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Visual Attention

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Attention in Early Scientific Psychology

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Attention is a salient feature of human mentality, at least in its conscious manifestations. Yet attention became a central topic in psychology only recently by comparison with such areas as sensory perception, imagination, or memory. Descriptions of the chief characteristics of attention were built up from classical antiquity to the seventeenth century. But attention first became a chapter heading in standard psychology textbooks during the 1730s.

This chronology has an air of paradox about it because it dates the entrance of attention into psychology prior to the commonly accepted dates for the origin of psychology itself. The origin of natural scientific psychology is now typically dated to 1879, or to sometime in the two preceding decades. This dating reflects a certain perspective on "natural scientific psychology" that equates it with the experimental psychology of Wundt and Titchener. If one takes a broader perspective, permitting the definitions of the terms "natural science" and "psychology" to vary across the historical past (according to their interpretation by past thinkers), then natural scientific psychology has a much longer history than is suggested by Ebbinghaus's celebrated phrase contrasting a "short history" with a "long past" (1908, p. 1).

It is from the perspective of this longer history that attention achieves chapter status in psychology textbooks only recently. Part 1 sets this entrance, by sketching the historical contexts in which psychology has been considered to be a natural science. Part 2 traces the construction of phenomenological descriptions of attention, and then compares selected theoretical and empirical developments in the study of attention over three time slices: mid-eighteenth century, turn of the nineteenth century, and late twentieth century. We shall find significant descriptive, theoretical, and empirical continuity when these developments are considered in the large. This continuity is open to several interpretations, including the view that attention research shows long-term convergence because it is conditioned by the basic structure of attention as a natural phenomenon. The less optimistic view would hold that theory making in at least this area of psychology

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has been remarkably conservative when considered under large-grain resolution, consisting in the reshuffling of a few core ideas.

Attention and the Origin of Psychology as a Natural Science

The historical development of psychology as a natural science has not been treated adequately in contemporary histories of psychology. From the time of Boring (1929, 1950), such histories primarily have served the function of providing a strong identity for the discipline of experimental psychology. Boring and his followers (e.g., Schultz & Schultz, 1987) have thus celebrated "foundings" and "founders," rather than explicitly posing and thoroughly investigating the question of whether scientific psychology should be seen as deriving primarily from the experimental psychology of Wundt and Titchener.

From Psyche to Mind

If psychology is considered in its root meaning, as the "science of the soul" (*logon peri tes psyches*), then it has been an autonomous discipline from the time of Aristotle's treatise *De Anima*. In Aristotelian terms, the literal meaning of the word psychology is the science of the soul (*psyche*), which was considered to be a vital or animating principle, and hence to possess the so-called vegetative powers such as nutrition and growth. When psychology is so understood, the study of the soul's cognitive powers, including sense, imagination, memory, and intellect, is a subdiscipline of it. Within this Aristotelian subdiscipline, the emphasis was on providing a taxonomy of the cognitive powers, and of characterizing the physical or qualitative relation between object properties and sensory states that represent those properties. Study of the soul itself fell under the umbrella discipline of physics, considered as the science of nature in general, but this fact carried no materialistic or reductionistic implications. Paradoxically, from our point of view, quantitative investigations of vision, including discussions of the perception of size and distance, were carried out in the distinct discipline of optics, which did not fall under physics and whose subject matter was understood to be the complete "theory of vision" (Hatfield, 1995).

In the course of the seventeenth century, the dominant Aristotelian conception of the soul was replaced, primarily, by Cartesian dualism. Descartes effectively equated soul with mind. He consequently redrew the line between body and soul, so that the functions of the vegetative soul were assigned to purely material processes, the sensory functions were attributed to mind and body conjointly, and purely cognitive (and volitional) functions were assigned to the mind alone (Hatfield, 1992). Although this turn toward dualism is well known, less well

known is that Descartes and his dualistic followers considered the immaterial mind to be a part of nature (Hatfield, 1994). In particular, the influential Cartesians Le Grand (1694) and Regis (1691) explicitly placed the study of mental operations, including sense, imagination, and memory, under the rubric of "physics" (again conceived as the science of nature in general). The notorious Cartesian interest in clear and distinct perception elicited several analyses of the phenomenology of cognition, and featured the role of attention in the act of judgment, especially in cases of allegedly self-evident cognition (Berlyne, 1974).

Attention in the Independent Discipline of Psychology

During the eighteenth century "psychology," understood as the science of the mind, was founded as an independent discipline. Professorships in psychology were established, textbooks were published, journals were started. As it happens, none of the chief practitioners of this new science of mind were materialists or reductionists: they were either dualists or were agnostic on ontology, adopting a position sometimes described as "empirical dualism" (Schmid, 1796). They sought "laws of the mind" by analogy with Newton's laws of motion. Among the proposed laws, the most widely accepted were the famous laws of association (such as the associative law of simultaneity, or that of resemblance). Other explicitly stated laws pertained to memory: Christian Wolff, who apparently coined the word "psychometrics" (1738, §522, p. 403), proposed that "goodness of memory" can be estimated by such quantitative factors as: the temporal latency of response to a memory demand, the number of tries it takes to retrieve an item from memory, and the number of acts it takes to fix an item in memory (1738, §191, p. 131); however, none of these tests were operationalized in his textbook. Wolff (1740) also formulated several generalizations concerning attention. One described an inverse relation between the intensity of attention and the extent of the cognitive material that can be brought under it: the greater the attention, the smaller the part of the visual field to which it extends (§360). Another contended that, with equally distributed attention, that part of a whole which otherwise is cognized most clearly will come to the fore (§367). A third suggested that conscious attention serves the process of combining spatial representations and temporal processes into spatially and temporally ordered wholes (§§380-5). Several of these generalizations concerning memory and attention are formulated as proportions, but they were not accompanied by quantitative data to support this relation.

