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Attention

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When agents pay attention, they do so selectively across modalities of mind such as perception and cognition. For example, they visually search for a friend in a crowd to signal to them or interpret a painting by scrutinizing it. They listen to an interlocutor to understand what is being said or secretly surveil a conversation to hear if they are being talked about. They memorize phone numbers to dial later or recall past events to answer a question. They reason through trains of thought or are pulled along by random ideas when the mind wanders. Sometimes attention is firmly controlled, as when focusing on work to meet a looming deadline. Other times attention is lured away, as when social media habits lead to involuntarily doom scrolling in an app. What agents do begins with attention. So, what is attention? *When subjects attend, their minds select, or are selected by, a specific target, leading them to respond to it.* Attention guides behavior in life and in the laboratory. Attention of this form is one of the most well-studied and well-understood of psychological phenomena. It is also a source of controversy.

History

William James famously described the ordinary experience of attention as follows:

> *Everyone 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. It implies withdrawal from some things in order to deal effectively with others, and is a condition which has a real opposite in the confused, dazed, scatterbrained state which in French is called* distraction, *and* Zerstreutheit *in German* (James, 1890, page 403).

James captured attention as subjects experience it, exemplified in the things they do, as listed earlier. In attending to something, one's mind takes possession of it, withdrawing from other things, to deal with it effectively. Yet, James's contemporary Karl Groos noted the following:

> "What is Attention?" *Not only is there no generally recognized answer to this question, but the different attempts at a solution diverge in the most disturbing manner* (translated from Groos, 1896, pages 210-211).

One hundred and twenty-five years after Groos' complaint, skepticism remains (Anderson, 2011; Hommel et al., 2019; Rosenholtz, 2024). Is attention really so perplexing [see Cognitive Ontology]? James' description seems right, but it relies on introspection, a method largely eschewed by cognitive science. Does modern science tell us something different?

Contemporary experimental research gathered steam with studies on auditory attention in the 1950s. Cherry (1953) used a dichotic listening paradigm to probe attention (Figure 1). Presented with two verbal streams via headphones, subjects were tasked with verbally repeating only one of the two. Similarly, subjects can auditorily

attend at a party when listening to one conversation among others. An opposite effect occurs when attention is *captured*. Moray (1959) probed the *cocktail party effect*, showing that while deliberately shadowing one auditory stream, subjects' attention could be captured if their name was uttered in the unattended stream. Attention can be voluntary or involuntary: in Cherry's experiment, the mind takes possession *of* a voice to deal with it; in Moray's, the mind is taken possession *by* a voice that compels the listener to deal with it.

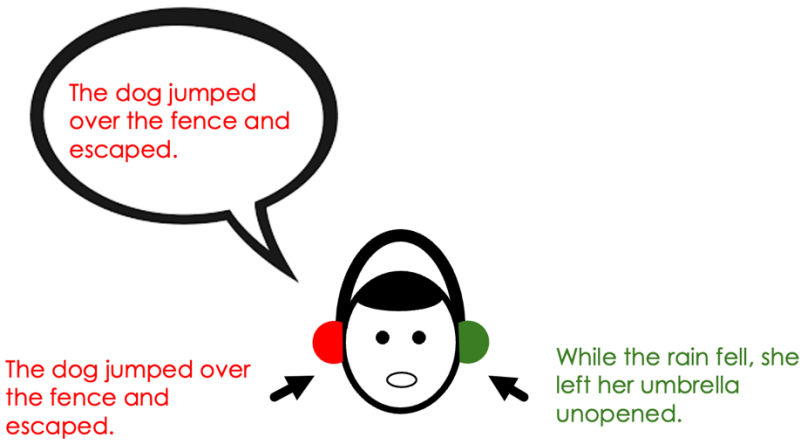

Figure 1
In dichotic listening, the subject hears two different verbal streams, one in each ear, and verbally shadows one of the two (here, the stream in the right ear, the *attended* channel, seen in red). The subject selects the heard words to repeat while "withdrawing" from the left ear (the unattended channel, seen in green).

Developments in information theory shaped attention research (Shannon, 1949). Given data from dichotic listening, Broadbent (1958) proposed a *filter theory* of attention (Figure 2A). While subjects could repeat attended words, they could not report much in the unattended channel beyond basic auditory features such as pitch or intensity. Broadbent postulated an informational bottleneck in the auditory system's processing capacity such that selection is needed to avoid information overload. Given detection limits in the unattended channel, Broadbent concluded that an attention filter blocks the unattended stream *early* in auditory processing (Figure 2B). Yet given observations like Moray's cocktail party effect, others argued that the filter operates late in processing (Deutsch & Deutsch, 1963; for discussion, see Pashler, 1998, chapter one). In late selection, filtering is needed at the decision stage, selecting among fully processed channels (Figure 2C).

