

1

INTRODUCTION TO PSYCHOPHYSICAL APPROACHES TO COGNITION

*Daniel Algom
Bar-Ilan University
Ramat-Gan, Israel*

2 ALGOM

Psychology, regardless of whether one deems it to be a full-grown *Naturwissenschaft* or a gargantuan undertaking in hermeneutics, a *Geisteswissenschaft* trying to make sense of human life -- a field set out to interpret or impart meaning to a manifold human condition -- carries its distinctive set of dichotomies. Reviewing the member dimensions of such a set may support a panoramic, yet in-depth appraisal of the current state of our science. A further gain may be reaped from such an examination. It may assist to disentangle those dichotomies that are fairly recent, perhaps the products of the prevailing paradigm or *Zeitgeist*, from earlier classifications that may prove to be more fundamental.

Pitting the sensory against the cognitive comes naturally to most contemporary psychologists. The terms denote a pair of polar processes, a contradistinction that permeates the gamut of psychological discourse from informal discussion to textbook organization. Sensory and cognitive usually carry the adjectives low-level or early and high-level or late, respectively. The classification also seems to carry an unmistakably modern ring. Most uninitiated observers and some seasoned psychologists surmise that the chasm between psychophysics and cognitive psychology is a byproduct (fortunate or unfortunate as the case may be) of the particular course of development traversed by modern experimental psychology.

Many trace the disparate development of the two fields, or rather their "incommensurability," to the advent of behaviorism. "Two opposed points of view," John B. Watson wrote in 1925, "are still dominant in American psychological thinking -- introspective or subjective psychology, and behaviorism or objective psychology." And, sure enough, fifty years after the publication of Behaviorism, the publisher succinctly avers on the back cover: "His statement is still true today" (Watson, 1925/1970). Watson's "subjective psychology" included the systems of Wundt, Titchener, and James, as well as Gestalt psychology. Concerning the latter, Watson correctly recognized its conceptual origin in Kant's philosophy --

outwitting in that respect the creators of Gestalt psychology themselves (who tantalizingly were unaware of the intellectual underpinning of their own endeavor). Although, today, Watson's is a minority voice vis-a-vis the relative merits of the two psychologies, the gap separating them apparently has not narrowed.

Others believe the divorce of sensation and cognition to be even more recent. Foremost among those are many of today's cognitive psychologists, who "Like the citizens of the United States, France, and the Soviet Union ... share a myth of revolutionary origin" (Leahy, 1987, p.454). Moreover, they claim that the revolution occurred fairly late such that their "subject seems so new that you might well think cognitive science erupted into the world complete, a few years back, like Athena springing fully adult from Zeus' head ... Even the field's practitioners can fall into this view" (Lieber, 1991, p.viii). Indeed, many proponents of information processing or cognitive science believe that "in 1960 a Kuhnian scientific revolution occurred during which information processing overthrew behaviorism" (Leahey, 1987, p.454). An objective review (if that is at all possible), however, concludes that " ... it is reasonable to doubt if there was a revolution" (Leahy, 1987, p.454), a well founded skepticism that I fully share (Algom, 1991). Nevertheless, even if the talk about the revolution of "information processing" really is tantamount to mythinformation processing, it might well have served to exacerbate the divide between sensation and cognition. For every revolution needs its nemesis, if only to justify its uniqueness; and sensory processes seem an ideal candidate for just that role. Hence, whereas sensation and cognition evolved independently in the first century BCE (Before the Cognitive Era, cf. Marks, 1991), the two became incommensurably distinct since. Or so the story goes.

Given psychology's young age as a science, it was perhaps inevitable that someone or another would propose that the separation of the cognitive and the sensory is provisional, but an accidental consequence of psychology's peculiar development. Hence, depending on one's vantage, the chasm comprises either

a childhood disease or part of psychology's rites of passage. The only problem with all such viewpoints is that they are wrong. Far from being a recent tentative development, the disassociation of sensation and cognition is as old as the first systematic inquiry of mind. The disjunction has its roots in antiquity, notably in the Platonic theory of knowledge; as such, it pervaded layers of Western culture, reaching well beyond the confines of psychology. My aim at this point is to make explicit the extent to which Plato's core notions about mind inform our contemporary discourse about perception and cognition.