Wolff's discussions of attention mark its introduction into psychology as a major topic. Comparison of the standard chapter headings from textbooks treating psychological topics supports this claim. In

Table 1, a summary of main topics from the seventeenth-century works in the Aristotelian and Cartesian traditions is compared with a summary derived from surveying standard textbooks from around the end of the nineteenth century (Ebbinghaus, 1911; James, 1890; Ladd, 1895; Wundt, 1874). Many of the topic areas are identical or closely equivalent: the external senses, the physiology of nervous processes, the control of bodily motion, higher cognition, and appetite and will. But within one area there was considerable change. Authors in the Aristotelian tradition, and immediate subsequent authors as well, recognized "internal senses" in addition to the traditional five "external senses." The "internal senses" included memory and imagination, as well as other cognitive powers or capacities. Nineteenth-century works continue to have chapters on memory and on imagination, but they contain two new chapters in comparison with the seventeenth century: chapters on association and on attention. The latter topics received only scattered treatment in the seventeenth century, in connection with other headings, including the senses, reasoning, and judgment. Wolff (1738) has a chapter on "attention and reflection," and his (1740) has one on "attention and intellect." Other works soon appeared with separate sections on attention, including Bonnet (1755, chap. 38) and Abel (1786/1985, pp. 81-106).

<i>On Soul or Mind</i> (seventeenth century)	<i>Psychology</i> (1874-1911)
External Senses	External Senses
Neural Structures and Processes	Neural Structures and Processes
Internal Senses: Memory and Imagination	Memory and Imagination Attention Laws of Association
Higher Cognition: Judgment and Reasoning Bodily Motion Appetite and Will	Higher Cognition: Judgment and Reasoning Bodily Motion Appetite and Will

Table 1. *Standard Psychological Topics in Textbooks.* Comparison of standard topics in textbooks treating psychological topics in the seventeenth century and in the period 1874-1911. Attention and Laws of Association appear in the latter but not the former. Category labels signify topical areas that may be named otherwise in the original textbook. Only the main common areas are shown.

Any adequate explanation of the increased attention to attention in the eighteenth century would have to trace the discussion forward from seventeenth-century treatises on logic and mind. It is already known that impetus was given to the investigation of both attention itself and the empirical conditions in which it is exercised by the Cartesian doctrine that knowledge consists in clear and distinct ideas (Berlyne, 1974). Clarity and distinctness, as understood in this tradition, are phenomenal characteristics. One recognizes clarity and distinctness, and even increases it, by paying attention to one's ideas. Descartes (1642) brought clarity and distinctness to the forefront of his own analyses of knowledge and cognition. The authors of the Port Royal *Logic* drew upon this analysis (Arnauld & Nicole, 1683, II.19., pp. 343, 363; VI.6, p. 422), and Malebranche (1980, I.18, VI.1.2-VI.2.1; pp. 79-81, 411-439) extended it greatly.

Careful study of the origin of attention as a topic in psychology would require a fuller examination of the development of psychology itself. At present, we have little knowledge of the development of either the theoretical or experimental side of psychology prior to the latter part of the nineteenth century. This means that we are lacking a good assessment of the relative roles of theory and experiment in the early development of psychology as an empirically based science. Although it is no doubt true that new experimental techniques were introduced to psychology in the latter half of the nineteenth century, it is also true that the extant theoretical formulations show significant continuity with the early nineteenth and even the eighteenth centuries. Part 2 considers both empirical and theoretical continuity in the history of the psychology of attention.

History of Research and Thinking on Attention

Titchener (1908) credits the new "experimental psychology" with three achievements, the third being "the discovery of attention": "What I mean by the 'discovery' of attention is the explicit formulation of the problem; the recognition of its separate status and fundamental importance; the realisation that the doctrine of attention is the nerve of the whole psychological system, and that as men judge of it, so shall they be judged before the tribunal of psychology" (1908, p. 173). Titchener's claim about the "discovery" of attention becomes less interesting if we focus on the rhetorical excesses of the third point, that "discovery" implies bringing attention to the centre of the "whole psychological system." If we just consider the first two points, Titchener's claim is clearly false: attention was noticed and discussed in the ancient and medieval worlds, and, as we have seen, had been introduced into the discipline of psychology by the 1730s. These developments can conveniently be

traced under the rubrics of *phenomenological* descriptions of attention, *theoretical* analyses, and *empirical* investigations.

Phenomenological Descriptions of Attention

Neumann (1971) surveys the introduction of various descriptive or phenomenological characteristics of attention across the span of Greek, Roman, and European thought. His remarkable results, summarized in Table 2, indicate that the primary attributes of attention had been recorded by the seventeenth century. We need not endorse his taxonomy of attention fully; although it provides a reasonably comprehensive description of the conscious manifestations of attention, his taxonomy also mixes the nonphenomenal category of "effector sensitivity" with descriptive categories, and it fails to note phenomenal reports of involuntary shifts of attention as a descriptive category (an added item in Table 2). Nor should we suppose that in every case Neumann is correct in identifying the "first" mention of each of these aspects (often he is not). His findings provide a listing of early descriptions of the main conscious or phenomenal manifestations of attention, showing that the main features had been recorded by the seventeenth century, at the latest. We shall consider these attributes one by one.

