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The subject of attention

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Abstract The absence of a common understanding of attention plagues current research on the topic. Combining the findings from three domains of research on attention, this paper presents a univocal account that fits normal use of the term as well as its many associated phenomena: attention is a process of mental selection that is within the control of the subject. The role of the subject is often excluded from naturalized accounts, but this paper will be an exception to that rule. The paper aims to show how we might reinstate the subject into the act of attention, endorsing the ordinary notion that attention is a direction of the mind by the subject, rather than a mere occurrence or happening. To do so, it lays out the best work of phenomenology, psychology, and neuroscience on specifying the ordinary notion of attention and, in finding them individually wanting, combines them into a unified view that avoids the problems of each. In this way the paper presents a "how possible" account of the ordinary notion of attention, wherein attention is enacted by a subject.

Keywords Attention · Phenomenology · Psychology · Neuroscience · Endogenous · Exogenous · Active · Passive

1 Introduction

Disagreements about the nature and influence of attention long precede the current tailspin. Hegel, for instance, asserted once that without attention "there is nothing for the mind" (Hegel 1971, p. 448). Hegel scholar Willem de Vries says in response that "this notion seems implausible, for attention (*Aufmerksamkeit*) is a fairly strong word, implying a high degree of conscious mental activity and willful self-control" (de Vries

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1988, p. 112). Indeed, the idea that mental content might rely for its existence on "a high degree of conscious mental activity and willful self-control" does seem implausible. But why think that attention is essentially tied to a *high* degree of mental activity? Could we extend the concept of attention to include lower degrees of mental activity that would make Hegel's idea less implausible, less fantastic? The current paper finds a positive answer to this question by examining various attempts to specify attention through the domains of phenomenology, psychology, and neuroscience, ultimately combining the findings from these domains into a common account of attention. The aim of the paper is to enable research on attention to more carefully target its phenomena. By providing a clearer target, it can provide clarity to current debates concerning the relationship between attention and other functions of the mind.

A starting point for specifying the concept of attention is understanding the term's ordinary usage. Against the possibility of identifying just one such usage, Jeremy Wolfe and Todd Horowitz contend: "even though William James famously declared that 'Everyone knows what attention is,' there is no single, satisfying definition of attention" (Wolfe and Horowitz 2004). Felipe de Brigard and Jesse Prinz similarly suggest that ordinary usage is "polysemous," but also claim that

> those who try to move beyond that suggestion that "everyone knows what attention is" often replace the folk concept with idiosyncratic definitions that settle crucial questions by fiat rather than facilitating the process of investigation and discovery. (de Brigard and Prinz 2010)

Although I share the frustration of these authors with respect to contemporary specialist usage of the term (which I find to be conflicting), I find that ordinary usage of "attention" centers around a unique concept that is not picked out by any other term in the English language: *the act of mental selection*.[1] Put another way, ordinary usage of "attention" centers around the concept of actively prioritizing select mental entities over others for the use of mental resources, resulting in a particular distribution of the available mental resources, whether the direction of this prioritization is "internal," "external," "focused," "spread," "undivided," "split," "paid," or "grabbed." This ordinary usage is picked out in most dictionary entries for "attention,"[2] even if contemporary philosophical and scientific accounts of the term stray widely.

I take it that the core conflict in contemporary specialist usage of "attention" is the extent to which attention is thought to be an act, rather than a mere occurrence. I think that most theorists would allow that attention is essentially concerned with the mental, whether the mental is understood in terms of its correlative phenomenal, behavioral, or neural activity (although, admittedly, many theorists appear willing to

[1] As used here, "mental" implies all that is capable of being fully contained within thought and/or memory and "selection" implies the prioritization of preferred over non-preferred entities.

[2] This usage is evident in the first entry for "attention" in the Oxford English Dictionary: "The action, fact, or state of attending or giving heed; earnest direction of the mind, consideration, or regard; esp. in phr. to pay or give attention. The mental power or faculty of attending; esp. with attract, call, draw, arrest, fix, etc." (Oxford English Dictionary 2012); the American Heritage Dictionary: "a. The act of close or careful observing or listening, b. The ability or power to keep the mind on something; the ability to concentrate, c. Notice or observation" (American Heritage Dictionary 2012); and even (less clearly but more vividly) the Urban Dictionary: "the thing that belongs to you which I have right now" (Urban Dictionary 2012).

apply the term to any selective processing in the central nervous system, whether it would normally be considered within the realm of the mental or not).[3] Moreover, I think that most theorists would agree that attention is essentially concerned with *prioritizing* select mental entities over others.[4] The point of conflict is over who or what is responsible for this act of mental selection. On the one hand, attention appears primarily (centrally, and in the first place) as an act: it appears to be directed by someone or something that is normally considered responsible for that direction.[5] On the other, attention sometimes has the characteristics of a passive occurrence: it can be moved by forces that seem beyond one's conscious experience and control. Predicting the now-standard answer to this latter phenomenon, F. H. Bradley argued over one hundred years ago that we should drop the understanding of attention as an act and instead embrace a reductive account of attention, wherein "any function whatever of the body or the mind will be active attention if it is prompted by an interest and brings about the result of our engrossment with its product" (Bradley 1886, p. 316). Many years later, G. D. Marshall countered Bradley's arguments with the claim that if attention were controlled entirely by natural interests then it would not sometimes require effort. Marshall takes the involvement of effort to be a sign that attention requires some amount of volition (Marshall 1970, p. 16). Of course, even granting that effort is a sign of volition, the fact that attention sometimes requires effort is not a sign that it always requires volition, leaving the problem that attention is sometimes passive, or effortless, still in need of explanation. That is, we still need an explanation for how an act could sometimes take on the characteristics of a passive occurrence.

