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Interview With John Cacioppo

How did you become interested in psychophysiology?

The disciplinary pale of economics, my undergraduate major, was appealing in terms of its quantitative logic and formal proofs, but its emphasis on forecasting aggregate end products rather than on understanding underlying mechanisms was less so. The assumptions about rationality were demonstrably incorrect at the level of an individual's behavior, but the dogma in economics was that such irrationalities cancelled after aggregation or that aggregate behavior was characterized by emergent properties that were not explicable in terms of individual behavior. The role of affect and cognition in rational and irrational social behavior intrigued me, however, and social psychology afforded an opportunity to study these processes and mechanisms. At that point in its history, I discovered, the science of social psychology centered on the holy grail of reportable mental contents, even though most cognitive, affective, and social processes occur unconsciously and are so powerful that they impact peripheral physiology with only selected aspects reaching awareness. If the thoughts and processes people experience represent only a small subset of the structures and operations that needed to be explored and understood, it seemed reasonable that principles and measures of the human brain and physiology could offer theoretical concepts and rigid constraints as well as an expanded set of manipulations and measures with which to explicate the mechanisms and processes of social behavior. Rather than a passive, dispassionate recorder and processor of information, for instance, the brain is a builder of meaning within a social context in ways sculpted by experience, personal and ancestral. There was an abyss between social and biological levels of analysis that needed to be bridged first, though, so much of our early work was designed to help bridge this abyss. Interdisciplinary research involving social scientists, cognitive scientists, and neuroscientists is now fairly common and is indeed advancing our understanding of phenomena in all three disciplines. I suspect we have only begun to see the benefits of reaching beyond the disciplinary pail for understanding complex human behavior.

How do psychophysiological tools enhance your work?

We simply could not ask the research questions we do without psychophysiological procedures. Psychophysiological methods, paradigms, and theories offer entry to a biological cosmos that does not stop at skin's edge. Individuals are revered in Western societies for stolid independence, discerning perception, objective analyses, cultivated tastes, dispassionate analyses, and articulate disquisition. It is little surprise that those aspects of human discourse that can be articulated or timed have sometimes been accorded special status, set apart from millions of years of evolutionary forces, beyond the reach of impulsive processes. It is also a mistake. Equally mistaken are reductionistic approaches that anticipate the richness of the mind will be revealed comprehensively simply by peering through a membrane wall or while riding the human genome through behavioral terrain.

If evolution is too distant to inspect rigorously its cousin, ontogeny, is not. During their early years, children demonstrate repeatedly that a great deal of human nature is shaped by biological forces, driven by bodily processes, and manifesting in physiological events, only occasionally and only a subset of which are articulated verbally or behaviorally. From birth, reciprocal influences between social and physiological events are apparent and crucial to normal growth and development. In time, children acquire a keen faculty to comment on events, both internal and external, and to construe these events in terms of a coherent conceptualization. As a meaning-ascribing species, exploration, prediction, attribution, and control are not mere extravagances but are among the heralds of a coherent state of being. Like the organization and processes underlying the undeniable percept that the sun circles the earth, however, the organization and processes underlying human perception, reasoning, judgment, and behavior may be far subtler than the apparent manifestations might lead one to suspect.

People routinely develop explanatory scenarios, but only the attentive and systematic observer tries also to disconfirm these accounts, to extend beyond commonsense observation and reasoning to do so, and to discover something about the governance of the world and of ourselves in doing so. The attentive and systematic psychophysiologist and neuroscientist understands that, without contrivances to extend their faculties, the reach of their observations will fall short of their questions; that the Heisenberg principle is not limited to esoteric elements in physicists' laboratories or imaginations; that they cannot comprehend the full scope or processes of mental existence without delving into biological reality. We need instruments and intellectual tools to assist us in this endeavor.

The most important instrument remains human genius, but psychophysiological methods, paradigms, and theories provide a gateway to a biological cosmos more fascinating and expansive than has been appreciated by most. The possibility that fundamental aspects of human nature might be discovered by focusing on the interaction between environmental stimuli and an information-processing organism was recognized more than 2,000 years ago. Only recently, however, have technological advances and scientific reasoning begun to enable investigators to use physiological principles and measures to address fundamental questions about the organization and governance of human nature and behavior.

Paralleling the growing interest in the concepts and methods of psychophysiology are technological developments in signal acquisition and analysis, as well as efforts in recent years to articulate standards for psychophysiological recording. As a result, psychophysiological analyses have never before been more powerful or accessible. Furthermore, decades of scientific research and debate on matters bridging the mind and brain have produced a wealth of knowledge that transcends techniques and measures. These developments have facilitated problem-oriented research in psychophysiology.