<i>Descriptive Aspect</i>	<i>Neumann</i>	<i>Hatfield</i>
Narrowing	Aristotle	Aristotle
Active Directing	Lucretius	Lucretius
Involuntary Shifts	—	Augustine
Clarity	Buridan	Aristotle/Lucretius
Fixation over Time	Descartes	Descartes
Effector Sensitivity	Descartes	Lucretius
Motivational Aspect	Leibniz	Augustine

Table 2. *Phenomenological Descriptions of Attention*. Early occurrences of phenomenological descriptions of various aspects of attention as reported by Neumann (1971) and found by Hatfield in the present study. Neumann does not include Involuntary Shifts as a category of phenomenological description. Neumann's original German terms are provided in the discussion.

Narrowing (Engeaspekt) This first aspect of attention attributes to it a narrow scope, such that stimuli are in competition to be perceived.

Neumann attributes this observation to Aristotle, who did not speak explicitly of attention, but who raised the following question about sense perception: "assuming, as is natural, that of two movements the stronger always tends to extrude the weaker, is it possible or not that one should be able to perceive two objects simultaneously in the same individual time?" (1984, chap. 7, 447a11–14). That Aristotle had in mind the phenomena of attention is made clear when he continues: "The above assumption explains why persons do not perceive what is brought before their eyes, if they are at the time deep in thought, or in a fright, or listening to some loud noise." Aristotle accepts the assumption that the stronger sensory stimulus does indeed tend to extrude the weaker, but he does not conclude that therefore two objects cannot be perceived simultaneously. For, he observes, we can perceive white and sweet at the same time (449a11–19). He seems to have held, however, that only one object is perceived at one time by the same sense (e.g., vision). But in this case, the presence of weaker stimuli affects the distinctness with which the stronger one is perceived: "If, then, the greater movement tends to expel the less, it necessarily follows that, when they occur, this greater should itself too be less distinctly perceptible than if it were alone" (447a22–24). In any event, Aristotle fixed the question of whether there can be a single perceptual response to simultaneous stimuli, and hence of the scope of sensory awareness, in the literature of psychology for subsequent millennia.

Active Directing (Taetigkeitsaspekt) Neumann attributes to Lucretius, in the first century B.C., the observation that human cognizers actively direct attention. Lucretius made two related points regarding the phenomenology of the mind's activity in sense perception. First, he observed that things are not seen sharply, "save those for which the mind has prepared itself" (1965/1967, IV.803–804). Thus, "do you not see that our eyes, when they begin to look at something that is tenuous, make themselves intent (*contendere*) and ready, and that, unless they do this, it is not possible for us to see clearly (*cernere acute*)?" (IV.808–810). Intentness and readiness, clearly activities of mind and not simply external orientings of the sense organs, result in some things being seen rather than, or more clearly than, others. But, second, the mind can alter its perception of things already at hand by directing its perception: "Even in things that are plainly visible you can note that if you do not direct the mind (*advertas animum*), the things are, so to speak, far removed and remote for the whole time" (IV.811–813). Consequently, Lucretius calls for "attentive (*attenta*) ears and mind" when he gives a long explanation (VI.920). In both of the cases described, the mind (*animus*) actively directs (*advertere*) its perceiving toward objects of

perception, whether these objects are merely anticipated (first case), or are present at the time. This "active directing" clearly implies the *voluntary* preparation of or direction of the mind in attending to objects of perception, and in the anticipatory case, is an early description of a *priming effect* (Johnston & Dark, 1987), though Lucretius did not use either of the italicized terms.

Though Aristotle did not use cognates for "attention" and Lucretius did so rarely, several cognate terms were entrenched in Latin vocabulary by the middle of the first century B.C. These included *attentio* and related words, *intentio*, straining or directing the mind toward something or concentrating the mind on something, and *animadversio*, turning the mind toward, noticing something (Glare, 1982, pp. 132–133, 200, 938). In the middle of the first century B.C., Cicero used these words regularly in his writings, including his work on oration, in which he, for example, opined that "with verse equal attention (*attendere*) is given to the beginning and middle and end of a line" (Cicero, trans. 1968, III.192). The Greek word for attention, *prosektikon*, apparently became common as the name of a faculty only with the writings of John Philoponus in the sixth century A.D. (see Hamilton, 1895, p. 945).

Involuntary Shifts Neumann credits Augustine of Hippo (A.D. 354–430) with fixing terms cognate with "attention" (*attentio*, *intentio*) into the technical vocabulary used to analyze cognition. In a work on music, Augustine discusses the role of attention or alertness in perception generally (1969, VI.5.9), and in the perception of musical phrases (VI.8.20–21). He describes the functioning of attention in religious experience (1991/1992), including cases in which attention is to be voluntarily directed (1991/1992, III.11.19, X.40.65), and he recognizes that attention can be drawn involuntarily. Augustine describes not only cases in which one is drawn toward objects of sensory pleasure, but also those in which objects of cognitive interest "tug at" one's attention (1991/1992, X.35.56). Augustine thus described involuntary shifts in attention (without using the term "involuntary"), implicitly contrasting them with cases of voluntary control.

Clarity (Klarheitsaspekt) Neumann credits Jean Buridan (14th c.) with the observation that simultaneous apprehension of more than one object decreases the clarity with which any of them is represented. Passages quoted above show that a relation between attention and clarity had been suggested earlier by Aristotle and Lucretius. Buridan (1518) presented a more varied description of this relation, using the terms "perfection" and "distinctness" to describe the dimension of perceptual cognition affected by stimulus plurality. Where Aristotle observed

that the simultaneous presence of several objects reduces the clarity with which the "strongest" alone is perceived, and where Lucretius noted that attention or mental preparedness can increase clarity of perception, Buridan remarked that the relation between distinctness and plurality varies. For a single object that is very large and wide, a lesser part of it is clearly visible though the whole is not, because it extends beyond of the field of view. But for a middle-sized object near at hand, the whole may well be more clearly perceived than its many parts. And in some cases, though we perceive the presence of many objects, we perceive them less clearly than if only one of them were present (Buridan, 1518, qu. 21, fol. 39v).