I make the case in this paper for a solution to this apparent conflict that avoids the reduction of attention to a mere occurrence while at the same time satisfying the "difficult" cases. In what proceeds I understand attention to be an act insofar as it is directed by a subject, where a subject is that to which we attribute such capacities as consciously experiencing, knowing, thinking, planning, and perceiving.[6] Starting with this understanding of attention—as subject-directed mental selection—I look to phenomenology, psychology, and neuroscience to specify criteria that reliably separate this type of mental selection from all other mental selection. In finding such criteria I provide a "how-possible" account of the ordinary notion of "attention," preserving its status as

[3] As evidence for the claim that most theorists consider attention to be a mental phenomenon, most articles on attention cite James as the authority on its definition, where the fact that attention is mental is explicitly discussed. For example: "Much of modern thinking about attention stems from William James' classic description, 'Everyone knows what attention is…the taking possession by the mind, in clear and vivid form, of one out of what seem several simultaneously possible objects or trains of thought" (Bisley and Goldberg 2003).

[4] A recent *Science* article, for example, describes attention as "the prioritization of relevant information" (de Fockert et al. 2001).

[5] As stated earlier, attention is defined as an act in most or all dictionary entries and that it is an act is central to ordinary usage, such as in the command to "pay attention." Because the essence of the concept of attention is act-based (and the sense of attention as "grabbed" or "caught" is secondary and dependent upon this first sense), the first experience we have of attention as attention is as an act; if we were unable to exert control over our attention (if we were more like infants, say) then we would not likely recognize it as attention at all, even in the secondary sense, but as a mere focusing or orienting.

[6] When I say "subject," I do not mean subject-as-mere-experimental-participant, and so I use the term "participant" to signify experimental subjects.

an act over a mere occurrence. Such an account is more favorable than competing accounts because it both avoids deflating the ordinary notion and, as I will demonstrate, allows the three domains of attention research—phenomenology, psychology, and neuroscience—to be brought together. I will argue that this combined approach has epistemic advantages over any of the individual domains.

2 Phenomenal criteria

A natural first attempt to specify attention might fixate on the phenomena immediately and directly available to the subject, since direction by the subject is a central feature of attention and since recognition of one's own subjectivity through such phenomena seems to be fundamental to the recognition of subjectivity in others. But the phenomena immediately and directly available to the subject can be carved up in different ways. One can divide the phenomena into sensory attributes and look for criteria of attention among those attributes. One can also divide the phenomena into experiential modes and look for criteria of attention among the modes. To illustrate the difference between these, pay attention to *this*. As you attend to the written letters, reflect on any changes in the sensory attributes of the percept. You may, for example, notice more detail in the structure of the letters. Now, attend to the written letters again but reflect instead on the experiential mode of attending. You may, for example, notice an increased involvement of effort while you attempt to prioritize the written letters over other competing visual stimuli.

As I will discuss below, a closer examination of these two categories of phenomena reveals that neither successfully specifies attention on its own. Attention is not required for changes in the sensory attributes: the letters may appear more detailed if seen through the fovea rather than the perifovea or if displayed at a higher resolution, neither of which implicates attention. For this reason I set aside any purely phenomenal attempt to find criteria for attention among the sensory attributes. Any attempt to find satisfactory criteria among the experiential modes is stuck with the problem of captured attention. As an instance of captured attention, take the case of your attending to

this.

You might describe the letters as having distracted you and as having drawn your attention away from the rest of the text. That is, you likely attended to the letters with either no effort or with so little effort that it was difficult to distinguish from no effort. Because of cases like this, accounting for captured attention renders the criteria of experiential mode (at best) difficult to determine, whether one uses the criterion of effort or some other feature of experiential mode. In the sections to follow I discuss these two attempts to specify attention through its subjective phenomena. Neither attempt is satisfactory on its own, but they can be buttressed with behavioral and neural evidence to develop a successful account of attention, as I show later on in the paper.

2.1 Sensory attributes

We may sympathize with Edward Titchener when he says that "the analytical study of attention must center about the sensory attribute of clearness or vividness" (Titchener

1910, p. 180), particularly after observing that the experience of attention usually involves an increase in clearness or vividness.[7] When we attend to the written letters in the example above, they seem clearer or more vivid, while the surrounding de-selected text simultaneously becomes less clear or less vivid.[8] However, a worry that counts against this early approach is that the ordinary usage of "attention" does not depend solely on reports of the experienced qualities of a stimulus, but also on the relation between the subject and the stimulus, of which reports of sensory attributes are a mere guide. For example, we would not say of someone who is staring intently at a low-resolution image that he or she is not paying attention to that image even if his or her resulting experience is reported to lack clearness. Similarly, we would not say of someone who reports having a clear percept of a salient, high-resolution image after a quick glance that he or she must have paid attention to that image. Thus, our ordinary ascriptions of "attention" appear to depend on the relationship between the subject and the stimulus.[9]

One reason that our ordinary ascription of "attention" might rely on the relationship between the subject and the stimulus is that we know that our own history changes our perception of stimuli. At the very least, we know that we are quicker at perceiving familiar stimuli than unfamiliar stimuli. One can much more easily spot one's spouse in a crowd, for example, than a new friend. Likewise, our old ringtone leads to a much quicker response than a new one. Some part of that speed has to do with recognizing the sound *as* one's ringtone, and some other part of that speed has to do with improved motor response, but I think that there is room enough left for an improvement in the speed of perception itself. Similar such examples lead us, I think, to find that the history of a subject makes a difference to the clearness or vividness of the subject's percept, such that our willingness to say that some or another subject is attending to a stimulus will depend on both the history of that subject and the stimulus in question. In any case, the ordinary ascription of "attention" to a subject does seem to depend on both the subject and the stimulus, and not simply on the clearness or vividness of the resulting percept.

William James likely shares this worry, though at first glance he may appear to agree with Titchener that attention is tied to the experience of clearness or "concentration."

> Every one knows what attention is. It is the taking possession by the mind, in clear and vivid form, of one out of what seem several simultaneously possible objects or trains of thought. Focalization, concentration, of consciousness are of its essence. (James 2010, p. 403)

[7] Titchener's use of "clearness" is somewhat special: "[Clearness] is the attribute which distinguishes the 'focal' from the 'marginal' sensation" (Titchener 1908, p. 26), and so I follow his decision in the 1910 article to use the term "vividness" to further specify the term.