In the age of brain imaging, what do you think the future holds for psychophysiology, particularly more traditional neurophysiological measures?

In decades past, studies of the neurophysiological structures and functions associated with psychological events were limited primarily to animal models, post-mortem examinations, and observations of the occasional unfortunate individual who suffered trauma to or disorders of the brain. Developments in electrophysiological recording, brain imaging, and neurochemical techniques within the neurosciences have increasingly made it possible to investigate the role of neural structures and processes in normal and disordered thought in humans. Raichle (2000) suggested that a major goal of functional brain imaging is to identify brain regions and their temporal relationships with the performance of well designed tasks- a goal to which psychophysiological methods and theory should have much to contribute.

Moreover, advances in ambulatory recording and its combination with experience sampling methodologies have removed the tether of the laboratory to permit in vivo investigations of biology and social behavior (Hawkley, Burleson, Berntson, & Cacioppo, 2002; Shiffman & Stone, 1998). The development of ambulatory recording procedures opens new and important sets of theoretical questions that psychophysiologists might ask, but needless to say ambulatory fMRI is not in the near future.

Finally, three principles we outlined as general heuristics for organizing research in social neuroscience (Cacioppo & Berntson, 1992; Cacioppo et al., 2002) and health (Anderson, 1998) also underscore the importance of both traditional psychophysiological approaches and contemporary brain imaging procedures. The principle of *multiple determinism* specifies that a target event at one level of organization, but especially at molar (e.g., social) levels of organization, can have multiple antecedents within or across levels of organization (Cacioppo & Berntson, 2002). On the biological level, for instance, researchers identified the contribution of individual differences in the endogenous opioid receptor system in drug use while on the social level investigators have noted the important role of social context. Both operate, and our understanding of drug abuse is incomplete if either perspective is excluded. Similarly, immune functions were once considered

to reflect specific and nonspecific physiological responses to pathogens or tissue damage. It is now clear that immune responses are heavily influenced by central nervous processes that are affected by social interactions and processes. For instance, the effects of social context now appear to be powerful determinants of the expression of immune reactions. It is clear that an understanding of immunocompetence will be inadequate in the absence of considerations of psychosocial factors. "Wet" as well as traditional psychophysiological measures clearly have a great deal to contribute to psychophysiology in the coming years.

A corollary to this principle, termed the *corollary of proximity*, is that the mapping between elements across levels of organization becomes more complex (e.g., many-to-many) as the number of intervening levels of organization increases (Cacioppo & Berntson, 1992). An important implication of this corollary is that the likelihood of complex and potentially obscure mappings increases as one skips levels of organizations. Cognitive neuroscience, therefore, is an important companion to social neuroscience because it helps bridge intervening levels of organization. Similarly, psychophysiological measures provide information about levels of organization between those one glimpse through brain imaging and behavioral measurements, and advances in theory and research are promoted by including measures of these intervening levels in organization.

The principle of *nonadditive determinism* specifies that properties of the whole are not always readily predictable from the properties of the parts (Cacioppo & Berntson, 1992). Consider an illustrative study by Haber and Barchas (1983), who investigated the effects of amphetamine on primate behavior. The behavior of nonhuman primates was examined following the administration of amphetamine or placebo. No clear pattern emerged between the drug and placebo conditions until each primate's position in the social hierarchy was considered. When this social factor was taken into account, amphetamine was found to increase dominant behavior in primates high in the social hierarchy and to increase submissive behavior in primates low in the social hierarchy. The importance of this study derives from its demonstration of how the effects of physiological changes on social behavior can appear unreliable until the analysis is extended across levels of organization. A strictly physiological (or social) analysis, regardless of the sophistication of the measurement technology, may not have revealed the orderly relationship that existed. Brain imaging might help us understand the underlying neural processes, but the study of these alone would likely not have revealed the more complex organization in these data.

The third principle, that of *reciprocal determinism,* specifies that there can be mutual influences between microscopic (e.g., biological) and macroscopic (e.g., social) factors in determining behavior (Cacioppo & Berntson, 1992). For example, not only has the level of testosterone in nonhuman male primates been shown to promote sexual behavior, the availability of receptive females influences the level of testosterone in nonhuman primates (Berntstein et al., 1983; Rose et al., 1972). Accordingly, comprehensive accounts of complex mental or behavior processes require a confluence of converging measurement procedures deployed in different contexts and time frames if we are to achieve comprehensive explanations for these processes.

What advice do you have for young psychophysiologists (e.g., regarding training, job preparation, publication, etc.)?

