for each entry offer extensive coverage of key areas including cognition sensation and perception emotion and motivation learning and skills language mental disorder and research methods The range of entries extends to related disciplines including psychoanalysis psychiatry the neurosciences and statistics Entries are extensively cross referenced for ease of use and cover word origins and derivations as well as definitions More than 100 illustrations complement the text This fourth edition has incorporated a large number of significant revisions and additions many in response to the 2013 publication of the American Psychiatric Association's latest edition of Diagnostic and Statistical Manual of Mental Disorders bringing the Dictionary fully up to date with the most recent literature of the subject In addition to the alphabetical entries the dictionary also includes appendices covering over 800 commonly used abbreviations and symbols as well as a list of phobias and phobic stimuli with definitions Comprehensive and clearly written this dictionary is an invaluable work of reference for students lecturers and the general reader with an interest in psychology **Virtual, Augmented and Mixed Reality** Stephanie Lackey, Jessie Chen, 2017-06-28 This book constitutes the refereed proceedings of the 9th International Conference on Virtual Augmented and Mixed Reality VAMR 2017 held as part of HCI International 2017 in Vancouver BC Canada HCII 2017 received a total of 4340 submissions of which 1228 papers were accepted for publication after a careful reviewing process The 45 papers presented in this volume were organized in topical sections named developing virtual and augmented environments interaction techniques in VAMR VAMR in education and training virtual worlds and games user experience in VAMR and health issues in VR *HCI International 2019 - Late Breaking Papers* Constantine Stephanidis, 2019-08-30 This year the 21st International Conference on Human Computer Interaction HCII 2019 which was held in Orlando Florida USA in July 2019 introduced the additional option of late breaking work which applied both for papers and posters with the corresponding volumes of the proceedings The 47 late breaking papers included in this volume were published after the conference has taken place They were organized in the following

topical sections user experience design and evaluation information visualization and decision making virtual and augmented reality learning and games human and task models in HCI and design and user experience case studies The Macmillan Dictionary of Psychology Stuart Sutherland,1995-12-18 This completely revised edition incorporates over a 1000 new terms that have come into usage since the first edition was published in 1987 In addition the definitions of many of the original terms have been revised and many new usages added The dictionary includes as many terms as possible from other related disciplines including psychiatry artificial intelligence linguistics statistics neurology neurophysiology brain chemistry genetics etc **Service Robot Applications** Yoshihiko Takahashi,2008-08-01 The aim of this book is to provide new ideas original results and practical experiences regarding service robotics This book provides only a small example of this research activity but it covers a great deal of what has been done in the field recently Furthermore it works as a valuable resource for researchers interested in this field *Universal Access in Human-Computer Interaction. Methods, Technologies, and Users* Margherita Antona,Constantine Stephanidis,2018-07-09 This two volume set LNCS 10907 and 10908 constitutes the refereed proceedings of the 12th International Conference on Universal Access in Human Computer Interaction UAHCI 2018 held as part of HCI International 2018 in Las Vegas NV USA in July 2018 The total of 1170 papers and 195 posters included in the 30 HCII 2018 proceedings volumes was carefully reviewed and selected from 4373 submissions The 49 papers presented in this volume were organized in topical sections named design for all accessibility and usability alternative I O techniques multimodality and adaptation non visual interaction and designing for cognitive disabilities **Current Catalog** National Library of Medicine (U.S.), First multi year cumulation covers six years 1965 70 Perceptual Organization Stephen Handel,2019-02-15 This textbook goes beyond introductory sensory perception by incorporating supplementary electronic materials to demonstrate the parallels between both hearing and seeing Each chapter intermixes seeing and hearing processes so that students can easily understand that perceptual organization is the same across different kinds of sensations and modalities Figures illustrating visual organization are paired with sound files demonstrating the analogous auditory organization While most books on sensation and or perception treat the senses individually there is growing awareness of just how important multisensory integration is to understanding the connection between sensory perception and cognition

In touch with the future Alberto Gallace,Charles Spence,2014-01-30 Out of all the human senses touch is the one that is most often unappreciated and undervalued Yet the surface of the human body the skin is actually one huge sheet of tactile receptors It provides us with the means to connect with our surroundings Despite the important role that vision plays in our everyday lives it is the skin that constitutes both the oldest and by far the largest of our sense organs The skin protects our body from the external world and at the same time informs us about what occurs on its surface In Touch With The Future explores the science of touch bringing together the latest findings from cognitive neuroscience about the processing of tactile information in humans The book provides a comprehensive overview of scientific knowledge regarding themes such as tactile

memory tactile awareness consciousness tactile attention the role of touch in interpersonal and sexual interactions and the neurological substrates of touch It highlights the many ways in which our growing understanding of the world of touch can and in some cases already are being applied in the real world in everything from the development of virtual reality VR environments tablet PCs mobile phones and even teledildonics the ultimate frontier in terms of adult entertainment In addition the book shows how the cognitive neuroscience approach to the study of touch can be applied to help improve the design of many real world applications products as well as to many of our everyday experiences such as those related to the appreciation of food marketing packaging design the development of enhanced sensory substitution systems art and man machine interfaces Crucially the authors makes a convincing argument for the view that one cannot really understand touch especially not in a real world context without placing it in a multisensory context That is the senses interact to influence tactile perception in everything from changing the feel of a surface or product by changing the sound it makes or the fragrance it has For students and researchers in the brain sciences this book presents a valuable and fascinating exploration into one of our least understood senses

The Routledge Spanish Bilingual Dictionary of Psychology and Psychiatry Steven Kaplan, 2011-02-01 The Routledge Spanish Bilingual Dictionary of Psychology and Psychiatry contains over 100 000 entries making this the most comprehensive and up to date dictionary of its kind The Dictionary provides concise comprehensive and current coverage of every word or phrase used in the study and practice of psychiatry and psychology This valuable reference tool covers all disciplines and sub disciplines both research based and clinical This is a vital resource to those in the healthcare professions to academicians and to those who work in translation and or interpretation healthcare and the law who are in contact with the English and Spanish speaking communities

Sensation and Perception John Harris, Jared Smith, 2022-04-21 Is the human eye like a camera What makes your ears pop on a plane Why did women in the Middle Ages put belladonna into their eyes This fully updated 2nd edition of Sensation and Perception is an accessible introduction to the field of perception It covers in detail the perceptual processes related to vision and hearing taste and smell touch and pain as well as the vestibular and proprioceptive systems From seeing in colour to pathologies of perception and from recognising faces to research methods this textbook is essential reading for any student of perception New material includes Applications features connect key content to real life contexts Thinking Critically feature pushes students beyond the basics End of chapter essay questions An entirely new chapter on Action Perception John Harris is Emeritus Professor of Psychology at the University of Reading Jared Smith is Senior Research Fellow at the Population Health Research Institute of St George's University of London

Macmillan Dictionary of Psychology Stuart Sutherland, 1991-06-18 A dictionary which aims to cover all the technical terms that a psychologist is likely to encounter including terms from neurophysiology neuroanatomy neurobiology neurochemistry ethology sociobiology linguistics artificial intelligence sociology anthropology statistics and philosophy

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