[8] The difference here is subtle, and has been measured by researchers to be of the order of only a few percentage points (Carrasco et al. 2004).

[9] Titchener notes the apparent interaction of several qualities of a stimulus (including its similarity to the current "ideas" of the subject) and the attribute of clearness, but maintains their independence as one of his "laws" of attention (Titchener 1908).

Note that James says here that concentration is the "essence" of attention, even noting later in the passage that the "real opposite" of attention is "distraction." James next asserts that any degree of concentration constitutes a state of attention:

> The awakening [of attention] may come about either by reason of a stimulus from without, or in consequence of some unknown inner alteration; and the change it brings with it amounts to a concentration upon one single object with exclusion of aught besides, or to a condition anywhere between this and the completely dispersed state. (James 2010, p. 404)

As Christopher Mole points out, this account appears self-contradictory since it holds both that attention is *essentially* concentration and that attention is anything between concentration and complete dispersal, or non-concentration (Mole 2011).[10] This apparent inconsistency can be resolved if we think of James' "attention" as a process that results in a range of sensory attributes, rather than as the resulting sensory attributes themselves. That is, it is resolved if we understand James to define "attention" as the *act* of concentration which has the *resulting experience* of anything from the concentration of certain sensory attributes to their complete dispersal.[11] This interpretation of James fits the description I have provided of ordinary usage, within which it is the relation between the subject and the stimulus that matters in determining the presence of attention, and not the quality of the resulting percept on its own.

This "process-first" view presumes that attention is its own process rather than a quality of other processes, which can be opposed to the "adverbial" view put forward by Mole (2011). The adverbial view of attention finds attention to be more analogous to "haste" than to "running," where we can either just run or we can run with haste, but we cannot just hasten on its own. Likewise, in Mole's view, we can either just think or we can think with attention, but we cannot just attend on its own. Mole argues that a process-first view cannot be successful because there is no single process that could capture the many phenomena associated with attention. To the contrary, I find that there is a unifying understanding of attention that can capture the various phenomena that we might want to include under its heading, the demonstration of which is the purpose of this paper. So one reason to accept this process-first view is negative: its impossibility has not yet been established. This negative finding is relevant because, as I mentioned above, the process-first view more closely fits the ordinary understanding of "attention," a revision of which would require some positive evidence of its inadequacy. A further reason is that the process-first view can serve as an explanation for the clearness or vividness associated with attention without being bound to these sensory attributes as defining features of attention. This is an advantage so long as we

[10] Christopher Mole tries to solve this seeming self-contradiction by suggesting that we ignore James' willingness to extend attention to dispersed states and "take seriously" his initial description of attention as focused rather than dispersed (Mole 2011, p. 158).

[11] I am assuming that James means by "concentration" in the second quote (e.g. in "…amounts to a concentration…") the resulting concentration in certain sensory attributes rather than the concentration of attention's resources. If the latter, the conflict dissolves in a different way, since it would not be a problem for attention to be essentially concentration but to concentrate its resources in different ways.

see that attention need not always come along with clearness or vividness, depending on the history of the subject and the stimulus before that subject.[12]

In sum, sensory attributes are ill-equipped to indicate the presence of attention without corresponding information about both the stimulus and the subject. If we knew, for instance, that a subject was looking at an unfamiliar, degraded stimulus then our assessment of the subject's attention from the subject's report of hazy, unclear phenomena would be different than if we knew that the subject was looking at a familiar, clear stimulus. However, this is only a problem for a stand-alone phenomenological account of attention through the sensory attributes. If we allow the phenomenological evidence to be supplemented with behavioral and neural evidence then the problem disappears, allowing phenomenological saliency (clearness or vividness) to serve as a marker of attention after all. I will discuss this naturalized, process-first account in more detail in the final section of the paper.

2.2 Experiential mode

Before we turn to the behavioral and neural evidence, there is another category of phenomenological evidence that might be used to supply criteria for attention—experiential mode. Experiential mode is based on *how* the subject experiences, rather than on *what* the subject experiences, and is normally divided into the active and passive modes. Attention theorists often focus on the active mode, wherein we "pay" attention, since this is the mode most commonly associated with attention, but attention can also be "grabbed," as when our attention is grabbed by a colorful advertisement or by an annoying conversation. This fact makes it difficult to base the distinguishing characteristic of attention on the active mode, since attention seems to span the full spectrum of experiential mode—from active to passive. To solve this "problem of captured attention," one can present a third mode beyond both the active and passive modes: the mode of pure givenness, or the "purely passive" mode. That is, the normally considered separable modes of "active" and "passive" can be reconceived as a spectrum of states that are all somewhat active and somewhat passive, where the purely passive mode exists outside of this spectrum altogether. In this re-conception, attention would encompass any mental selection from that which is willed by the subject or "active" to that which is willfully accepted by the subject or "passive," whereas any mental selection outside of the subject's control, or "purely passive," would not count as attention.

This tripartite view of experiential mode is first introduced in the work of Edmund Husserl. For Husserl, attention is "a *tending of the ego toward an intentional object*" (Husserl 1975, p. 80). This can be an effortful "tending," as in the active direction of attention to a stimulus, or it can take place without effort, as when the stimulus seems to intrude upon consciousness and the subject or "ego" is merely actively receptive to a stimulus that is otherwise passively given (Husserl 1975, pp. 60–79). In other

[12] That is to say, attention need not *vary* with clearness or vividness, so even accepting that there are degrees of clearness or vividness (as Titchener does) will not help an account that yet maintains that attention *just* is clearness or vividness (or the degree of clearness or vividness), such as Titchener's.

words, Husserl would likely say of the above examples of the large text, the colorful advertisement, and the annoying conversation that the subject is active in allowing him or herself to be distracted; the large text, the colorful advertisement, and the annoying conversation could be actively suppressed by the subject with effort, but are instead allowed to disrupt the subject's thoughts because the subject "turns toward" the distracting stimuli in willfully allowing them to intrude. A sign that this turning toward is active in the case of captured attention is that there are instances where the same stimulus does not serve as a distraction—where the large text, the colorful advertisement, and the annoying conversation do not manage to disrupt one's stream of thought because of greater attention to that stream of thought. It is a comparison with these instances that warrants the claim that the subject actively allows the capture of attention to occur when the subject finds him or herself distracted.