Each graduate student brings with them tremendous talent, interest, and curiosity. Be patient and true to your ideals. Theoretical work in psychophysiology benefits from a well developed understanding of the prior empirical and theoretical work on a problem and from informed intuitions. Intuitions develop about the subject matter through years of study, investigation, and problem solving just as chess masters develop a sophisticated set of cognitive structures that change the very appearance of the chess board. In part because the subject matter is so personal, students new to psychology arrive with many intuitions, prior beliefs, and naïve theories about psychological processes and behavior based on unsystematic experiences and observations. These intuitions can hinder *or* foster theoretical progress, with the former more likely when one is impatient.

Although students may bring entry biases from a lifetime of instrumental ways of thinking about behavior, they also bring a fresh perspective and an open-mindedness that should never be lost, for these are features that lead one to re-examine rather than mindlessly defend one's intuitions, assumptions, and theoretical structures. This, in turn, can foster theoretical progress. How might one develop or retain these properties? Each individual is unique, but perhaps one should both take theory in the field very seriously and not take theory in the field very seriously, each in turn. If the goal of theory construction is to produce an intellectual structure which provides adequate predictions of what is observable, and a useful framework for answering questions and solving problems in the given domain, then the process of theory construction should be imaginative and playful within the constraints provided by logic and evidence. The creative processes of theory construction and refinement are more likely when a prepared mind meets an empirical anomaly. Burying oneself in biological or psychological journals to the exclusion of a rich and happy life is to ignore new hypotheses that can come from observing and interacting with friends and family, enjoying literature and culture, and benefiting from a normal life.

Disappointment over an experimental outcome can be followed by the thrill of curiosity and the discovery of the possible if into the breach of the unknown steps informed intuition. Whether or not one realizes it, intuition serves as a guide in a variety of decisions one must make in any scientific theory and program of research. Given the likelihood that an experimental hypothesis provides a good fit to nature revealed through empirical inquiry is the joint probability that all those propositions upon which it is based are also good fits to nature, uninformed intuitions (or a defensive posture towards one's own theory and data) can provide a fast track to a frustrating program of research.

Perhaps some of the means for mitigating entry biases and for articulating and re-examining "cultivated" scientific intuitions might also lessen the effect of other inherent information processing errors in human cognition. And perhaps rather than theories and paradigms serving like mighty waves that arise and roll across the sphere only to crash, wither, and be replaced by another generation, formalisms and paradigms will grow across generations as relationships between mentor-student and older and young investigators become more a mutual partnership than a learned hierarchy, and the complementary strengths in naïve and scientific intuitions have a chance to subtly minimize the inherent problems in each.

Students tend to be taught (or want to learn) what is at the cutting edge in a scientific field because developments are unfolding rapidly and the demands of the academic job market place an emphasis on contributing to the literature early and often. As a result, they may not be given the opportunity to develop a meaningful appreciation for the origins of the unfolding scientific advances in the field, much less the origins and advances in related scientific fields. This can contribute predictably to both empirical and theoretical work in a field that is derivative, insular, and nongeneralizable. Providing (or taking) the time to understand the common origins of major lines of thought in a given field and, over time, in related fields, can yield rich associations, connections, and structures involving what otherwise might have seemed to be unrelated data.

There are other predictable impediments to theoretical progress on practical problems, of course. For instance, theoretical work in settings in which experimental control is absent or incomplete means that disconfirming evidence can often be attributed to other causes than deficits in the theory. Given the power of confirmatory biases, confidence in the accuracy of a scientific theory are unlikely to be quick to erode (Greenwald et al., 1986). Cycling between the laboratory (where one can exercise experimental control) and the field (where one can examine predictions in a more complex, multivariate context) may help counteract the effects of such as bias (Cialdini, 1980). This is just one way in which ambulatory psychophysiological recording procedures may fuel new advances in theory and research.

I further believe that comprehensive accounts in a field as complex as psychophysiology are more likely to come from collaborative, interdependent programs of scientific research rather than from independent, insulated efforts that use parsimony as an excuse for atomistic thinking. Training the next generation of psychophysiologists to should eschew interdisciplinary or collaborative research until post-tenure rather than teaching them how to formulate and lead such research teams strikes me as short-sighted.

Finally, with the emergence of transdisciplinary pursuits, the potential scope and consilience of theory in psychophysiology has increased but so has the potential for error. Complex behavior tends to have multiple

antecedents within and across levels of organization. As such, comprehensive accounts of complex behavior will require the specification of both multiple causal mechanisms and moderator variables that govern the conditions under which they operate (Cacioppo & Tassinary, 1990). I hope that my comments here stimulates further discussion of the special features and needs of multi-level theories, as the development of multi-level theories is indeed a direction in which psychophysiology appears to be headed.

What has been a highlight of your academic career thus far and is there anything you would have done differently?

The highlight without a doubt is that my students and colleagues are such wonderful people and friends. I wouldn't change a thing.