#### ORIGINAL MANUSCRIPT



## A hybrid approach to dynamic cognitive psychometrics

#### Dynamic cognitive psychometrics

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#### Abstract

Dynamic cognitive psychometrics measures mental capacities based on the way behavior unfolds over time. It does so using models of psychological processes whose validity is grounded in research from experimental psychology and the neurosciences. However, these models can sometimes have undesirable measurement properties. We propose a "hybrid" modeling approach that achieves good measurement by blending process-based and descriptive components. We demonstrate the utility of this approach in the stop-signal paradigm, in which participants make a series of speeded choices, but occasionally are required to withhold their response when a "stop signal" occurs. The stop-signal paradigm is widely used to measure response inhibition based on a modeling framework that assumes a race between processes triggered by the choice and the stop stimuli. However, the key index of inhibition, the latency of the stop process (i.e., stop-signal reaction time), is not directly observable, and is poorly estimated when the choice and the stop runners are both modeled by psychologically realistic evidence-accumulation processes. We show that using a descriptive account of the stop process, while retaining a realistic account of the choice process, simultaneously enables good measurement of both stop-signal reaction time and the psychological factors that determine choice behavior. We show that this approach, when combined with hierarchical Bayesian estimation, is effective even in a complex choice task that requires participants to perform only a relatively modest number of test trials.

Keywords Cognitive psychometrics - Choice behavior - Response inhibition - Stop-signal paradigm - Reaction times

Cognitive psychowerrics (Batchelder, 1998, 2009; Kellen, Winiger, Dunn, & Singmann, 2021; Vandekerckhove, 2014) measures mental capacities in a way that is informed by information-processing models from experimental psychology and the neurosciences. Importantly, if these models are to support valid inferences about psychological and neural processes, their parameters must have sufficiently good measurement properties, i.e., it should be possible to obtain accurate and precise parameter estimates from data in realistic research settings. Originally developed for categorical data using multinomial processing tree models (Riefer &

Batchelder, 1988), cognitive psychometrics has increasingly taken on a dynamic aspect, taking into account how long it takes for cognitive processes to produce behavior. This has been the case both in reinforcement learning models accounting for dependencies between sequences of discrete choices (O'Doherty, Cockburn, & Pauli, 2016) and in evidenceaccumulation models for the response time (RT) associated with each choice (Donkin & Brown, 2018), and more recently in these two frameworks combined (Miletić et al., 2021; Pedersen, Frank, & Biele, 2017). Dynamic cognitive psychometrics has underpinned advances in areas ranging from theory-driven computational psychiatry (Huys, Maia, & Frank, 2016; Weigard, Heathcote, Matzke, & Huang-Pollock, 2019) to aging research (Garton, Reynolds, Hinder, & Heathcote, 2019; Ratcliff, Thapar, & McKoon, 2001). However, as dynamic cognitive psychometrics is increasingly applied to the complex tasks that are of interest in applied domains, maintaining good measurement properties becomes increasingly challenging.



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# **Dynamic Cognitive Procebes**

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#### **Dynamic Cognitive Procebes:**