Thus, Husserl's specification of attention includes even the mere acceptance of a stimulus by the subject. Because this pushes the boundary between active and passive into the realm of what we hitherto might have called "passive," Husserl says that we must accept the existence of a "deeper passivity":

> Thus *the distinction between active behavior and passive acceptance or suffering does not have the same meaning for naïve consciousness, turned directly toward pregiven objects, as it does for the reflective regard* which already finds in acceptance of the pregiven, in contemplative apprehension of it, an element of activity and, as a result, must obtain a *more radical conception of passivity* than that entertained by naïve consciousness. This [more radical] conception is that of *pure affective pregivenness*, of *passive belief in being*, in which there is nothing yet of cognitive achievement: the mere "stimulus" which proceeds from an existent in the environing world, as, e.g., the barking of a dog which "just breaks in on our ears," without our previously having given our attention to it, without our having turned toward it as a thematic object. Wherever it is a matter of attention, such an activity of the lowest level is already present. (Husserl 1975, p. 60)

This passage is difficult, but I interpret Husserl to be claiming that the naïve observer separates active from passive by separating what the subject wills from what the subject willfully accepts, whereas we (those of us who have benefited from the "reflective regard") should separate active from passive by separating what the subject willfully accepts from what is merely presented to the subject by his or her environment, which is the result of a purely passive process.

Importantly, Husserl argues that we should break from the position of the naïve observer because we know that by introspecting upon experiential phenomena we have already turned toward the stimuli presented therein, which means that the stimuli prior to that turning toward are presented to us in a form of experience yet more passive than anything we could find through introspection (where this purely passive mode of experience may or may not be "conscious"). Put another way, introspection requires that the object of introspection is cognized (or "accessed," in the language of Block (2011)), but there may be an experiential mode and/or experienced objects prior to cognition (or "access"). In fact, we know that purely given objects must exist because of our capacity to turn toward and introspect objects that are not already cognized. The purely given object that existed before the turning toward of introspection and

attention should be understood as having been experienced in a mode of "more radical" passivity, according to Husserl. This form of experience involves its own system of salience, such that prominent items can "pull" at the subject or "ego," but "apprehension" of those items requires that the subject turns to them.[13] Thus, in Husserl's picture, the problem of captured attention together with reflection on the nature of introspection shows us that attention should include everything from willed direction by the subject to willful acceptance of an otherwise passively given stimulus, which can be differentiated from a mere "relief of salience," which does not require any activity by the subject.

Although a tripartite view of experiential mode, such as Husserl's, can answer the problem of captured attention, it leaves us with a significant hurdle: the extension of activity into the realm of what was hitherto considered passive makes the activity of attention more difficult to identify from within experience. We normally use felt effort as a guide to the presence of attention, but the felt effort of willful acceptance is either absent or so weak as to be difficult to detect. The phenomenal experience of willful acceptance is, at best, a subtle experience that I gather many will have a hard time recognizing, making it difficult for those people to distinguish the experience of attention from that of non-attentional mental selection.

Fortunately, we do not have to stay within the realm of subjective phenomena—we can use subjective phenomena (such as felt effort and clearness or vividness) as a guide in trying to find more concrete criteria of attention through the behavioral and neural responses to objective stimuli. Some attempts to find such criteria are reviewed in the next two sections. In the final section of the paper I will show that the ordinary notion of attention (as subject-directed mental selection) can be delimited through a combination of the evidence from subjective phenomena, behavior, and neural response. In refining ordinary usage, the offered sketch of attention should gain the advantage over more revisionary understandings of attention.

3 Behavioral criteria

Although phenomenal evidence is insufficient for a clear and consistent specification of attention, we can supplement phenomenal with behavioral evidence. A relevant behavioral divide is that between stimulus-driven, "exogenous" behavior and internally-driven, "endogenous" behavior, the difference between which is largely studied through the difference between reaction times to a target following a peripheral cue at the location of the target and a central cue that symbolically directs attention to the target, respectively. If peripherally-cued behavior were ever purely stimulus-driven, rather than under the subject's control, then this behavioral divide could help supply behavioral criteria of attention (as it is ordinarily understood). Unfortunately, research on this divide has been unable to provide a clean break between truly exogenous and endogenous behavior, finding a difference instead between willful acceptance of a

[13] Husserl prefers to describe this pull of the bare stimulus on the subject with the phrase "relief of salience" (Husserl 2001, p. 215), but his translator calls it (incorrectly, I think) "a passive attention" (Husserl 2001, p. xlix).

stimulus (following the peripheral cue) and willed direction of attention (following the central cue). This latter divide more properly fits the full spectrum of attention as described by Husserl, where the peripherally-cued behavior fits the lowest level of activity and the centrally-cued behavior fits the highest level of activity. As Posner puts it in his groundbreaking and widely-cited article, "Orienting of Attention":

> Attention can be directed by a central decision…or it can be drawn by a peripheral stimulus…Comparisons of exogenous (reflexive) and endogenous (central) control of orienting is made difficult because external signals do not operate completely reflexively but will only summon attention and eye movements if they are important to the subject. Moreover, central mechanisms that may control covert orienting, such as the parietal lobe also receive input from subcortical centres involved in overt orienting. Nonetheless it would be useful to attempt to compare central and peripheral systems for producing changes in orienting as a model system for the interaction of external and internal control. (Posner 1980, p. 19)

