

Philosophers from the time of Plato and Aristotle struggled with the nature of the mind, its relationship to the body and to objective physical reality. For Aristotle, sensations and their relationship to perception and reasoning were of central importance. Attention was not an essential aspect of Aristotle's epistemology; sensory experience was thought to take on the form of the external world [1]. Descartes in his quest to create a philosophy of the mind observed "Regarding those matters which I think I see utterly clearly with my mind's eye ... when I turn to the things themselves which I think I perceive very clearly, I am so convinced by them that I spontaneously declare: let whoever can do so deceive me" [2]. In his writings and those of the other renaissance philosophers of his time, one sees the emergence of the role of consciousness in the process of perceiving, as in his use of the idea of "my mind's eye." Clearly based on introspection, Descartes made a crucial distinction between "external" sense perception and perception that was genuinely clear and distinct. For Descartes, the external senses resulted in "a spontaneous impulse to believe something," but he did not view this type of impulse as irresistible, whereas clear and distinct perceptions that become conscious were seen as irresistible. While it is beyond the scope of this chapter to review the various philosophical perspectives on consciousness and the nature of attention, it is apparent that even though many of the renaissance philosophers did not explicitly use the term attention, they were struggling to make sense of experiential phenomena that was at its essence attentional.

Psychology emerged as a distinct discipline from philosophy and physiology in the last half of the nineteenth century. In the study of the mind, psychology was distinguished from philosophy by the introduction of experimental methods borrowed from scientific disciplines, especially physics; efforts measure and quantify mental processes; and attempts to empirically demonstrate that a hypothesized mental process was common to many people and not confined to a single author's introspection and inference. In terms of subject matter, psychology differed from philosophy in its emphasis on attention as a central concept within the domain of consciousness. In this section, we will review the concepts of attention advanced by psychologists in the nineteenth and early twentieth centuries, including Wilhelm Wundt, Edward Titchener, William James, and W. B. Pillsbury, and the schools of psychology that developed from their work.

Wilhelm Wundt, one of the founders of experimental psychology, considered attention and consciousness to be central problems for this newly emerging field. The first chapter of his introductory psychology textbook was devoted to attention and its relation to conscious experience [3–5]. Wundt stated "the exact description of consciousness is the sole aim of experimental psychology." The central place of attention was based on Wundt's definition of psychology as the investigation of the facts of which we are conscious and the laws which govern their relations and combinations. The most important question facing psychologists was the nature of the interface between outside world and the

human mind, i.e., the *apperceptive* focus. Attention could be understood based on the extent to which particular representations of the outside world are in consciousness (*gegenwärtig*), which ultimately correspond to the degree to which consciousness is “turned towards [*zugewandt*]” these representations. When representations become part of the conscious field of vision, then according to Wundt the part of the field upon which our attention is directed is an inner focal point of vision. Entry of a representation into the field of inner vision was referred to as “perception,” while entry into the focal point of vision was referred to as *apperception*. For Wundt, consciousness was a function of attentional scope, which when narrowly focused through *apperception* could result in either active selection and focus of a perceived representation or passive response to salient representations that “suddenly thrusting themselves into the center of attention.” Wundt’s description of attention is similar to that of James, in that it emphasizes selectivity and focus, but also makes an interesting distinction between active and passive forms of attention.

Wundt characterized consciousness as a large “apprehended” field of sensory and mentally derived content. Attention is focused on a small area of this apprehended field, and this small area makes up the “apperceived” element or elements of consciousness. The more focused attention is on a particular element, the less clear the apprehended background will be. What is the maximum size of this focal area? Wundt and other investigators soon found that the maximum number of perceptual or semantic elements which could be attended concurrently was between three and seven. Wundt felt that this represented the maximum number of disparate elements the mind could manipulate as a whole. The degree to which an impression was enhanced by attention was indicated by its “clearness” in consciousness. Wundt’s conception of attention as a focal point in a wider field of consciousness would have pervasive influence in further development of attentional models.

Structuralism: Edward Titchener was a student of Wundt’s from the United States and returned to the country to continue psychological research. In a review of the current literature on attention, Titchener [6, 7] argued that all models of attention involved the concept of enhanced clearness of attended sensations and ideas. On the basis of this review, Titchener proposed a two-factor process of attention: increased clearness of attended sensations or ideas, coupled with inhibition of other impressions or memory images. Titchener, like his colleagues, wanted to put psychological models on an empirical or experimental basis, and he discussed the determinants of clearness for sensory events. His list of conditions for clearness extraordinarily anticipated entire categories of experimental investigation of attention that subsequently emerged in the twentieth century. For this reason, we will discuss them in detail.