Dynamic Cognitive Processes Nobuo Ohta, Colin M. MacLeod, Bob Uttl, 2005-04-04 The conference from which this book derives took place in Tsukuba Japan in March 2004 The fifth in a continuing series of conferences this one was organized to examine dynamic processes in lower order cognition from perception to attention to memory considering both the behavioral and the neural levels We were fortunate to attract a terrific group of con tributors representing five countries which resulted in an exciting confer ence and as the reader will guickly discover an excellent set of chapters In Chapter 1 we will provide a sketchy road map to these chapters elu cidating some of the themes that emerged at the conference The conference itself was wonderful We very much enjoyed the vari ety of viewpoints and issues that we all had the opportunity to grapple with There were lively and spirited exchanges and many chances to talk to each other about exciting new research precisely what a good confer ence should promote We hope that the readers of this book will have the same experience moving from careful experimental designs in the cognitive laboratory to neural mechanisms measured by new technologies from the laboratory to the emergency room from perceptual learning to changes in memory over decades all the while squarely focusing on how best to explain cognition not simply to measure it Ultimately the goal of science is of course explanation We also hope that the reader will come away absolutely convinced that cognition is a thoroughly dynamic interactive system Cognitive Processes Nobuo Ohta, Colin M. MacLeod, Bob Uttl, 2009-09-03 The conference from which this book derives took place in Tsukuba Japan in March 2004 The fifth in a continuing series of conferences this one was organized to examine dynamic processes in lower order cognition from perception to attention to memory considering both the behavioral and the neural levels. We were fortunate to attract a terrific group of con tributors representing five countries which resulted in an exciting confer ence and as the reader will guickly discover an excellent set of chapters In Chapter 1 we will provide a sketchy road map to these chapters elu cidating some of the themes that emerged at the conference The conference itself was wonderful We very much enjoyed the vari ety of viewpoints and issues that we all had the opportunity to grapple with There were lively and spirited exchanges and many chances to talk to each other about exciting new research precisely what a good confer ence should promote We hope that the readers of this book will have the same experience moving from careful experimental designs in the cogni tive laboratory to neural mechanisms measured by new technologies from the laboratory to the emergency room from perceptual learning to changes in memory over decades all the while squarely focusing on how best to explain cognition not simply to measure it Ultimately the goal of science is of course explanation We also hope that the reader will come away absolutely convinced that cognition is a thoroughly dynamic interactive system **Dynamic Processes and Reading Novels** Irene O'Leary, 2025-05-12 This book is about the dynamic processes that generate novel reading It takes the view that the world is composed of dynamic processes and introduces a process dynamics approach to articulate this stance This fresh perspective draws on literary studies process philosophy and neuroscience to argue that

dynamic literary and microcognitive processes constantly reconfigure the conditions that they co create during reading Analyses of The PowerBook by Jeanette Winterson The Curious Incident of the Dog in the Night time by Mark Haddon and Oryx and Crake by Margaret Atwood consider style narration allusion and creativity in interaction with diverse microcognitive processes involved in reading The analyses are strengthened by taking live action into account illuminating changes that many critical perspectives miss or standardise and avoiding reliance on illusory ideal readers and readings In proposing a process approach to dynamics and its analysis this book paves the way for new research across disciplines

Cognitive Dynamics Eric Dietrich, Arthur B. Markman, 2014-03-05 Recent work in cognitive science much of it placed in opposition to a computational view of the mind has argued that the concept of representation and theories based on that concept are not sufficient to explain the details of cognitive processing These attacks on representation have focused on the importance of context sensitivity in cognitive processing on the range of individual differences in performance and on the relationship between minds and the bodies and environments in which they exist In each case models based on traditional assumptions about representation have been assumed to be too rigid to account for the effects of these factors on cognitive processing In place of a representational view of mind other formalisms and methodologies such as nonlinear differential equations or dynamical systems and situated robotics have been proposed as better explanatory tools for understanding cognition This book is based on the notion that while new tools and approaches for understanding cognition are valuable representational approaches do not need to be abandoned in the course of constructing new models and explanations Rather models that incorporate representation are quite compatible with the kinds of complex situations being modeled with the new methods This volume illustrates the power of this explicitly representational approach labeled cognitive dynamics in original essays by prominent researchers in cognitive science Each chapter explores some aspect of the dynamics of cognitive processing while still retaining representations as the centerpiece of the explanations of the key phenomena These chapters serve as an existence proof that representation is not incompatible with the dynamics of cognitive processing The book is divided into sections on foundational issues about the use of representation in cognitive science the dynamics of low level cognitive processes such as visual and auditory perception and simple lexical priming and the dynamics of higher cognitive processes including categorization analogy and decision making Dynamic Relationality Theory of Creative Transformation Kerimcan Ozcan, Venkat Ramaswamy, 2024-11-13 Dynamic Relationality Theory of Creative Transformation Grounding Machinic Ecosystems in Life Experiences introduces a visionary approach to understanding the evolving relationship between technology and human experiences It delves into the transformative potential of Machinic Generalized Intelligence MGI where AI and human intelligence converge harmoniously creating a new paradigm of interactive machinic life experiences. This book challenges the traditional tech centric view advocating for a life and experience first perspective. It presents the Dynamic Relationality Theory DRT a novel conceptual framework that redefines our interaction with technology