In this passage, Posner notes that his central/peripheral cueing paradigm imperfectly splits endogenous from exogenous behavior since neither cue engenders a reflexive response and since, moreover, the paradigm mixes in other forces, such as those of motor control. He suggests that the paradigm may yet be used to *model* the difference between truly exogenous and endogenous influences on behavior, a suggestion that I will call into question below. Attention researchers appear nonetheless to take the Posner cueing paradigm to divide stimulus-driven from internally-driven behavior when they synonymize "exogenous" with "involuntary" and "endogenous" with "voluntary" in using that paradigm. A recent *Nature* paper by Herrmann et al., for example, declares: "We found that attention, both exogenous (involuntary) and endogenous (voluntary), can affect performance…These two variables were manipulated in a cueing task" (Herrmann et al. 2010).[14] I aim to show that the difference between peripherally-cued and centrally-cued responses may not reflect a difference in voluntariness or endogeny, but in other differences between the conditions of the paradigm. Thus, the differences found between these conditions should not be presumed even to model the difference between truly endogenous and exogenous influences on behavior without the additional support of either phenomenal or neural evidence.

3.1 Reaction time

The reaction time to a target (RT) is widely thought to reflect a difference between exogenous and endogenous influences (Yantis 1998). In the classic Posner cueing paradigm experiments on RT, two different kinds of cue are used to indicate the location

[14] This approximate formulation is also found in Trappenberg et al. (2001)—"localized sensory (exogenous) and voluntary (endogenous) inputs"; Eimer and Driver (2001)—"endogenous (voluntary) as well as exogenous (involuntary) spatial attention"; Busse et al. (2008)—"exogenous (reflexive) and endogenous (voluntary) shifts of visual spatial attention"; and a number of other highly-cited articles.

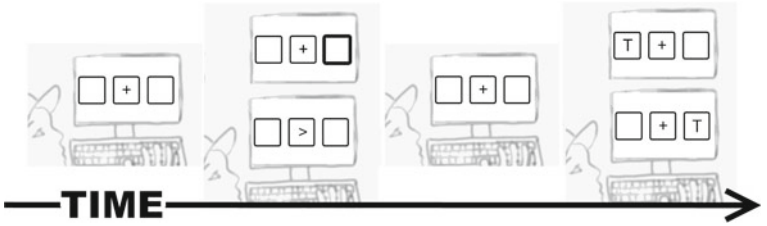

Fig. 1 Sample RT experiment: fixation, cue, fixation again, and target. The cue can be either central (*below*) or peripheral (*above*). The target can be either valid (*below*) or invalid (*above*)

of a target while the gaze is fixed at a central point (Posner 1980).[15] The central cue is presented at fixation, symbolically directing the participant to expect the target either to the left or to the right of the central point (e.g. with an arrow). The peripheral cue, on the other hand, directs the participant to expect the target at the cue's location, which is either to the left or to the right of the central point. The difference between the RT following a peripheral versus a central cue is meant to tell us the difference between exogenous (peripheral cue) and endogenous (central cue) influences on behavior (see Fig. 1 for a sample RT experiment).

The RT experiments use two different conditions to measure the impact of these cues on RT. In one condition, the "valid condition," the participant is cued to the correct target location. In the other condition, the "invalid condition," the participant is cued to the location on the opposite side of fixation from the target. If the participant expects the target at an invalidly-cued location, RT to the target should be longer than if the participant expects the target at a validly-cued location or does not expect the target at any location in particular. The RT difference between peripheral and central cues in the valid condition is meant to illustrate the difference in *processing speed* for exogenous and endogenous cues. The RT difference between peripheral and central cues in the invalid condition is meant to illustrate the difference in *strength of influence* by exogenous and endogenous cues.

In a 1981 study by John Jonides, the RT is shortest when the target is preceded by a valid peripheral cue, or when the target is correctly predicted by a cue in the same location as the target. The RT is longest when preceded by an invalid peripheral cue, or when the target is incorrectly predicted by a cue on the opposite side from the target. When compared to the peripheral cue, the central cue brings about a longer RT in the valid condition, but a shorter RT in the invalid condition (Jonides 1981). Because the central cue does not hinder behavioral response as much as the peripheral cue in the invalid condition, it appears to have less of an overall effect on expectation (it is less "potent"). Because the central cue results in longer RT's than the peripheral cue in the valid condition, it appears to engage expectation more slowly.

Although these RT findings illustrate a difference between peripheral and central cues, they do not show that the RT difference derives from a difference in degree of voluntariness or endogeny. A possibility mentioned by Jonides is that the central

[15] Gaze is verified in these experiments through either eye tracking or tasks that are shorter than the time it takes to shift gaze (around 100 ms).

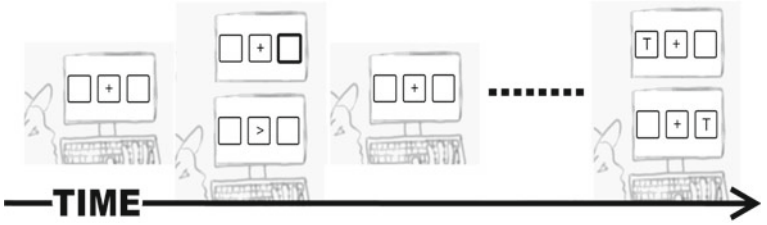

Fig. 2 Sample IOR experiment: fixation, cue, fixation again, and target. As with the standard RT experiments, the cue can be central or peripheral and the target can be valid or invalid. Unlike standard RT experiments, IOR experiments vary the duration of the second fixation, which is called "Variable Onset Asynchrony" or "Variable SOA"

cue has to be processed more deeply than the peripheral cue, where this processing could occur outside of the purview of the subject's control. Perhaps the central cue is processed more slowly because it requires symbolic processing in brain areas some distance from the visual areas required to process the peripheral cue. Perhaps the central cue requires processing in higher-level spatiotopic areas (because it shows up at a location other than the target), whereas the peripheral cue can be processed in lower-level retinotopic areas (because it shows up at the same location as the target). In either case, the difference in RT would represent a difference in internal processing time that does not necessarily reflect the added voluntariness or endogeny provided by the central cue, and so does not necessarily divide willful acceptance of a stimulus from willed direction of attention. Because it does not necessarily divide willful acceptance of a stimulus from willed direction of attention, it does not necessarily divide lower from higher levels of activity, voluntariness, or endogeny, and so RT cannot be assumed even to *model* the divide between exogenous and endogenous influences on behavior. Note that one way of solving this problem would be to add data concerning the neural processing of peripheral and central cues in order to rule out these other confounds. Another would be to add data concerning the subject's phenomenological experience. These potential solutions will be discussed in the final section of the paper.