Fixation (Fixierungsaspekt) In the seventeenth century, Descartes (1596–1650) described more fully the *Taetigkeitsaspekt* of attention by clearly distinguishing between the voluntary fixation of attention and involuntary shifts. As had Augustine, Descartes noted that attention may be involuntarily drawn to things. He described cases in which attention is drawn to what is novel, a phenomenon he attributed to the emotion of wonder: "Wonder is a sudden surprise of the soul which brings it to consider with attention the objects that seem to it unusual and extraordinary" (1985, §70). In such cases, attention is not under voluntary control, but is simply drawn to the novel thing. The mind can, all the same, choose to stay fixed on one object: "when we want to fix our attention for some time on some particular object," this volition causes physiological changes that maintain the relevant physiological state of the brain (§43), and that "serve to keep the sense organs fixed in the same orientation so that they will continue to maintain the impression in the way in which they formed it" (§70). We can also voluntarily fix our attention on mental contents in order better to remember something (§75). Finally, the mind or soul can avoid noticing some new things by fixing attention on others: "The soul can prevent itself from hearing a slight noise or feeling a slight pain by attending very closely to some other thing, but it cannot in the same way prevent itself from hearing thunder or feeling fire that burns the hand" (§46). Descartes here posits a balance between the power of fixation and the strength of involuntary changes in attention. He indicates that within limits we can retain our fixation, but that these limits can be surpassed by loud stimuli, and presumably by strikingly novel stimuli. Malebranche added that it is functionally appropriate that sensory materials should attract our attention, because "the senses represent objects as present," and "it is fitting that of several good or evils proposed to the soul, those present should affect and occupy it more than absent ones, because the soul must decide quickly what it should do about them" (Malebranche,

1980, I.18, pp. 79–80). The positions of Descartes and Malebranche presuppose a limited span of consciousness (*Engespekt*), the contents of which are subject to alteration by voluntary or involuntary shifts in attention (see also Locke, 1975, II.19.3).

Later authors, including Wolff (1738, §237) and Stewart (1793, p. 113), describe cases in which a cognizer can track one phenomenon, such as a conversation, while ignoring other sensory objects. Stewart argues that the ability to switch at will between two present conversations implies that the untracked conversation must be represented:

When two persons are speaking to us at once, we can attend to either of them at pleasure, without being much disturbed by the other. If we attempt to listen to both, we can understand neither. The fact seems to be, that when we attend constantly to one of the speakers, the words spoken by the other make no impression on the memory, in consequence of our not attending to them; and affect us as little as if they had not been uttered. This power, however, of the mind to attend to either speaker at pleasure, supposes that it is, at one and the same time, conscious of the sensations which both produce (Stewart, 1793, p. 113).

Stewart's suggestion that the unattended conversation is still present in consciousness, though unnoticed, is related to the more recent distinction between automatic and controlled processing in relation to selective attention (Johnston & Dark, 1987). Stewart (1793, chap. 2) discusses a version of the latter distinction at great length in connection with the role of attention in memory fixation, and in connection with the conscious, voluntary control of cognitive or motor tasks that later become habitual or automatic (though he counsels against use of the latter term).

The ability to track either of two conversations implies the ability to shift attention without an accompanying change in the orientation or direction of the body or sense organs. Such a possibility was implied by earlier descriptions, from Aristotle on, of cases in which a person does not notice what is in front of him or her: in those cases, a person might attend to first one sequence of thoughts and then another, or switch from internal reverie to attend to a sound, while the gaze remains fixed (and blank). Wolff (1738, §256) provides the first explicit notice I have found of the ability to shift visual attention among the parts of a fixed perceptual representation without changing the total representation. He describes perceiving a whole tree (presumably in one glance, standing at some distance), and then shifting attention from leaves to branches to trunk; or perceiving a single leaf, and shifting attention from its shape to its colour. It is not clear from these

descriptions that Wolff envisaged a genuine decoupling of attention from the axis of vision, and he elsewhere maintained that the two are strongly coupled (1740, §§358–364).

Effector Sensitivity (Effektorischer Aspekt) The effectoric aspect attributes to attention the power of making it "easier" for the sense organs (or effectors) to receive an impression. There are two factors here that should be kept distinct. Originally, some thinkers observed that one can prepare to perceive an expected object, through mental concentration and by pointing mobile sense organs, such as the eyes, in the proper direction. Although Neumann credits this observation to Descartes, it can be found much earlier in Lucretius's remark about intentness and readiness, quoted above. A second effectoric aspect arises with the hypothesis that attention can affect the sensitivity of the sensory receptors or nerves themselves. Strictly speaking, this is not merely a phenomenal-descriptive aspect of attention, because it posits hypothetical physiological changes in sensory receptors or nerves to explain how attention affects sensory acuteness (otherwise, the *Effektorischer Aspekt* would not differ from the *Klarheitsaspekt*). This hypothesis about effector sensitivity is not found in the passage Neumann cites from Descartes (§70) nor elsewhere in Descartes's works; Descartes simply claims that fixation of attention can keep the sense organs steadily pointed at a target object.