emphasizing cocreative emergent experiences over mere digital platformization Through an interdisciplinary approach combining philosophical insights and social theories with practical applications this book navigates the complexities of digitalized life ecosystems employing concepts and tools from assemblage theory category theory sheaf theory differential topology and gauge theory For readers grappling with the complexities of AI and its societal implications this book offers clarity and direction It provides a robust theoretical framework to understand the changing landscape of human technology interaction Furthermore it integrates philosophical insights and ethical considerations into the discussion of AI and technology providing a well rounded perspective that aids in ethical decision making and responsible innovation It also delves into practical applications and future implications of AI aiding readers in applying these concepts in real world scenarios By moving beyond a purely technological focus this book equips readers with the insights needed to navigate the ethical philosophical and practical challenges posed by the integration of AI into daily life A crucial resource for academics professionals and policymakers this book serves as a guide to making informed decisions and fostering responsible innovation in the age of AI Provides a novel and holistic approach comprehensive framework of Dynamic Relationality Theory DRT to understanding the interplay between AI and human experiences helping readers grasp the complexities of this coevolution Uses an interdisciplinary approach which integrates philosophical sociological and technological perspectives offering a multifaceted view that is crucial for a deep understanding of the subject Focuses on ethical and societal implications guiding readers through the moral complexities of technology integration **Event-Related Dynamics of** Brain Oscillations Christa Neuper, Wolfgang Klimesch, 2006-12-03 Research on brain oscillations and event related electroencephalography EEG and event related de synchronization ERD ERS in particular became a rapidly growing field in the last decades A large number of laboratories worldwide are using ERD ERS to study cognitive and motor brain function and the importance of this tool in neurocognitive research is widely recognized This book is a summary of the most current research methods and applications of the study of event related dynamics of brain oscillations Facing the rapid progress in this field it brings together on the one side fundamental questions of the underlying events which still remain to be clarified and on the other side some of the most significant novel findings which point to the key topics for future research In particular the chapters of this volume cover the neurophysiological fundamentals and models Section I new methodological approaches Section II current ERD research related to cognitive Section III and sensorimotor brain function Section IV invasive approaches and clinical applications Section V and novel developments of EEG based brain computer interfaces and neurofeedback Section IV Engineering General Intelligence, Part 2 Ben Goertzel, Cassio Pennachin, Nil Geisweiller, 2014-07-08 The work outlines a detailed blueprint for the creation of an Artificial General Intelligence system with capability at the human level and ultimately beyond according to the Cog Prime AGI design and the Open Cog software architecture Ruling Distributed Dynamic Worlds Peter Sapaty, 2005-06-24 A seguel to Mobile Processing in

Distributed and Open Environments this title introduces an extended universal WAVE WP model for distributed processing and control in dynamic and open worlds of any natures. The new control theory and technology introduced in the book can be widely used for the design and implementation ofmany distributed control systems such as intelligent networkmanagement for the Internet mobile cooperative robots RapidReaction forces future Combat Systems robotics and AI NMD spaceresearch on other planets and other applications. This title Demonstrates a much simpler and more efficient application or application of the planets and other applications. Cultivates a new kind of thinking about how large dynamic systems should be designed organized tasked simulated and controlled Introduces an extended universal WAVE WP model for distributed processing Compares the universal WAVE WP model to other existing systems used in intelligent networking The Handbook of Brain Theory and Neural Networks Michael A. Arbib, 2003 This second edition presents the enormous progress made in recent years in the many subfields related to the two great questions how does the brain work and How can we build intelligent machines This second edition greatly increases the coverage of models of fundamental neurobiology cognitive neuroscience and neural network approaches to language Midwest Principles of Brain Dynamics Mikhail I. Rabinovich, Karl J. Friston, Pablo Varona, 2012-07-06 Experimental and theoretical approaches to global brain dynamics that draw on the latest research in the field The consideration of time or dynamics is fundamental for all aspects of mental activity perception cognition and emotion because the main feature of brain activity is the continuous change of the underlying brain states even in a constant environment The application of nonlinear dynamics to the study of brain activity began to flourish in the 1990s when combined with empirical observations from modern morphological and physiological observations This book offers perspectives on brain dynamics that draw on the latest advances in research in the field It includes contributions from both theoreticians and experimentalists offering an eclectic treatment of fundamental issues Topics addressed range from experimental and computational approaches to transient brain dynamics to the free energy principle as a global brain theory The book concludes with a short but rigorous guide to modern nonlinear dynamics and their application to neural dynamics

