Mathematical Psychology First Postulate: Event Structure Formula

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Abstract

"Experimental empirical program"and "theoretical program"constitute key scientific programs. Psychology remains in an experimental stage dominated by the "experimental empirical program," where pursuing an axiomatic, self-consistent, and complete mathematical framework serves as an intrinsic driving goal and represents the core aspiration of APA' s Unifying Psychology. "Mathematical psychology" proposes key mathematical postulates, deduces fundamental problems in psychology, and achieves surprising consistency with classical discoveries: perceptual functional structure, semantic encoding, control structure of learning experiments, structural system of knowledge, and completeness of information channels. The "event structure formula" has become the primary postulate due to its ability to connect the underlying logic of material information structure expression and information cognitive processing mechanisms. This opens up a new approach to deducing psychological mechanisms using axioms and postulates. Based on this originality, this paper will review the mathematical achievements of the event structure formula and expand its extended derivations.

Full Text

The First Postulate of Mathematical Psychology: The Event Structure Formula

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Abstract

The "experimental-empirical program" and the "theoretical program" constitute key scientific paradigms. Psychology remains in an experimental stage dominated by the "experimental-empirical program," with the pursuit of an axiomatic, self-consistent, and complete mathematical framework as its internal driving goal—this is also the core appeal of APA' s Unifying Psychology. "Mathematical Psychology" proposes key mathematical postulates to deduce fundamental psychological questions, showing surprising consistency with classical discoveries: perceptual functional structures, semantic encoding structures, control structures in learning experiments, knowledge structural systems, and information channel completeness. The "Event Structure Formula" serves as the primary postulate because it can connect the underlying logic of material information structure expression and information cognitive processing mechanisms. This opens a new pathway for deducing psychological mechanisms using axiomatic postulates. Based on this originality, this paper will review the mathematical achievements of the Event Structure Formula and extend its derivative implications.

Keywords: Mathematical Psychology, Unifying Psychology, Event Structure Formula

There are three traditions in human knowledge acquisition: the classical tradition, the experimental-empirical tradition, and the theoretical tradition. Divine revelation, speculation, natural observation, and predecessors' experience constitute the primary methods of knowledge acquisition in the "pre-scientific stage," known as the "classical tradition." Building upon the rationality of the "classical tradition," the "scientific stage" transitions from the "classical tradition" to the "experimental-empirical tradition." After a brief incubation period of the "experimental-empirical tradition," physics was the first among the three major sciences (physical science, biological science, and psychological science) to achieve a breakthrough, realizing an axiomatic, logically self-consistent framework with mathematical representation, thereby entering the "theoretical tradition." Physics can thus be divided into four stages: experimental-empirical, phenomenological theory, theoretical framework, and mathematical expression (Yang, 2003). This classification method is equally meaningful for other disciplines.

The Essence of Experimentation

The essence of experimentation lies in using the resultant effects induced by interactions between objects to infer backward the principles of interaction and attribute patterns within phenomenological characteristics. Experimental effects are variable, whereas interaction relationships and material attribute quantity relationships remain invariant.

The Default Program of Experimental Empiricism

The default program of experimental empiricism is to seek invariant relationships (i.e., laws) within variable phenomena, which means studying invariance within variability. Universality and invariance serve as the criteria for judging "laws," also known as Noether' s Theorem (Noether, 1918), a philosophical principle applicable to both natural and social sciences. Since experimental discoveries in a particular field possess local characteristics, they are often expressed as laws or effect patterns within that local domain, constituting "experimental hypotheses" or "phenomenological theories."

By taking the patterns and laws of experimental effects from different subdomains of the same object as premises in the form of postulates (or axioms), and logically connecting them to enable mutual deduction, a complete and self-consistent "theoretical framework" is constructed. If expressed in mathematical language, this enables precise description, explanation, prediction, and control. Therefore, from the essence of scientific development, structuralism, functionalism, behaviorism, humanism, psychoanalysis, cognitivism (also called schools), etc., each grasped a particular subsystem within the overall "human"system. The diverse, classical experimental effect discoveries and laws accumulated across these different periods essentially belong to "psychological experimental phenomenology."