Specific mention of heightened sensitivity in the sensory nerves is found in the eighteenth-century work of Charles Bonnet (1720–1793), a Swiss naturalist. Bonnet (1769) described a situation in which he was paying attention to one object among several, each of which he assumed to be simultaneously affecting the sense organs with equal force: "Induced by some motive to give my attention to one of these objects, I fix my eyes on it. The perception of that object immediately becomes more lively: the perceptions of the neighboring objects become weaker. Soon I discover particularities in that object that previously escaped me. To the extent my attention increases, the impressions of the object become stronger and augment. Finally, all this increases to such a point that I am scarcely affected except by that object" (1769, §138).¹ Bonnet goes on to explain that the liveliness of a sense perception is expected to vary in direct proportion with the "movement" or activation of sensory nerves, and since in this case each of several objects is assumed to affect the nerves with the same force, the increased liveliness of the perception of the target object must be due to an increase in the activation of the relevant nerves resulting from the influence of the mind in accordance with the fixation of attention (*ibid.*, §§139–141). He also produced a physiological explanation, involving the redirection of

limited neurophysiological resources, for the reciprocal relation he described between the strengthened perception of the target object and the weakened perception of neighboring objects (*ibid.*, §142).

Motivational Aspect (Motivationalen Aspekt) Neumann credits Leibniz (1646–1716) with having introduced motivational factors to the description of attention, citing a passage in which Leibniz observes that “we exercise attention on objects which we pick out in preference to others” (Leibniz, 1981, II.19.1). Indication that one object can be picked out in preference to others through attention is found earlier in Augustine’s mention of the voluntary direction of attention, and in Descartes’s discussion of fixation, and perhaps implicitly in Lucretius’s discussion of mental preparedness.

Overview Some sense of how comprehensively these descriptions cover the domain may be gained by comparing them with a survey of the chief “processes” of attention (Parasuraman & Davies, 1984) or “manifestations” of attention (LaBerge, 1995) described in recent reviews. Parasuraman and Davies found that attention researchers had described three chief processes in attention: *selective*, *intensive*, and *alerting and sustaining* (1984, pp. xii–xiii). To a first approximation, their selective process corresponds to the Active Directing category, intensive to the combined Narrowing and Clarity categories, and alerting and sustaining to a combination of Involuntary Shifts, Effector Sensitivity, and Fixation. LaBerge (1995, pp. 12–13) lists *selective*, *preparatory*, and *maintenance* manifestations of attention, which correspond respectively to the Narrowing and Active Directing, Effector Sensitivity, and Fixation categories.

Theoretical Analyses of Attention

The phenomenal descriptions of attention in the previous section are comparatively theory-free: they impose a descriptive vocabulary on the phenomena of attention, by classifying attentional acts as voluntary or involuntary, by relating attention to limitations on the momentary scope of sensory awareness, and by relating attention to phenomenal clarity and distinctness. Terms such as “voluntary” or “phenomenal clarity” are not, of course, theory neutral. Still, the descriptive vocabulary used in the previous section, save for the invocation of Effector Sensitivity and related hypothetical physiological mechanisms, does not engage in the theoretical activity of positing explanatory mechanisms or structures to account for the observed attentional phenomena. Moreover, the instances in which these descriptive categories were used arose in a variety of intellectual contexts, which only sometimes,

as with Wolff and Bonnet, involved a systematic examination of the attentional capacities of the human mind.

On occasion, the ancients and early moderns did discuss theoretical frameworks for understanding attention. John Philoponus provides an early discussion of the concept of attention itself, considered as a lynchpin for all cognition. In his commentary on Aristotle’s *De Anima*, III.2, he favorably reviews the following position, attributed to “recent interpreters” of Aristotle:

The attention, they say, assists in all that goes on in man. It is that which pronounces *I understand, I think, I opine, I resent, I desire*. The attentive function of the rational soul, in fact, pervades in all the powers without exception – the rational, the irrational, the vegetative. If then, they proceed, the attentive faculty be thus thorough-going, why not let it accompany the sensations and pronounce of them, *I see, I hear, etc.*? for to do this is the peculiar office of what is recognisant of the several energies. If, therefore, it be the attention which pronounces this, attention will be the power which takes note of the energies of sense. For it behoves that what takes note of all should itself be indivisible and *one*; seeing also at the same time that the subject of all these operations; *Man*, is one. For, if this faculty took cognisance of these objects, that faculty of those others, it would be, as he himself [Aristotle] elsewhere says, as if you perceived that, *I this*. That, therefore, must be one to which the attentive function pertains; for this function is conversant with the faculties – both the cognitive and the vital. In so far as it is conversant with the cognitive energies it is called Attention (as translated in Hamilton, 1895, p. 942).

Attention is assigned the function of unifying human consciousness, by “taking cognisance” of the materials provided by the various senses. Attention is not here described as selecting, but rather as uniting and hence delimiting the momentary cognitive contents of any individual cognizer. Although Philoponus assigned theoretical centrality to attention in the analysis of cognition, extended theoretical analysis of attention apparently did not soon become common. From considering sources from antiquity through the seventeenth century, I have found that attention received the kind of hit-and-miss notice chronicled in the sequence of phenomenal-descriptive observations. Such theoretical analysis as did occur arose primarily in the contexts of applying terms and concepts developed elsewhere to the description of attention, of drawing variously phenomenally based distinctions, such as that between involuntary and voluntary attention, or of discussing the function of attention.