Titchener discussed a range of stimulus properties which could increase attentional response (clearness). These include the intensity of a stimulus; sudden onset of a stimulus, or sudden change in its properties; stimulus movement; cessation of a stimulus; and the novelty or strangeness of a stimulus, particularly when it had a quality which compelled attention, such as pain, or stimuli which are “intimate, worrying, wicked things. The taste of bitter, the smell of musk, the sight of yellow belong, for me, to the same category; the least trace of them fascinates me.” (This last passage is one of the few in which these psychologists of consciousness touch on the influence of personality and unmentionable predilections on attention. Freud goes virtually uncited in turn of the century discussions of psychology).

Titchener also discussed contextual influences on attention. Stimuli were likely to be attended when a sensation was similar to the current contents of consciousness. He proposed a law of prior entry, suggesting that the stimulus for which we are predisposed takes less time than similar stimulus for which we are unprepared to produce its conscious effect. He noted that the optimal interval between a preparatory signal and a stimulus was about 1.5 s. The concept of prior entry resurfaces in this century in studies of stimulus priming. Attention allows fixation on a stimulus even when it is less salient than other ongoing events. For example, a person can attend to a speaker, even when the speaker’s

voice diminishes in volume or when the noise level in the room is louder than the speaker's voice. Finally, he observed that attention is labile, constantly shifting, and that this variation in attention was central in origin, rather than being due to fatigue of sensory organs.

Functionalism: William James was the most influential nineteenth century psychologist working in the United States. The intellectual breadth of James' magnum opus, "The Principles of Psychology," [8] is quite remarkable, in part due to the breadth of the man himself: He held academic appointments in philosophy and physiology, in addition to his work in the field of psychology. James changed his view of attention in different works, and this discussion will draw on his development of attention in the Principles of Psychology. James, like Titchener, felt the empiricist philosophers avoided discussions of attention since it contradicted a central premise of empiricism. Empiricists argued that experience shaped the mind, but attention implies that experience is chosen rather than given. James defined attention as, "the taking possession by the mind, in clear and vivid form, several simultaneously possible objects or trains of thought...It implies withdrawal from some things in order to deal effectively with others." James clearly thought of attention as an active process, almost motoric in character, with both activating and inhibiting effects on conscious contents. His view of attention also included a cognitive or motivational component, since he thought the attention we focused on an object was a function of our interest in it.

James discussed attention in terms of several dimensions. These included the source of the attended content, the source of its interest, and its active or passive character. Attended objects could either be sensory or ideational in origin. Interest could be due to the immediate nature of the object or derived from the object's associations. James considered attention to have two forms: passive and active. Passive attention was considered to be reflexive and effortless, while active attention was voluntary and effortful. James thought that volitional attention could not be sustained more than a few seconds without constant effort. Effort, then, was the result of conflict of interest in the mind, e.g., when we have to focus attention on an uninteresting object for a remoter reward. If this effort resulted in the object acquiring interest in itself, then the attention would be sustained passively. He argued that attention could not be maintained on an object which did not change, unless one intellectually considered different aspects of the object to maintain interest. James considered the possibility that our inward sense of effort in directing attention was the by-product of epiphenomena; that effort merely reflected external influences acting simultaneously on the mind. While James appears to have rejected this position, his arguments anticipate the broad behaviorist agenda of making conscious phenomena an epiphenomenal function of environmental effects.

James suggested that attention had the general effect of improving performance, making us perceive, conceive, distinguish, and remember better than otherwise. In addition, it shortens reaction time, facilitating both sensory recognition and response selection. He stressed the importance of mental set in perception: "The only things which we commonly see are those which we pre-perceive, and the only things which we pre-perceive are those which have been labeled for us, and the labels stamped into our mind."