3.2 Inhibition of return

Inhibition of return, or IOR, is another type of evidence thought to distinguish endogenous from exogenous influences on behavior. IOR studies use the same paradigm as RT studies but look instead at the *inhibition* of target detection by peripheral and central cues. Both RT and IOR experimental setups involve central gaze, central and peripheral cues, and valid and invalid conditions, but in IOR experiments the time between cue and target onset (the "Stimulus Onset Asynchrony," or SOA) is varied (see Fig. 2 for a sample IOR experiment). One of the important findings from this research is that peripheral, but not central, cues bring about inhibitory responses at the cued location after around 250 ms.

Michael Posner and Yoav Cohen published a paper in 1984 showing that peripheral and central cues yield different inhibitory effects. Namely, when the time between cue and target is increased beyond 250 ms, the initial advantage of peripheral cueing is

reversed, whereas the advantage of central cueing is unchanged (Posner and Cohen 1984). After this time, it appears as though the peripherally-cued location is inhibited, giving the advantage to the uncued location. That is, when there is more than 250 ms between a peripheral cue and its target, response to the target is faster for the uncued location than for the peripherally-cued location. As Posner and Cohen write: "These results show that facilitation can be obtained either from peripheral or from central cues. However, the inhibition effect does not occur if the cue is a central one" (Posner and Cohen 1984, p. 541).

Although it is tempting to think of any inhibitory effect as resulting from voluntary attention, additional research seems to show that IOR represents the contribution of oculomotor planning, instead. A review by Bruce Millikan and Steve Tipper, for example, presents research showing that IOR *does* take place for central cues when the participants are allowed to move their eyes and even when eye movements are planned and then cancelled by the participant. That is, if participants fixate and are cued at center, but plan to direct their eyes to the cued location, that location receives an inhibitory influence at around 250 ms, just as though it were peripherally cued. However, this inhibitory effect occurs even when the participant attempts to override it by "cancelling" the movement, showing that the effect is involuntary. This indicates that IOR is connected to "the automatic programming of an eye movement to its location" (Milliken and Tipper 1998, p. 214).[16] Thus, IOR does not reveal a difference in degree of endogeny or voluntariness so much as the planning of eye movements from the absence of such planning, and so cannot be used to model the divide between exogenous and endogenous influences on behavior any more than reaction time.

As was predicted by Posner in his influential paper, differences between peripheral and central cueing can obscure the distinction between behavior that is controlled by the subject and behavior that is outside the control of the subject. For this reason, any criteria that distinguish "endogenous" from "exogenous" influences on behavior through the Posner cueing paradigm alone will not be useful in our quest to find a clear and consistent specification of attention. That is, neither reaction time nor inhibition of return can tell us, by themselves, whether or not attention is present, at least in its ordinary sense. However, if we add information about the subject's phenomenal experience or neural state than we may well be able to determine the presence or absence of attention. I will discuss how we might go about this determination in the final section of the paper.

4 Neural criteria

So far I have looked at the strongest available phenomenal and behavioral criteria for the ordinary notion of attention from within the perspective of the disciplines that discovered those criteria (phenomenology and psychophysics, respectively) and have found those criteria wanting. At least, the criteria are not sufficiently clear and consistent to reliably indicate the presence or absence of attention on their own. As I have mentioned throughout the paper, it is my intention to combine phenomenal,

[16] A more recent review by Raymond Klein also cites oculomotor planning as the likely cause of IOR, though it notes a more complex relation between oculomotor planning and IOR than that suggested by Millikan and Tipper (Klein 2000).

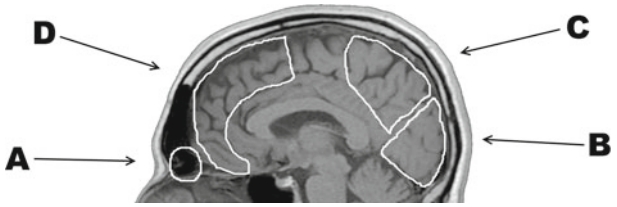

Fig. 3 Select neural areas, medial view: (A) The eyes, from which the majority of the visual signal travels to (B) the occipital cortex (including human V4), and then on to (C) the parietal cortex (including LIP and IPS), finally reaching (D) the prefrontal cortex (including FEF and DLPFC)

behavioral, and neural evidence in order to yield the most complete specification of attention. Before I get to that section of the paper, I will need to review the final set of criteria, which have emerged out of the modelling community within human neuroscience. Two related concepts have been central to the study of attention within this community. First is the concept of neural competition: limited neural resources (e.g. glucose) together with the cost of processing stimuli (e.g. glucose uptake by the astrocytes) have led neural modellers to look for the different ways that the brain might resolve competition for neural representation between stimuli. Second is the concept of top-down feedback (and recurrency resulting from such feedback): top-down feedback is one input into the resolution of neural competition that has been correlated with the voluntary direction of attention. Work spinning off of these two concepts provides a potential mechanism of attention in the brain and thus further potential criteria of attention.

4.1 Neural competition

One of the most successful recent models of attention, the Normalization Model, is based on the idea that stimuli must compete for neural and informational resources, an idea shared by most empirically-informed attention researchers (Kahneman 1973; Lavie 1995; Knudsen 2007; Carrasco 2011). The idea of centralized resource distribution in the brain is famously criticized by Allport (1989), but the claim that there are limitations on neural and informational resources does not depend on centralized distribution. The Normalization Model, for instance, has multiple layers of resource distribution rather than centralized distribution.