With the development of psychology as an independent science in the eighteenth century, attention came under more systematic theoretical

and empirical scrutiny. In Wolff's psychology textbooks from the 1730s, attention was defined as the "faculty of bringing it about that in a perception compounded from parts, one part has greater clarity than the others" (1738, §237). What theoretical order Wolff brought to attention came in his chosen dimensions of empirical analysis. Having chosen cognitive clarity as the primary effect of attention, he set about to analyze the conditions under which clarity occurs. He found that attention to merely imagined representations is impeded by simultaneous sensory stimulation (§238), that attention to such representations is more easily conserved when fewer things act on the external senses (§240), that it is easier to attend to one image than to several (§241). He distinguished several dimensions in which attention admits of degree. These include *intensity* (not his term): attention is greater if it is harder to distract (§243); *longevity*: attention may last for longer or shorter periods (§244); *extension*: one may be able to pay attention to one or to several objects at once (§245); *voluntary control*: attention may be more or less subject to voluntary control (§246), and so on. In his *Psychologia Rationalis*, Wolff continued the same sort of analysis, now focusing largely on the relation between the direction of the visual axis and the focus of attention, describing the movement of the eyes in relation to voluntary attention and involuntary shifts of attention (§§358–365). He speculated on the physiological conditions accompanying and affecting attention (§§374–378), and he formulated the generalizations about attention mentioned in Part 1.

After Wolff, the literature on attention in the eighteenth century virtually exploded. This large literature has been the subject of a monograph by Braunschweiger (1899), which remains useful. Braunschweiger divided the theoretical dimensions of this literature into several categories. He distinguished *sensory* and *intellectual* dimensions of the literature of attention: attention can select among external objects available for perception, but it can also direct "inner" cognitive states such as imagination and memory, or "inner" cognitive processes such as self-reflection or self-observation (1899, pp. 25–31). In connection with this discussion, thinkers took various stances on the essence of attention itself (pp. 31–36), treating it either as a causal-explanatory factor in its own right, or as a phenomenon needing to be explained. Some treated attention as a *faculty* (i.e., as a mechanism that exists even when it is not in use), others as *mental effort* (i.e., as an activity of mind that exists only in its exercise), others as a *state of mind* (i.e., as a quality of sensations or perceptions, such as clarity). In the first two cases, attention is the result of causal agency; in the latter, it is an attribute of experience.

Braunschweiger (1899) analyzed several other eighteenth-century discussions. These included: degrees of attention, which extended

Wolff's treatment; the stimulus to involuntary attention and the control exercised in voluntary attention; the physiological correlate of attention; the effects of attention, from sensory acuity to memory and higher cognition; the means of improving attention; and limitations on or hindrances to attention. Throughout Braunschweiger's analysis, the primary theoretical results are manifested in taxonomies of the dimensions of variation in and conditions on the exercise of attention.

The main dimensions of theoretical variation attributed by Parasuraman and Davies (1984) and Johnston and Dark (1987) to late twentieth-century theories can be located within eighteenth-century discussions. Parasuraman and Davies found three main theoretical tendencies at work: the view of attention as a selective mechanism, the analysis of attention in terms of processing resource allocation, and the distinction between automatic and attentional processing. Wolff (1738) defined attention as a selectional process operating over degrees of clarity, though subject to both voluntary and involuntary control. As we have seen, Bonnet (1769, §142) explained the reciprocal relation between strengthened representation of a target object and weakened representation of neighbouring objects by postulating that limited neurophysiological resources must be allocated, with consequences for subsequent perceptual representation. Finally, the distinction between processes that are under the control of voluntary attention and those that occur without even being noticed was commonplace in eighteenth-century psychology, partly as a result of the postulation of unnoticed and hence automatic inferential processes to explain size and distance perception (forerunners of unconscious inference, on which see Hatfield 1990, chs. 2, 4, 5). Stewart reviews this distinction in the eighteenth-century literature (1793, chap. 2). Johnston and Dark (1987, pp. 66–70, citing James, 1890) divide twentieth-century theories into those that see attention as a cause, as opposed to those that see it merely as an effect. In Braunschweiger's (1899) terms, the faculty and mental effort positions correspond to the former classification, the state of mind position to the latter.

Empirical Investigations of Attention

It would be arbitrary to seek a firm dividing line between phenomenal descriptions of aspects of attention and empirical investigations proper. To suppose that the latter must involve experiment would only push the problem back one step, as the concept of experimentation has itself undergone considerable development since the rise of modern science. If we adopted too stringent an attitude toward experiment – say, restricting it to the standards of mid-twentieth-century journals of experimental psychology – we would be faced with the paradoxical re-

sult that much of Helmholtz's and Wundt's work on visual perception, as indeed much of Newton's work in optics, does not count as experiment. Consequently, here I will focus the discussion of empirical investigations on those empirical claims from the eighteenth century that are presented as part of a systematic scientific treatment of attention. My principal primary sources will be Wolff's (1738, 1740), Bonnet's (1755), and Abel's (1786/1985) eighteenth-century textbook treatments of attention and its empirical laws. As a standard of comparison with traditional experimental psychology, I return to Titchener's (1908) review of the results of the "new psychology" of the late nineteenth century, which will, to fix referents, be coordinated with the recent reviews of Johnston and Dark (1987), Kinchla (1992), and LaBerge (1995).