James also considered the phenomena of inattention. He cites Helmholtz's argument that we leave impressions unnoticed which do not contribute to conscious discriminations. For example, if I am kneading bread, I may not notice the individual sensations that combine to let me recognize the object I am kneading as dough. Individual sensations such as the degree and orientation of pressure on each fingertip, the temperature of the dough, its moistness, its elasticity, and its color all merge into a unitary percept. We attend to the object itself and ignore its individual sensory properties. We lose awareness of a sensation, then, when it becomes integrated into a larger percept or concept.

Inattention can also be brought about by redundant stimuli. Predictable or repetitive stimuli also tend to fade from consciousness [3, 4, 6, 7]. Ebbinghaus also notes the role of practice in reducing

consciousness of complex sensory and motoric activities [9]. The more practiced, and therefore the more habitual, an action, the less conscious effort it takes to perform it. Eventually, it becomes difficult for a person to describe exactly what they do to carry out a well-practiced, complex activity like reading or riding a bicycle. It is a truism in sports that great players seldom become great coaches, possibly because they have lost awareness of the details of performance which preoccupy junior or weaker players.

W. B. Pillsbury, a professor of philosophy and director of the Psychological Laboratory at the University of Michigan, wrote a book on attention which summarized the investigations and concepts advanced in the previous century [10–14]. Pillsbury adopted the concept of attention as clearness put forward by Wundt and stressed the involvement of attention in other psychological processes like memory and its biological basis.

Pillsbury, like contemporary psychologists, linked attention to what we would call working memory. According to Pillsbury, the number of separate objects that can be attended to at once is four or five for vision, five to eight for audition, and that the duration of a single act of attention was usually between 5 and 8 s.

His biological speculations regarding attention were surprisingly contemporary and must be regarded as inspired speculation given the rudimentary understanding of neurophysiology and psychophysiology at that time. He concluded that the anatomical seat of attention lies the frontal lobes, which were association centers mediating between sensory and motor areas of the cortex. He speculates that there are two physiological processes underlying attention, reinforcement or facilitation, and inhibition. Reinforcement or facilitation is the increase in activity of one nerve cell due to the activity of another, while inhibition is the opposition of two cells in their activity. He ascribed fluctuations in attention and decay of attention over time to the effects of fatigue of cortical cells and the influence of rhythmic activity from the respiratory and vasomotor centers on cortical cells. He noted the association of attentional activity with motor phenomena, such as changes in sensory organs to focus on a stimulus, widespread contraction of voluntary muscles, and alterations in respiratory and cardiac rhythms. He also appreciated the effects of neuropathology and psychiatric disorders on attention. He concluded that degenerations of the mind are usually accompanied by weakened or deranged attention. In psychiatric illness, mania is associated with instability of attention and paranoia or obsessions (“fixed ideas”) with distorted attention.

Summary. In the nineteenth century, psychology had emerged as a discipline distinct from philosophy. This distinction lies both in methods, as psychology supplemented philosophical reasoning with experimental tests, and in conceptual foci. Attention was intensely discussed and investigated by the foremost psychologists of the nineteenth century. Combining experimental techniques, psychophysiological speculation, and self-observation, these early psychologists made remarkable progress in the characterization of attentional phenomena. They described the structural and temporal properties of attention, its activation by top-down (mental) and bottom-up (environmental) events, and its biological correlates.

Attention was thought to be a focus within the larger field of consciousness, which could be directed to a very limited number of related concepts or percepts. The number of discrete objects which could be encompassed simultaneously was found to be between three and eight. Not only was the capacity of attention finite, but the focus of attention decayed rapidly in time and was subject to constant fluctuation. Attention both enhanced attended conscious content and inhibited consciousness of non-attended content.

Attention could be passively elicited by events or volitionally deployed. Qualities of stimuli which passively elicit attention include intensity, stimulus onset and offset, changes in the properties of a stimulus, movement, and novelty or strangeness of a stimulus. Stimuli could also elicit attention when

they were anticipated or had interest to the observer. Active attention was effortful, volitional, and of short duration. Attention shows continual fluctuation over time, both in its content and intensity.

In addition to the mental and temporal attributes of attention, early psychologists also theorized regarding its biological basis and peripheral effects. Reinforcing and inhibitory interactions between nerve cells were felt to mediate attention. The frontal lobes were thought to be a major anatomic structure involved in the elaboration of attention. Attentional activity was noted to influence voluntary musculature, cardiac, and respiratory activity. Brain damage and psychiatric disorders were observed to frequently affect attentional performance.