However, the "variability and diversity" of phenomenology often tempts the academic exploration direction of "experimental-empirical research" toward "complexity, diversity, and individual differences" —precisely the opposite of the default program of experimental empiricism. This creates an essential conflict with the universality and invariance of laws. Exploration in this direction may constitute valuable trial-and-error and necessary costs for psychological research.

Miller (2003) and a recent historical review of the "integration crisis in cognitive science" (Núñez, Allen et al., 2019) argue that the overall progress of cognitive science has deviated from its initial programmatic 设定 (cognition as computation), slowing down after early rapid expansion, exposing cognitive bottleneck problems and latent developmental crises. Whatever conclusions are drawn, this represents serious reflection on the exploration and development of "cognition" over many years.

The crystallization of these explorations collectively suggests that the complete set of phenomenological discoveries revealing the essence of psychology may have been accomplished. A new path begins to emerge: using axiomatic systems to logically organize classical phenomenological discoveries in psychology and establish a self-consistent and complete mathematical framework for psychology. Mathematical methods urgently need to integrate with psychology to complete psychology' s mathematical theoretical system. The development of psychology now stands at a critical crossroads of major transformation from the "experimental-empirical tradition" to "theoretical unification."

The APA has long had profound insight into this situation, and since 1997, has specially established the "Unifying Psychology" lecture series to receive critical advances from any field at any time, attempting to promote this key breakthrough. "Cognition as computation" may be the last local sub-program of "psychological experimental phenomenology." The "unification program" has begun to gestate.

1. Fundamental Questions about Universal Human Processing

"Material interaction" constitutes the fundamental mechanical relationship in the physical world. Objects possess attribute quantities, and the characteristic values (eigenvalues) of each attribute quantity constitute the initial conditions of objects, which also represent the differences distinguishing objects from one another. That is, attribute quantities are universal quantities, while characteristic values represent individual differences.

The effects induced by object interactions constitute phenomenological characteristics (also called results). Object interactions and the initial conditions of objects form the "cause," while effects constitute the "effect." The relationship between cause and effect is "causality." Different characteristic values (different initial conditions) produce different results. That is, differences in causes lead to different effects, making causal phenomena often complex. However, the attribute quantities corresponding to the "cause" and the relationships between attribute quantities do not change with variations in the value of the "cause," meaning that the laws of causality are invariant—the universality of "laws." If this can be expressed mathematically, precise prediction becomes possible. This is the root of science' s pursuit of mathematical expression.

The interactions between objects in the physical world and their induced effects are called "events."An "event"(called "stimulus"S in psychology) is loaded through some information medium (communication medium) (some neural channels act directly), interacts with humans, forms mental images (mental representations), and thus constitutes on-site processing of event information. After the human brain (cognitive system) makes decisions about events to be executed (future events), it drives the body' s motor system (biomechanical system) and energy supply system to perform behavioral responses, that is, Response (R). The universal interaction relationship is simplified into an S-R model, where S sets the initial conditions of the external "event," interacts with the person, and induces behavioral response R. S and the human's mental processing mechanism together constitute the "cause," while R constitutes the "effect." The detection of interaction relationships is precisely the detection of causal laws. The "human"is regarded as a black box, and black-box detection belongs to universal methods in natural science. Psychology' s S-R model (including its variants) naturally follows "causal laws" and "knowability theory." It is also the universal mode by which humans process the natural world, transcending laboratory detection modes and possessing ecological significance.

Regarding the existence of universal human processing mechanisms, from the perspective of stimulus effects on humans (excluding the mind-body relationship), the following two fundamental questions must be answered: (1) The universal form and mathematical expression of event information structure. This paper will review how events (or stimuli) possess a unified mathematical expression. This unified structure corresponds to the functions of various cognitive subsystems within the human cognitive system. That is, the universality of information structure in the physical world naturally "tunes" the human cognitive system, meaning that the universality of the physical world determines the universality of the material foundation of the cognitive system. This unified mathematical expression surprisingly aligns with classical discoveries in psychological experimental phenomenology. (2) The relationship between mental images of the physical world and their material foundation. How do the interaction rules (mechanical relationships), effects (phenomenological characteristics), and causal laws (dynamic relationships) of material events, after processing by different cognitive functional units in the human cognitive system, become "completely" mapped onto the human mental system to form "images" (or representations), enabling humans to perceive information about the external world?