Dynamics of decision making: from evidence to preference and belief Erica Yu,David A. Lagnado,2014-10-24 At the core of the many debates throughout cognitive science concerning how decisions are made are the processes governing the time course of preference formation and decision From perceptual choices such as whether the signal on a radar screen indicates an enemy missile or a spot on a CT scan indicates a tumor to cognitive value based decisions such as selecting an agreeable flatmate or deciding the guilt of a defendant significant and everyday decisions are dynamic over time Phenomena such as decoy effects preference reversals and order effects are still puzzling researchers For example in a legal context jurors receive discrete pieces of evidence in sequence and must integrate these pieces together to reach a singular verdict From a standard Bayesian viewpoint the order in which people receive the evidence should not influence their final decision and yet order effects seem a robust empirical phenomena in many decision contexts Current research on how decisions

unfold especially in a dynamic environment is advancing our theoretical understanding of decision making This Research Topic aims to review and further explore the time course of a decision from how prior beliefs are formed to how those beliefs are used and updated over time towards the formation of preferences and choices and post decision processes and effects Research literatures encompassing varied approaches to the time scale of decisions will be brought into scope a Speeded decisions and post decision processes that require the accumulation of noisy and possibly non stationary perceptual evidence e g randomly moving dots stimuli within a few seconds with or without temporal uncertainty b Temporally extended value based decisions that integrate feedback values e g gambling machines and internally generated decision criteria e g when one switches attention selectively between the various aspects of several choice alternatives c Temporally extended belief based decisions that build on the integration of evidence which interacts with the decision maker's belief system towards the updating of the beliefs and the formation of judgments and preferences as in the legal context Research that emphasizes theoretical concerns including optimality analysis and mechanisms underlying the decision process both neural and cognitive is presented as well as research that combines experimental and computational levels of analysis The Temporal **Dynamics of Cognitive Processing** Timothy Michael Ellmore, Peter Ford Dominey, John Magnotti, 2016-07-26 From our ability to attend to many stimuli occurring in rapid succession to the transformation of memories during a night of sleep cognition occurs over widely varying time scales spanning milliseconds to days and beyond Cognitive processing is often influenced by several behavioral variables as well as nonlinear interactions between multiple neural systems This frequently produces unpredictable patterns of behavior and makes understanding the underlying temporal factors influencing cognition a fruitful area of hypothesis development and scientific inquiry Across two reviews a perspective and twelve original research articles covering the domains of learning memory attention cognitive control and social decision making this research topic sheds new light on the temporal dynamics of cognitive processing <u>Digital Capitalism and New Institutionalism</u> Daniil Froloy, 2023-12-19 Modern institutional economics was created to study the institutions of pre digital economies and is based on reductionist approaches But digital capitalism is producing institutions of unprecedented complexity This book argues therefore that not only the economic institutions themselves but also the theoretical foundations for studying those institutions must now be adapted to digital capitalism The book focuses on the institutional complexity of digital capitalism developing an interdisciplinary framework which brings together cutting edge theoretical approaches from philosophy first of all object oriented ontology sociology especially actor network theory evolutionary biology and cognitive science In particular the book outlines a new approach to the study of institutional evolution based on extended evolutionary synthesis a new paradigm in evolutionary biology which is now replacing neo Darwinism The book develops an enactivist notion of extended cognition and cognitive institutions rejecting the individualistic and mechanistic understanding of economic rationality in digital environments The author experiments with new philosophical approaches to investigate institutional complexity for