The multiple-layer approach is earlier described by Serences and Yantis (2006), who reason that even neurons with the smallest receptive fields can be responsible for overlapping stimuli that must compete to gain informational representation. As with single neurons, a collection of neurons may have a collective receptive field containing many overlapping stimuli. Serences and Yantis find that this competition can be resolved through local "priority maps" (e.g. in the frontal eye field (FEF) and lateral intraparietal area (LIP) for vision—see Fig. 3 for a map of select neural areas) that code the relative priority of stimuli against the spatial layout of the neural region in question, where the priorities are based, in part, on the current activities and goals of the organism (Serences and Yantis 2006).

The concept of priority maps is taken up in John Reynolds and David Heeger's Normalization Model of Attention, where the concept is divided into three types of "fields." First, there are "stimulation fields," where stimuli are automatically given relative priority based on the selectivity of an individual neuron. Second, there are "suppressive fields," where stimuli are automatically suppressed by competitors represented by surrounding neurons. Third, there is an "attentional field" that modulates neural activity based on the organism's current goals (Reynolds and Heeger 2009, p. 173). When we add to this story the fact that the size of both the stimulus and the attentional field can vary, we get a range of predictions about how attention will modulate neural competition. Specifically, when the stimulus size and attentional field size match, attention will result in an overall signal gain for the stimulus, but when the stimulus size is much smaller than the attentional field size, attention will result in an increased differentiation between the preferred and non-preferred stimuli. This prediction essentially combines those of "response gain models," which predict an increase in signal amplification for the preferred signal against the non-preferred signal (e.g. Treue et al.'s Fixed Gain Factor Model), and "contrast gain models," which predict an increase in signal differentiation between the preferred and non-preferred signal (e.g. Reynolds et al.'s Contrast Gain Model) (Reynolds and Heeger 2009, p. 168). Marisa Carrasco even claims in a recent review of the literature on attention that this combined prediction of the Normalization Model has been "confirmed" (Carrasco 2011, p. 1498).

The Normalization Model is a promising route for finding criteria that separate non-attentional selection from attentional selection because it includes a separation between the selective processing that is automatic or pre-subjective and the selective processing that is connected to the subject's current goals. Namely, the stimulation and suppressive fields would fall within the remit of non-attentional selection, whereas the attentional field would fall within the remit of attentional selection. However, more work will need to be done to apply this model to neural and behavioral evidence. Since the neural mechanism of the attentional field is left up for grabs in Reynolds and Heeger's model, I will next suggest one possible mechanism that fits the model: top-down feedback from the prefrontal areas.

4.2 Top-down feedback and recurrency

One way that priority maps (such as the "attentional field") have been argued to influence competitive selection is through feedback and recurrency, where recurrency is a state of electromagnetic phase synchrony between neural areas brought about through neural feedback. In perhaps the first paper to use the phrase "recurrent processing," Victor Lamme and Pieter Roelfsema claim that there are two types of processing: a fast and parallel "feedforward sweep" and "recurrent processing" (Lamme and Roelfsema 2000, p. 574). The evidence for recurrent processing, they say, is the fact that neural tuning changes over time, that these changes can be based on information from *outside the receptive field* of the neuron in question, and that the entire process of change is slow, such that "recurrent connections have to be involved in those visual tasks in which longer delays are obtained" (Lamme and Roelfsema 2000, p. 575). Because

we normally attend to whole objects, the features of which are processed in different brain regions, Lamme and Roelfsema postulate that attention will require the feedback of recurrent processing (Lamme and Roelfsema 2000, p. 576). Michael Spratling and Mark Johnson created a model based on Lamme and Roelfsema's predictions (where "top-down modulation…affects the ongoing competition between cells") and found that this model properly replicates the neurobiological data from a number of studies on attention (Spratling and Johnson 2004, p. 219).

Presuming that the competitive selection brought about by the attentional field is thus based on feedback and recurrent processing, we are left with the question of which neural areas are responsible for this feedback. Sarah Shomstein and Steven Yantis correlate the dorsolateral prefrontal cortex (DLPFC) with voluntary attention by looking at participants' ability to shift attention to various auditory stimuli while in an fMRI scanner (Shomstein and Yantis 2006). Robert Desimone finds that the "normalization" of (visual) attention is brought about through gamma range synchronization originating in the frontal eye fields (FEF):

> Recent evidence shows that inputs from the frontal eye fields (FEF) in prefrontal cortex initiates coupled gamma frequency oscillations between FEF and area V4 in the ventral stream during attention, and these oscillations are phase, or time-shifted to allow for conduction and synaptic delays between the two areas, thereby achieving maximally effective communication. (Desimone 2009, p. 683)

Eric Knudsen claims that the lateral intraparietal cortex (LIP) is responsible for adjudicating top-down (spatial) selection by "translating" top-down signals into the "reference frames" of lower-level neural areas (Knudsen 2007, p. 69), where parietal areas (like the intraparietal sulcus, or IPS) are regularly claimed to be the gateway of (at least) spatial attention (see, e.g., Baluch and Itti 2011). Finally, Behrad Noudoost and Tirin Moore show how neurotransmitters, such as dopamine and acetylcholine, can allow areas of the prefrontal cortex (such as DLPFC and FEF) to exert control over other brain areas (such as V4 in the visual cortex) (Noudoost and Moore 2011, p. 585).

While different articles may dispute whether the DLPFC (Hajcak et al. 2010), FEF (Gregoriou et al. 2009), or LIP (Colby and Goldberg 1999) are most central to the feedback of attention, all such articles use the language of "prefrontal feedback" (or "frontoparietal feedback" in the cases where the parietal cortex is thought to be a mediary) and recurrent processing. Although incomplete, one reason to think that this work is on the right track is that the prefrontal cortex has been correlated with voluntary control in numerous studies outside of attention research (Roskies 2010). Thus, this work is incomplete but suggestive of a mechanism that could split the influence of attention from that of non-attention, fitting the Normalization Model.