These early characterizations of the phenomena of attention are quite remarkable in the extent to which they capture many of its most important features. Both James' and Wundt's approaches to nature of attention were strongly influenced by a long history of philosophical inquiry into the nature of the human mind. Their definitions also lack specificity and the operational precision that is now possible given that many years of experimental study of these phenomena that have transpired over the past century. Yet, it is clear that for both of these early psychologists, attention was at center of their emerging science and also that both appreciated the complexity of attention and the fact that attention has several important elements, including focus, intensity, and selectivity involving engagement and/or disengagement. Furthermore, there was a recognition that it was not constant over time, as it could be actively engaged, while at other times can occur in passive response to a salient stimuli.

Attention in Psychology of the Early Twentieth Century: Following these pioneering investigations into the nature of attention, there was a period of between 30 and 50 years when attention largely disappeared from psychological inquiry in the United States. During this period, psychology was dominated by *behaviorism*, which focused psychological experimentation on overt behavior that was observable and largely rejected the study "mental" phenomena that could not be directly operationalized in terms of empirical stimulus–response relationships [15, 16]. Yet, despite the fact that behaviorism largely avoided the term "attention," learning theory and the experimental findings of behavioral researchers actually made significant contributions to our current understanding of attention. Behavioral principles underlying attentional processes will be discussed in greater detail in Chapter 5.

Gestalt psychology represented the other major school of psychology to emerge during this period. It was an outgrowth of the German rationalist philosophical approach, characterized by the philosophical work of Emanuel Kant [17]. Gestalt psychologists focused on the fact that our mind is capable of perceiving who objects out of incomplete elements [18, 19]. According to gestalt, percepts are affected by their environmental context, leading to examination of "figure–ground" relationships, and the idea that "the whole is often more than the sum of its parts." An example from music illustrates this concept. When a 12-note melody is played in two different keys, the listener will recognize it as the same song, even though the notes differ. Yet, if a note in the tune is played incorrectly relative to the other notes that comprise the tune, the listener will immediately respond to this discordance. This type of response to discordant information based on prior memory for a song provides an illustration of attention relative to the gestalt. Similarly, the gestalt principles of *similarity, proximity or contiguity, continuity, closure, area, symmetry, and figure–ground* provided explanations of how preferences for certain perceptual information can occur based on the spatial and temporal configuration of that information. For example, the principle of proximity posited when stimulus elements are placed close together, they tend to be perceived as a group. The idea of figure–ground emphasized that the visual system automatically differentiates object forms from the surrounding background, so that the object is naturally perceived as a "figure," while the surrounding area is perceived as "ground." The relationship of the figure to the ground influences the salience of the information that is derived from the image.

From a gestalt perspective, there was little need for an attentional construct to explain selection, as object discrimination arises as an emergent property of the characteristics of stimuli in the

environmental field and the natural tendency of peoples to detect the dominant gestalt. This perspective provided valuable insights into the interrelationship between perception and attentional processes. It also was in some respects a predecessor to subsequent cognitive theories that would view attention as an emergent manifestation of other types of processing occurring in the brain (e.g., pop-out models of attention), rather than as a discrete cognitive operation. It also has resonance with certain computational approaches to attention that we will discuss later. Yet, the gestalt approach also had a number of limitations. One problem was the lack of an exact definition of concepts like *similarity* or *proximity*. In the case of similarity, there is no a priori basis for predicting which stimulus properties are perceptually similar and which properties require cognitive effort to discriminate. Furthermore, the fact that selection was viewed solely as a manifestation of perceptual biases tended to negate efforts to focus on the influence of other important determinants of attention, including motivation, reward, response demands, and the relationship of attention to other cognitive processes.

It was only in the middle of the twentieth century that attention regained the degree of theoretical importance that the early cartographers of the mind first assigned to it. With the emergence of cognitive psychology, attention again assumed a central position in psychological science. Many of the early problems confronting psychologists who studied attention were at least partially overcome with the development of specific experimental paradigms capable of manipulating and measuring attentional phenomena and the evolution of specific theories and models of attention that could be tested empirically. Yet, even as the psychological science of attention has matured, it is remarkable how consistent current conceptions of the phenomenology and basic elements of attention are with the principles of attention laid out a century ago. Furthermore, many of the questions regarding the relationship between attention and consciousness continue to be the subject of philosophical inquiry and debate [20–24].

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