The most famous of Plato's schemes for subdividing the "mind" or "psyche" is their tripartition in the Republic into rational, affective, and appetitive systems. A great divide, indeed a constitutional conflict is said to pit the rational against the appetitive portion (the affective system is not involved in that fundamental psychological contrast as Plato repeatedly notes). In this schema, the appetitive apparatus "apprehends sensory perceptions, sensual demands, and concrete, particular, mortal objects," whereas the rational part deals with the "claims of the higher mental functions" (Simon, 1972, p.396). One can hardly avoid imparting value(s) to the conflict, "contrasting ... *higher* and *lower* forms of mental activity" (Simon, 1972, p. 396; emphases added) as the contrast is repeatedly couched in terms of a division between earth-bound bodily processes and heavenly mental processes. Summarized in Table 1.1 are the contrasting attributes of (what Simon characteristically enough depicts) "baser parts of mind" and "higher parts of mind."

I tried to summarize -- without claiming exhaustiveness or even representativeness -- some of the attributes popular in current usage of sensory and cognitive processes. They are listed in Table 1.2. Shedding the veneer of modishness from our current nomenclature, one cannot fail to notice how much the portrayals of sensory and cognitive on the one hand, and appetitive and rational on the other, are interdependent. The Platonic split between bodily and

mental processes continues to inform the modern partition of psychological processes into perceptual and cognitive. So does the inferior status of empirically derived or sensory information in Plato's theory of knowledge. The spontaneous allocation of the terms "high-level" and "low-level" to cognitive and sensory processes, respectively, betrays a deep-rooted metaphor in Western thought.

Table 1.1: Plato's division of the mind. The contrasting attributes of "higher" and "lower" forms of mental activity (After Simon, 1972).

Lower Portion	Higher Portion
Appetitive	Rational
Somatic	Psychic
Being born and perishing	True being
Opinion (doxa)	True knowledge (episteme)
Pictorial, illusory	Ideational
Shadow	Sun
Asleep, dreaming	Awake
Childish	Adult
Imitation	Abstract understanding
Flux	Stability
Conflict	Harmony
Heterosexual	Homosexual and asexual
Mortal	Immortal, timeless
Particular	General

Table 1.2: The contrasting attributes of sensation and cognition commonly used in current experimental psychology	
Sensory	Cognitive
Peripheral	Central
Mechanistic	Decisional
Low-level	High-level
Simple	Complex
Front-end	Back-end
Automatic	Inferential, heuristic
Involuntary	Voluntary, creative
Early	Late
Impenetrable	Penetrable
Primitive, primary	Sophisticated, secondary
Physiologically constrained	Semantic, symbolic

Ironically perhaps the sensory-cognitive duality entered psychophysics itself, influencing the *Weltanschauung* of several of its key figures. Again, the roots are early indeed. Democritus, who some 2500 years ago wrote, "Sweet exists by convention, bitter by convention, color by convention; atoms and void [alone] exist in reality," espoused a psychophysics that comprises (at least) two structures or processes: a sensory system that reacts to impinging energy and a cognitive system that acts on the input of the former (Marks & Algom, 1990; see the chapter by Marks for a fuller discussion of the implications for a psychophysics based on Democritus ideas). The attributes perforce follow naturally: the sensory apparatus is early and mechanistic, the cognitive apparatus is late and symbolic. The last term is noteworthy; for the basic notion conveyed by Democritus seems to be that perceptual experiences exist as representations of the world. As Marks

demonstrates convincingly in his chapter, this view traces a venerable tradition through Galileo, Locke, and Newton, to contemporary cognitive psychology.

Fechner also proposed a dual-track psychophysics with "inner psychophysics" far outweighing "outer psychophysics". Wundt borrowed Leibniz's distinction between *perception* and *apperception* to mark activities that we now would label sensation and cognition. Under the rubric of perception Wundt included the processes by which the sensory system modulates and responds to incoming stimulus energies and information. Subsumed under apperception were attentive processes by which people focus selectively on various aspects or elements of perception. Hence, perception has been said to be automatic, mechanical, even "thoughtless" (cf. Fancher, 1990), whereas apperception, by way of contrast, is voluntary, conscious, even creative. However, unlike many of their predecessors, Fechner and Wundt eschewed explicit value judgments. No one psychological component was deemed superior; rather, both (all) portions were considered indispensable for the proper functioning of a unitary mind.