example the ideas of the flat ontology and the assemblage theory. The flat ontology approach is applied to the study of human robot institutions as well as to thinking about post anthropocentric institutional design Assemblage thinking allows for a new much less idealistic look at blockchain and smart cities Blockchain as digital institutional technology is considered in the book not from the viewpoint of minimizing transaction costs as is customary in the modern institutional economics but by using the theory of transaction value which focuses on improving the quality of digital transactions. The book includes a wide range of examples ranging from metaverses cryptocurrencies and big data to robot rules smart contracts and machine learning algorithms Written for researchers in institutional economics and other social sciences this interdisciplinary book is essential reading for anyone interested in the interplay of institutional and digital change Dynamic Decision and Adjustment Processes in Commuter Behavior Under Real-time Information Karthik K. Srinivasan, Hani S. Mahmassani, 2002 Advanced Traveler Information Systems ATIS by providing real time traffic information can assist trip makers in selecting efficient travel choices and aid the attainment of desirable system goals including reduced costs and increased efficiencies The success of ATIS in achieving such goals critically depends on user behavior in response to information This research focuses on investigating dynamic aspects in commuter behavior under real time information A dynamic interactive travel behavior simulator that enables a consistent representation of the nonlinear time dependent interactions between network performance trip makers choices and information is used to observe trip maker behavior Using the simulator interactive experiments are conducted where a range of experimental factors including network loading day to day traffic evolution and ATIS information strategies are varied and the consequent trip maker behavior is observed Constituent models are proposed to analyze the choice dimensions of route departure time and compliance The dynamic kernal logit DKL formulation is presented for analyzing these data and its theoretical and computational suitability established The results confirm the significance of compliance and inertia as key mechanisms influencing route choice Departure time adjustments appear to be based on a sequential heuristic search Calibrated models also provide evidence of learning adjustment perception judgment and updating processes in trip maker behavior Empirical results indicate that real time information and time dependent network conditions are strong determinants of trip maker behavior in a commuting context The nature and quality of ATIS information accuracy and reliability the magnitude of network loading and its day to day evolution and users past traffic experience are important influences on how commuters select routes and departure times At the unobserved level general dynamic and stochastic patterns including heterogeneity state dependence habit persistence and correlations are present in trip makers decisions These substantive results have important implications for network state prediction travel demand forecasting design and evaluation of ATIS services and deployment of Intelligent Transportation System ITS programs User behavior models developed here can be integrated with dynamic network traffic assignment models to obtain more accurate system performance modeling capabilities with considerable applications in tactical and strategic system planning and traffic

operations The Dynamic Cognitive Processes Underlying Creativity Gina Maria Palermo, 2023 Despite the growing importance of creativity and innovation at work the abilities that allow people to develop new and useful ideas in the workplace remain unclear Advances in research suggest that several core cognitive processes underlie creative thought such as problem finding information gathering incubation idea generation evaluation and implementation Although multiple studies have investigated these processes individually few researchers have observed the joint impact of these processes on creativity or its dynamism Current process models suggest that we go through these processes in a linear and logical sequence from finding a problem to the implementation of an idea However some scholars have posited that multiple iterations or feedback loops may exist throughout the creative problem solving effort To the author's knowledge this study is the first to empirically investigate the feedback loops or transitions between processes and how they are related to creative output The first study employed a mixed method approach to investigate the core cognitive processes underlying creativity by presenting 24 participants with an ill defined problem to solve by thinking out loud The frequencies of and time spent engaging in each cognitive process as well as the transitions from one process to another were investigated quantitatively A deductive thematic analysis was then conducted on the high and low creative output individuals to further explore these cognitive processes and to understand whether there was a difference in how the participants engaged in them Results revealed that the frequencies time spent and number of transitions between idea generation evaluation and implementation were positively correlated with creative output The total number of transitions was also found to be positively related to creativity scores These findings were also supported by the qualitative analysis conducted Following the findings from the first study Study 2 involved the same 24 participants in an online experiment designed to capture the dynamic cognitive processes underlying creativity in an objective and automated manner The results from this study cross validated adequately with the results obtained in Study 1 and the frequencies and time spent engaging in idea generation and implementation were found to be positively related to creative output No significant correlations were found between the transitions between processes and creative output however this outcome might have been due to the small sample size Nevertheless the total number of transitions engaged was significantly positively related to creative output The online experiment was then tested on a larger sample size N 146 A series of correlational and regression analyses confirmed the findings from Studies 1 and 2 The frequencies of idea generation evaluation and implementation and time spent engaging in evaluation and implementation were found to be positively related to creative output supporting the previous findings Two subsequent multiple regression analyses revealed that the frequencies and time spent engaging in the processes had a combined effect on creative output but only implementation was found to have a significant independent effect on creativity in both models Additionally significant differences were found between high and low creative output individuals when exploring the percentage of time spent engaging in certain processes compared to the other processes Furthermore an inverted U relationship was also