Titchener organized his review of the experimental psychology of attention around seven empirical "laws," or general (though not strictly universal) "statements of the behaviour of conscious contents given in the state of attention" (1908, p. 211). The first law states that "*clearness is an attribute of sensation, which, within certain limits, may be varied independently of other concurrent attributes*" (ibid.). Titchener takes this independence to be well confirmed for most attributes, though he cites considerable controversy with respect to intensity, finally concluding that clearness can vary independently of intensity (loud and soft sounds can be equally clear), but that clearness can affect intensity (an attended, and hence "clear" sensation may seem to differ less than stimulus intensity would suggest from an unattended, hence unclear, sensation produced by a tone of greater intensity). Earlier, Wolff held that we can voluntarily shift attention and hence affect the clarity of perceptions that otherwise would not be clear (1738, §§236–237). Bonnet, as quoted above, states a relationship between attention and the "liveliness" of perceptions, with their other qualities presumed to remain the same, and Abel (1786/1985, §195) maintains that attention can be varied at will to affect the clarity of sensory representations. Clarity is only rarely mentioned in recent discussions of attention (e.g., LaBerge, 1995, p. 27). The related notion of accuracy in perceptual judgment, usually not stated in phenomenal-descriptive terms, remains central (LaBerge, 1995, p. 9).

Titchener's second law is the *law of two levels*, which accepts that "increased clearness of any one part-contents of consciousness implies the decreased clearness of all the rest," and asserts that only two "levels or degrees of clearness may coexist in the same consciousness" (1908, p. 220). Titchener reviews several opinions, including those that posit three or four levels of clearness, and sides with those that posit only two: focal attention, and what is outside it. (He confounds figure/ground reversal with clarity of representation in arguing for his

position: 1908, pp. 228–229.) Eighteenth-century opinion was divided on this question. Wolff did not address it directly, but *de facto* he spoke only of the focus of attention (which in vision may be larger or smaller, inversely with the degree of attention) and what is outside it (1740, §360), though in other contexts he allowed that attention may be divided among several objects, without stating whether each target has equal clarity (1738, §245). Bonnet asserted an "infinity" of degrees of attention (1755, pp. 130–131). In an example from vision, he described these degrees as falling off continuously from the centre of the visual field to the boundary of peripheral vision. Abel observed that attention can be directed on one object, or it can be divided among several, presumably in different degrees as the ideas themselves are livelier or more pleasant (1786/1985, §§213, 237–241; see also Schmid 1796, pp. 324–325). Recent spotlight metaphors suggest a two-level division (Johnston & Dark, 1986, pp. 50–56), though LaBerge interprets the zoom-lens metaphor as permitting a gradation (1995, p. 27). The conception of attention as a processing resource that can be allocated to one or more spatial positions in differing amounts is consistent with multiple levels of attention (Kinchla, 1992, pp. 712–713).

Titchener gives two laws in the third instance, both pertaining to the temporal relations of attention (1908, pp. 242–247). The *law of accommodation* concerns the relation between cuing and reaction time: it takes a certain period (1 to 1.5 sec) to focus attention once cued; reaction time improves with cuing. The *law of inertia* states that it is more pleasing, or easier, to hold attention on one object than to shift it. Eighteenth-century literature does not contain reaction-time results, and so has no correlate to the first of these laws. As for the ease or difficulty of shifting attention, Wolff (1738, §§246–247) observed that in some instances attention tends to wander, and the problem is keeping it in place, and Abel (1786/1985, §214) listed a number of conditions that affect the duration of attention.

Titchener's fourth is the *law of prior entry*, according to which "the stimulus for which we are predisposed requires less time than a like stimulus, for which we are unprepared, to produce its full conscious effect" (1908, p. 251). Although observation of the connection between attention and mental preparedness goes back at least to Lucretius, the eighteenth century made no advances here that I have found. In recent literature, the correlate to Titchener's *accommodation* and *prior entry* is the *priming effect*, which has been studied extensively (Johnston & Dark, 1987, pp. 46–47; Kinchla, 1992, pp. 724–733), along with the notion of attention as *preparatory to perception* (LaBerge, 1995, pp. 12–13).

Titchener's fifth is the *law of limited range*, which says that for brief (tachistoscopic) exposures of objects within the scope of clear vision,

"a practiced observer is able to cognise from four to six of them 'by a single act of attention'" (1908, pp. 260–261). In the eighteenth century, this question was not posed in connection with tachistoscopic presentation. The earlier question concerned the number of objects that can be held in clear consciousness, apperceived, or attended to, at one time. Opinions were divided. Krueger held that through attention the understanding is able to make just one of its representations clearer at a time (1756, pp. 228–229). Bonnet tested the question by seeing how many objects he could imagine at one time. He reported: "I find considerable variety in this connection, but in general the number is only five or six. I attempt, for example, to represent to myself a figure with five or six sides, or simply to represent five or six points; I see that I imagine five distinctly: I have difficulty going to six. It is perhaps true that regularity in the position of these lines or points greatly relieves the imagination, and helps it to go higher" (1755, p. 132).

The task of determining how many items can be cognized clearly at one time was pursued with relative continuity over a period of two hundred years. In the 1830s the Scottish philosopher and psychologist William Hamilton proposed the following experiment to answer the question: "If you throw a handful of marbles on the floor, you will find it difficult to view at once more than six, or seven at most, without confusion; but if you group them into twos, or threes, or fives, you can comprehend as many groups as you can units . . . You may perform the experiment also by an act of imagination" (1859, p. 177). Hamilton controlled for time by fixing the onset of the task and operating under instructions that the number of marbles must be taken in "at once," that is, in one cognitive act. Later in the century, Jevons (1871) performed a similar experiment by throwing various quantities of black beans into a shallow round paper box and estimating their number as soon as they came to rest. His results, originally reported in *Nature*, are shown in Table 3. He concludes that since a 5% error rate was obtained when the number of beans reached five, the proper figure for the limit of correct numerical estimation by a "single act of mental attention" is four. In the middle of the twentieth century, Kaufman, Lord, Reese, and Volkman (1949) studied the discrimination of visual number using dots projected on a large screen, varying the instructions for speed and accuracy. They found no errors for two, three, or four dots. For both accuracy and speed instructions, error began at five dots; the errors were fewer for accuracy instructions and reaction time longer. Kaufman et al. (1949) also reported reaction times from a similar experiment by Saltzman and Garner (1948), which showed that the times increase monotonically as the number of stimuli is increased from two to 10. Following Saltzman and Garner,