Let me pose now the question of real import, regardless of the dating of the split between sensation and cognition in contemporary psychology. Does that partition serve a useful purpose? I think not; nor is the division tenable on any substantive ground. Therefore, the unification of these two branches of experimental psychology is highly desirable -- theoretically as well as methodologically. That is the premise on which the present volume was motivated.

I should probably issue a caveat before proceeding. We can and must, of course, separate "sensory" and "cognitive" factors in empirical research. One can manipulate them independently in a research protocol, and yet conceptually integrate both in the overall model of response to stimuli. This integration, I argue, is *sine qua non* for meaningful psychological theorizing. One should construe

psychological phenomena in terms of *both* sensory and cognitive contributions. Signal Detection Theory (SDT) is a good example for first providing explicitly for both sensory and cognitive influences, and then integrating them within the framework of a comprehensive model (see the chapters by *Melara* and *Ward* for discussions of the role of SDT in psychological analysis). Again, a few remarks, mainly of historical savor, may help highlight the principal issue.

Plato's partition of the mind, and particularly his denigration of sensory knowledge did not leave room for the development of good *psychological* theories of perception, learning or memory. As the chapter by *Algom* attempts to show, Aristotle did succeed in creating such theories precisely because he discarded much of the Platonian dualism, especially as far as psychology is concerned. Amongst his other contributions, Aristotle largely anticipated the modern discipline of *memory psychophysics* (note the coalescence of the sensory and the cognitive), coming close to proposing a (re)perceptual, analogous account of memory. That perception and cognition tap but different aspects of an otherwise inseparable psychological whole was grasped by additional Greek precursors of our subject. Epicharmus, for instance, living approximately 2500 years ago, said, "The mind sees and the mind hears. The rest is blind and deaf" (cited in Coren & Ward, 1989). Which is an excellent way of saying that "mental experience" (i.e., the only experience available to us) is composed of elements that by themselves do not reflect the integrated reality that they sample.

My point, of course, is not to refute the existence per se of perceptual and cognitive processes. What I do refute is the possibility to conceive them independently. We simply lack differential access to one process free of influence from the other. Both phenomena are products of processing by the entire mind. Sensation is as fully psychological as cognition; it is neither less nor more direct, simple, or early. Not is it easier to observe. Introspection does not provide a window to sensation, that is to say to sensation *only*. If it is a window, then it

affords a look (blurred, to be sure) at the end-product of an entire psychological process. That is what the students of the Wurzburg school so painstakingly demonstrated (and what Wundt failed to accept). Indeed, the assumption that introspection provides an exclusive opening to sensation precipitated its demise as an experimental method as well as the downfall of structuralism. And, as *Marks'* chapter makes it clear, any such Window Hypothesis is doomed to fail regardless of the vista facing the window.

The crucial point is to recognize the need to provide for (a) mind in any serious psychophysical undertaking. Our most influential theories have indeed provided for one, as the chapter by *Ward* demonstrates. At times, though, the role of the mind has been implicit, but searching for it is well worth the effort, because many long-standing psychophysical issues could be resolved if only we knew more about the nature of its influence. Thus, contrary to common impression, S.S. Stevens did provide a critical function for conscious, cognitive processes in his psychophysics. Any sensory judgment presupposes an intentional process of abstracting the judged dimension from the totality of the stimulus. The operation of *matching* requires the abstraction of a commensurate dimension on the basis of which the sensory analysis is prosecuted. And the dimension of choice is dictated by a goal-directed organism. As *Ward* points out, the "goal" in Stevens' system corresponds to the elaborated machinery of "cognitive algebra" in *Anderson's Integration psychophysics*. The hegemony of psychological (as opposed to merely sensory or conscious) operations is the hallmark of *Anderson's* refreshing approach. *Galanter*, too, explores the links between *intentions* and behavior, and shows how a comprehensive psychophysics must start with the former to model the latter. All of which revives the integrated nature of Wundt's notions of apperception and perception, if not Fechner's metaphysics.

The sensory should not be at war with the cognitive; their genuine theoretical integration -- however fuzzily sketched at first -- should yield deeper

understanding and practical progress. That it does is demonstrated by a new and ambitious expressive theory proposed in the chapter by *Galanter*. His approach comprises the potential to resurrect psychophysics from the laboratory and apply it to real-life situations. Moreover, the confluence of the sensory and the cognitive should not be construed too parochially, because it surfaces at all levels of psychophysical inquiry. *Gescheider, Bolanowski, and Vorrillo* elucidate in their chapter the sensory-cognitive interplay present at the level of the psychophysical magnitude judgment. And *Rollman* does the same in his chapter on pain, at several levels of analysis. Pain has posed a puzzle for laymen and scientists alike largely because of the virtually intractable interweaving of its sensory and cognitive components. This feature may account for the designation of pain as a "passion of the mind" (rather than as a perceptual system) by Plato and Aristotle.