The components of human cognitive function—perception, reasoning, judgment, decision-making, etc.—each bear independent cognitive functions. In encoding and decoding event attribute quantities, characteristic information, and information structures, they collectively follow rules of unity and completeness. That is, no additional processing stages are needed for event description, enabling the information and structure of the "mental (representational) event" obtained through cognition to align with the maximal set of attribute quantities of the "objective event" in the physical world. In other words, the "dimensions" of cognition of the physical world are complete or total. This paper will review how, based on the Event Structure Formula, the human cognitive system is complete in forming cognitive dimensions of mental events, constituting a cognitive closed loop.

The two forms of mathematical expression mentioned above—the former representing the information expression form of the physical world, the latter representing the logical relationships between cognitive functional units. Clarifying the mathematical essence of both is necessary to answer the logical relationship between "matter" and "mind."

Gao (2021) proposed and established the theoretical system of "The Mathematical Principle of Psychology" (MPOP), and announced the first mathematical postulate: the Event Structure Formula, which deduces the internal mathematical logic of human mental processing mechanisms. Considering this originality, this paper briefly describes the "Event Structure Formula" and its deduced mathematical achievements, and extends its derivative implications.

2. Event Structure Formula

The essence of operation in the physical world (physics, biology, human and society) is that objects interact with each other and induce interaction effects. Interactions and their effects constitute "events." That is, "events" are the universal expression form of information about object interactions in the physical world. The variable change information in "events" interacts with human sensory organs and enters the human cognitive nervous system, that is, stimuli (S) enter the human brain, which is the origin of human cognition of the external world. "Event"information undergoes a series of basic cognitive processing stages —including modulation encoding, acquisition, transmission, decoding, judgment and decision-making, and self-cognitive control—to achieve on-site processing of events, decision-making about future events, and acquisition of human experiential methods. That is, events connect the mathematical logic of human cognitive functional units and constitute the core of human cognitive content (human knowledge and experience).

Therefore, the mathematical expression of events represents the fundamental relationship underlying material operation expression, mind-matter relationships, body-mind relationships, and human experience, and is listed as one of the axioms of psychology in mathematical psychology.

2.1 Mathematical Meaning of the Event Structure Formula

Objects in events are categorized into physical objects, biological objects, and sentient animals and humans. The basic forms include two expression types: where , , , , , represent object 1, object 2, interaction medium, time, location, respectively, constituting the physical event structure expression . When either object 1 or object 2 is a sentient object (humans or sentient animals), is used to represent it, where and represent behavioral motivation target objects and internal motivation target objects, respectively (Gao, 2021). and represent initial conditions and event result effects, respectively. Mathematically speaking, for each formula, the initial values at the time of event occurrence (represented by) and the values at any moment (represented by) of all elements except and are···

2.2 Set Representation of Event Structure Formula Elements

Each element mentioned above possesses multiple attributes; therefore, each element requires a set of attribute quantities to represent it: $1230phyEwwietwc = + + + + + + 1230psyEwwietwbtmtc = + + + + + + + + 1w2wit3wphyEpsyEbtmt0ce0ce0ceP\{\}1, 2, , 1, 2, ijPpimjn ===$ $ijviji0ce\{\}1, 2, iijPpjn == siR\{\}1, 2, 0, , iijtVvjntT === 0ce\{\}1, 2, iijVvjn ==$ $T()\{\}001, 2, ; 0icVimt === ()\{\}1, 2, ; 0, , ieVtimtT === phyEpsyEPsRiPsiRPsRVsiRiVsiRVsRphyEps$ where represents the th attribute of the th element in the event structure formula, and and represent the number of elements and the number of attributes, respectively. In this attribute set, each attribute constitutes an independent

dimension, forming the attribute space describing events, denoted as , with its maximum dimension being . For a specific event, due to differences between objects and different characteristic values of attributes, the set of characteristic values for each event from initial moment to end moment T can be expressed as:

represents the characteristic value of the th attribute of the th element

Note: Figure translations are in progress. See original paper for figures.