they concluded that there is no such thing as a single "span of apprehension" or capacity of momentary cognition. Hence, they did not present their findings as bearing on attention, but they focused instead on the judgment of numerosness itself, and coined the term *subitizing* for cases in which number is determined "suddenly" (1949, p. 520). This literature about subitizing is not commonly included in current discussions of attention. However, a correlate of Titchener's fifth law, and of the question posed by Bonnet, Hamilton, and Jevons, occurs in recent literature through comparisons of attention to a bottleneck (LaBerge, 1995, p. 34).

		Actual Numbers													
		3	4	5	6	7	8	9	10	11	12	13	14	15	
Estimated Numbers	3	23													
	4		65												
	5			102	7										
	6			4	120	18									
	7			1	20	113	30	2							
	8					25	76	24	6	1					
	9						28	76	37	11	1				
	10							1	18	46	19	4			
	11								2	16	26	17	7	2	
	12									2	12	19	11	3	2
	13											3	6	3	1
	14											1	1	4	6
	15												1	2	2
	Totals		23	65	107	147	156	135	122	107	69	45	26	14	11

Table 3. Data showing W. Stanley Jevons's estimates of the number of black beans thrown into a white paper box at the moment at which the beans come to rest, in comparison to the actual number of beans thrown. Adapted from Jevons (1871).

Titchener's sixth is the *law of temporal instability*, which says that attention is unstable in itself. Titchener cites Wundt (1874) to the effect that attention is constantly broken, from moment to moment (Titchener 1908, p. 263). However, Titchener himself considered the estimate of two to three minutes for the self-limiting duration of focused attention to be conservative (p. 268). Wolff (1738, §244) noted that the ability to hold attention fixed varies from individual to individual, without giving a temporal estimate. Recent empirical work discusses this topic under the rubric of *sustained attention*, or the *duration of attention*

(LaBerge, 1995, pp. 35–38); these findings suggest a duration on the order of hundreds of milliseconds.

Seventh and finally, Titchener expresses the wish that there were a law for measuring the *degree of clearness* or the degree of attention. Finding no single measure extant, he discusses several candidates, including the effect of distractors on some measure of performance (such as errors in a well-practised sensory discrimination task). Other proposed measures of "attentional degree" or "attentional capacity" include measures of simultaneous range of attention (cf. law five), the effect of attention on sensory discrimination (cf. law four), the effect of attention on the formation of associations, and finally its effect on reaction time (1908, pp. 279–280). In the eighteenth century, Wolff discussed several measures of degree of attention, including ease of distraction, capacity, and duration (1738, §§243–245). Contemporary work assesses various dimensions of attention through sophisticated measures of performance characteristics such as reaction time and performance error (Kinchla, 1992).

These comparisons suggest that there is both continuity and divergence across the past 250 years of attention research: continuity at the global levels of theoretical conceptions and main dimensions of analysis, discontinuity in the development of sophisticated instrumentation for testing reaction time (late nineteenth century) and sophisticated approaches to measuring the fine-grained spatial and temporal characteristics of attention-based and unattended processing (twentieth century). As elsewhere in psychology, current work on attention tends to be fragmented: there are traditions of work on attention as a selective mechanism (which might be early or late, voluntary or involuntary), as allocation of processing resources, and as something to be contrasted with automatic processing. Within these theoretical traditions, elaborate flow-chart models are being developed and tested. New empirical questions have arisen concerning the extent to which semantic (as opposed to simple physical) dimensions of stimuli are processed outside the focus of attention. New neural imaging techniques now make it possible to track the neurophysiology of attention more closely than before. At the same time, the questions that were at the centre of discussions in the eighteenth century and earlier, the cognitive function of attention, are less frequently posed, and the functioning of attention in higher cognition is less frequently discussed. As many authors have observed, "attention" now defines a complex field of research that may or may not be unified by a single underlying process or set of phenomena. It is less common now for a single author to attempt a systematic taxonomy of all the phenomena of attention. There is richness of results and of microtheory, but theoretical unification remains elusive.

Concluding Remarks

Examination of the early history of attention reveals that the chief phenomenal descriptive aspects of attention had been recorded by the seventeenth century. The main theoretical positions were formulated by the end of the eighteenth century, and the primary areas of experimental investigation by the end of the nineteenth. Experimental technique has been much refined, and new instruments make possible fine-grained analyses of the psychophysics of attention. These permit formulation of sophisticated questions about the temporal course, spatial distribution, and content-related characteristics of attentional processing.

Titchener's claim that research on attention was born with the "new" experimental psychology of the late nineteenth century is false. His claim in fact differs markedly from the attitude of William James, who is now cited more prominently than Titchener on attention. James referred freely to eighteenth-century works, including those of Wolff and Stewart (James, 1890, chap. 11). The extent to which the theoretical context set by eighteenth-century psychology conditioned and controlled the psychology of Wundt, Titchener, and indeed James, and thereby set the context for twentieth-century psychology, is at present unknown. This state of ignorance has largely resulted from the misbelief that scientific psychology is itself only slightly more than 100 years old. For the case of attention, I hope to have shown that that contention is at least 150 years off the mark.

Note

1 Unless otherwise indicated, all translations are the author's.

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