observed between information gathering and creative output as well as between overall time taken and creativity The number of transitions made during the task were also predictive of creative output regardless of time spent engaging in the task Mediation analyses were then conducted to test the causal relationship between idea generation and creative output The results revealed a full mediation effect of idea generation on creative output through the transitions from idea generation to implementation The results were largely consistent across all three studies. The frequency and time spent in idea generation evaluation and implementation were more or less found to be positively correlated with creative output in all three studies including the frequent shifts between them The creative process appears to consist of multiple feedback loops up to the point where a solution to an ill defined problem is fully formed Indeed the total number of transitions engaged were positively correlated with creativity output across all three studies Investigating these loops revealed that certain transitions from one process to another were predictive of creative output in Study 3 The process of generating a solution through a form of a generate and refine method appeared to be the most effective thought sequence or strategy in predicting creativity This thesis provides new insights into the cognitive processes underlying creativity how they function independently and holistically and most importantly how frequent shifts between the processes can predict creative output This research also addresses the need to develop an instrument that captures the creative process and its dynamism in an objective valid and cost effective manner Furthermore the research findings also have several implications for creativity research and practice such as creativity interventions Lastly this research puts forward alternative strategies that could be useful in both organisational and educational settings Abstract Neocortical Dynamics and Human EEG Rhythms Paul L. Nunez, Brian A. Cutillo,1995 Underlying principles are considered in the context of a variety of EEG and MEG data including spontaneous activity and transient and steady state evoked potentials Several connections between general theoretical ideas concerning predictions of coherent spatial structure in neocortical dynamics such as standing waves and actual data are also discussed

Brennan,1925 Psychological Tests and Testing Research Trends Paul M. Goldfarb,2007 Psychological testing or Psychological assessment is a field characterised by the use of samples of behaviour in order to infer generalisations about a given individual By samples of behaviour one means observations over time of an individual performing tasks that have usually been prescribed beforehand These responses are often compiled into statistical tables that allow the evaluator to compare the behaviour of the individual being tested to the responses of a norm group The broad categories of psychological evaluation tests include Norm referenced IQ achievement tests Neuropsychological tests Personality tests Objective tests Rating scale Direct observation tests Psychological evaluations using data mining This book presents new and important research from around the world

EMBC 2004 IEEE Engineering in Medicine and Biology Society. Conference, 2004

The relationship between creativity and sport in comparative research on mountaineers, parachutists, and

track and field athletes Zygmunt Sawicki, Aldona Litwinska, Karol Görner, 2025-11-17 Scientific Study from the year 2025 in the subject Sport Sport Psychology language English abstract The research question is if and how do the specific conditions of mountaineering translate into higher creativity levels compared to disciplines with lower risk and emotional load Preliminary theoretical assumptions lead to further research questions Do climbers exhibit higher creativity than athletes from other domains that do not integrate similar levels of risk and emotional intensity What specific factors for example personality traits cognitive processes lifestyle motivational mechanisms influence creativity in the context of high altitude climbing Do different aspects of creativity broad exploratory and narrow reflective refining develop to different extents depending on the discipline The theoretical framework of this study builds around several key components First we will outline the analogies and differences between sport and creativity definitions criteria and models of creativity and the characteristics of selected sports including mountaineering along with their similarities and differences Second we will provide a detailed analysis of mountaineering from the standpoint of factors relevant to creativity cognitive predispositions and intelligence cognitive processes such as flexibility of thinking ideation associations and problem solving personality traits behavioral disorders emotions motivation lifestyle risk autonomy solitude life outside routine and product traits relatively unique experiences and outcomes of climbers actions Finally we will present the hypotheses that will guide the design of the subsequent chapters

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