However, without phenomenal and behavioral data to support this division, the division between prefrontal feedback and other processing is not a meaningful criterion of attention. That is, the neural data will largely stand or fall on the strength of its correlation with either phenomenal or behavioral data, since these are the only domains in which the concept of attention has independent force. This is not merely a linguistic truth but a conceptual one, and has to do with the fact that phenomenal and behavioral data are epistemically prior when it comes to knowing the mind. In the

next, final section I will discuss how one might combine the phenomenal, behavioral, and neural data to come up with a meaningful and complete specification of attention.

5 Attention in three domains

Thus far I have presented three separate domains of research in the hopes of finding successful criteria of attention and have shown how each individual domain fails to supply successful criteria. In this section I will show how we can combine the three domains to arrive at a complete specification of attention after first motivating the decision to combine them.

In terms of motivation, there are clear epistemic drawbacks to relying on the evidence from any one of the domains listed above. The phenomenal criteria of clearness or vividness and felt effort are the most directly associated with attention but the criterion of clearness or vividness is incomplete without further information about the subject's history and the objective stimulus, whereas the criterion of felt effort fails to provide clear evidence in the hard cases, when there are low levels of effort required. The behavioral criterion of increased reaction time mixes in the influence of voluntariness with that of other internal processing demands, making the findings from that area of inquiry difficult to assess on their own. The neural criterion of prefrontal feedback depends on subjective phenomena and behavior for its meaning, i.e. for its application to the concept of attention, and will thus need to be tested using the evidence available from those other domains. In sum, none of the three domains that I discussed in this paper supply a complete specification of attention.

It is my contention that the search for criteria of attention is unsuccessful in each of these individual domains because of the metaphysical status of attention. Recall this paper's working definition of attention as "subject-directed mental selection"—a mental process. Neither subjective phenomena, behavior, nor neural processes share the same metaphysical status with mental processes. A mental process can bring subconscious thoughts and memories into the space of subjective phenomena, which is something that subjective phenomena cannot do (i.e. mental processes have powers that extend beyond subjective phenomena). Behavior requires the observable movement of some part of the body (by definition), but mental processes do not require this (i.e. one essential feature of behavior is not also an essential feature of mental processes). Finally, mental processes must have components that are either thoughts or memories (by definition), but neural activity need not have any such components (i.e. one essential feature of mental processes is not also an essential feature of neural activity). Thus, mental processes have a metaphysical status that transcends subjective phenomena, behavior, and (at least some forms of) neural activity. It is therefore no surprise that one type of mental process, that of actively prioritizing mental entities, would transcend the evidence available within any one of these domains of inquiry and would require the combination of these separate efforts.

This brings us to the combination of the three domains. Even if we assume that mental processes, such as attention, can be picked out in any of the three domains (but transcend beyond any individual domain), we still need a method of combining them. How might one do this? First, what not to do: one should not combine the domains

in such a way that one domain falls prey to the weaknesses of another. For example, given that the Posner cueing paradigm may not capture the relevant difference between endogenous and exogenous influences on attention, it would be a mistake to look for the neural correlates of these endogenous and exogenous influences by using a single Posner cueing paradigm (as in, e.g., Rosen et al. 1999 and Peelen et al. 2004). One could instead do a contrastive study between Posner cueing paradigms, e.g. between paradigms that use more or less oculomotor planning, to see how the neural distinction between endogenous and exogenous influences might be targeted (by ruling out other influences). Such a study was undertaken by Maurizio Corbetta and Gordon Shulman several years ago, in which they uncovered two distinct neural networks: one for "preparing and applying" a response to the central cue (the "dorsal frontoparietal network") and the other for detection of novel stimuli, such as the peripheral cue (the "ventral frontoparietal network") (Corbetta and Shulman 2002). However, rather than dividing attention from non-attention, both systems uncovered by Corbetta and Shulman could arguably be included under the term "attention," fitting the more active and passive forms, respectively. Thus, more work is needed to do this type of study while looking for the divide between attention and non-attentional mental selection.

The ideal combination of the three domains of evidence would take advantage of the information provided by the individual domains while also avoiding the pitfalls of each individual domain when taken alone. At the most general level, the phenomenological and psychological domains provide more direct information about the presence of attention, but are not always able to separate attention from other forms of mental selection. The neural domain, on the other hand, appears able to separate attention from non-attention but relies on these other domains to target the attentional phenomena. Thus, a combined approach should use the phenomenological and psychological domains to pick out attentional phenomena within the neural domain, where the divide between attention and non-attentional mental selection appears to be the cleanest.

More specifically, a combined approach can avoid the very pitfalls within the individual domains that were discussed in this paper. Clearness or vividness requires information about both the history of the subject and the objective stimulus, both of which can be provided from within the psychological domain. When the signs of felt effort become too weak to separate from the absence of effort we can look for a phase change in neural activity to see whether the subject is still in the active mode or has switched to a purely passive mode. To determine whether central and peripheral cues are picking out endogenous and exogenous influences within a particular paradigm we can compare the neural correlates for those cues with the neural correlates for cues that mix in oculomotor planning, symbolic processing, spatial separation from cue, and other such confounds. In other words, a combined approach can take advantage of the fact that the individual domains are looking at the same underlying phenomena from different perspectives, with different oversights.

6 Final remarks

In this paper I have put forward several ways of investigating subject-directed mental selection, an understanding of attention that I claimed best fits ordinary use of the

term. Although I argued that not one of these methods suffices as a specification of attention on its own, I suggested that a combined approach would allow us to move from the imperfect criteria supplied by the individual domains to a more complete specification of attention. Specifically, by combining phenomenal, behavioral, and neural research I think that we can find clear, consistent criteria of attention. What I have said here is enough, I think, to provide a "how possible" account of the ordinary notion of attention. Further conceptual and empirical work will be required to find more exact criteria of attention through this combined approach.

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