I believe the case is compelling for cognitive effects to be considered seriously by psychophysicists. By the same token, cognitive theory should be informed by sensations or what we profess to know about them. Unfortunately, for many a cognitive psychologist, sensation still appears to be the last bastion of fixed mechanistic (i.e., psychologically trivial) properties, best left to those unprepared or uninterested enough to deal with real psychology. That an "interface" between models of cognitive psychology and psychophysics is not only possible but badly needed is shown in the chapter by *Malara* on the psychology of similarity and categorization. There, unifying models from the two domains led to several important insights. A variety of interesting cognitive issues can be couched in terms of sensory processing, or modelled by techniques borrowed from modern combinatorial or multidimensional psychophysics. It seems no accident that several contributors to this volume independently use the term *cognitive psychophysics*.

The approaches to Cognitive Psychophysics attempts to legitimize cognitive influences in psychological theorizing (and, conversely, to provide for the

sensory in cognitive theory). Moreover, it attempts to change the traditional approach of classical psychophysics to explore the pathway between sensation and cognition unidirectionally, from the periphery to the center only (*Anderson*), depicting an organism whose behavior is essentially reactive (*Galanter*). A satisfactory theory should rather start from the person says *Galanter*; it should shift the conceptual base of classical psychophysics and work from the center outward, says *Anderson*. These ideas surface in virtually every chapter in this volume and capture the essence of the approach dubbed here Cognitive Psychophysics.

The legend has it that Hermann Ebbinghaus, while in Paris, came across a copy of Fechner's Elemente der Psychophysik, which inspired him to study memory in the same manner as Fechner examined sensation. It took a century, though, after the establishment of psychophysics and the modern field of memory for a discipline of *memory psychophysics* to emerge. The chapter by *Algom* traces that development and assesses the prospects of that young offspring domain. In a similar vein, mental imagery has been considered for decades a cognitive subject unrelated to psychophysics. No more. Modern research has shown that mental images display visual characteristics in common with perceived objects. They exhibit constraints that, in various respects, correspond to those in visual perception (cf. Finke, 1989). The chapter by *Baird* and *Hubbard* examines this fascinating subject, reinforcing again the usefulness of psychophysical approaches to cognition.

A final remark on the organization of chapters. Although all contain data and theory, some are primarily theoretical in outlook, others are primarily empirical, examining special modalities, domains, or issues. The former four appear next. However, as the demarcation is fairly vague in the present case no formal division to sections is warranted.

References

- Algom, D. (1991). *Perakim betoldot hapszichologia* [Issues in the history of psychology]. Tel-Aviv: Ministry of Defense Publishing House.
- Coren, S., & Ward, L.M. (1989). *Sensation & Perception* (3rd ed.). New York: Harcourt Brace Jovanovich.
- Fancher, R.E. (1990). *Pioneers of psychology* (2nd ed.). New York: Norton.
- Finke, R.E. (1989). *Principles of mental imagery*. Cambridge, MA: MIT.
- Leahey, T.H. (1987). *A history of psychology* (2nd ed.). Englewood Cliffs, NJ: Prentice-Hall.
- Lieber, J. (1991). *An invitation to cognitive science*. Cambridge, MA: Blackwell.
- Marks, L.E. (1991). The dynamics of ratio scaling. In S.J. Bolanowski, Jr., & G.A. Gescheider (Ed.), *Ratio scaling of psychological magnitude* (pp. 27-42). Hillsdale, NJ: Erlbaum.
- Marks, L.E., & Algom, D. (1990). Context effects and loudness scales: Ghosts in the auditory machine? In F. Muller (Ed.), *Fechner Day '90*. Wurzburg, Germany: International Society for Psychophysics.
- Simon, B. (1972). Models of mind and mental illness in ancient Greece: II. The Platonic model. *Journal of the History of the Behavioral Sciences*, **9**, 3-17.
- Watson, J.B. (1925/1970). *Behaviorism*. New York: Norton.