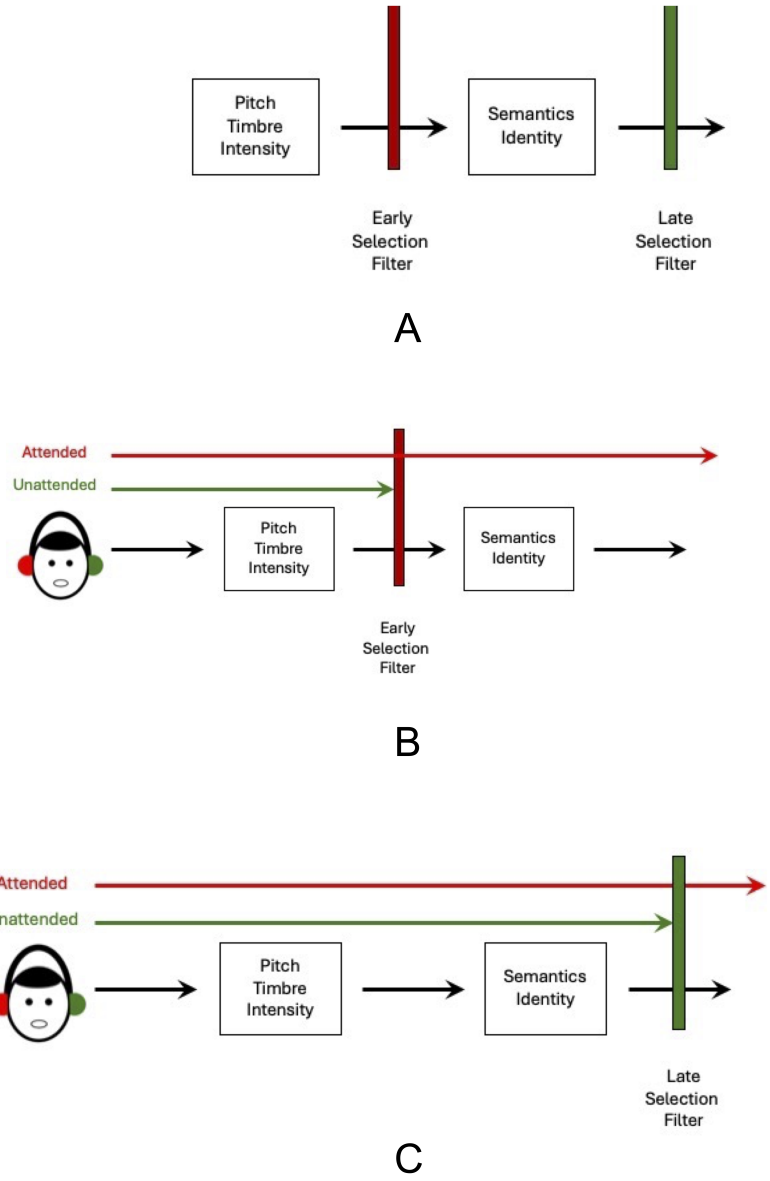

Figure 2

(A) Auditory processing is separated into early-stage processing of audible features such as pitch and late-stage processing of higher-order features like meaning or identity. Early selection filters operate before late-stage processing, while late selection filters allow processing to go to completion with information filtered "post-perceptually." (B) Broadbent's filter model involves early-stage blocking of the unattended channel. (C) The late-stage model allows all channels to proceed to completion with a "post-perceptual" filter for decision-making or action.

Research into visual attention achieved prominence in the 1960s. In *visual search*, subjects look for a target in an array of stimuli. Intuitively, the subject selects each stimulus to decide whether it is a target or distractor. If a

target, it is selected for report. If a distractor, the subject looks further for the target (but see Rosenholtz et al., 2012). Consider searching for a red *E* in an array containing red *F*s and green *E*s. In such *conjunction* search (target is red *and* "*E*"), search times increase linearly with the number of distractors (Figure 3, left). In other cases, an object "pops out," as when a single green *E* appears among red *E*s (Figure 3, right), and reaction time is largely unaffected by the number of distractors. Such data led to the *Feature Integration Theory of Attention* developed by Treisman and coworkers (e.g., Treisman, 2006; Treisman & Gelade, 1980; cf. Guided Search, Wolfe, 2021).

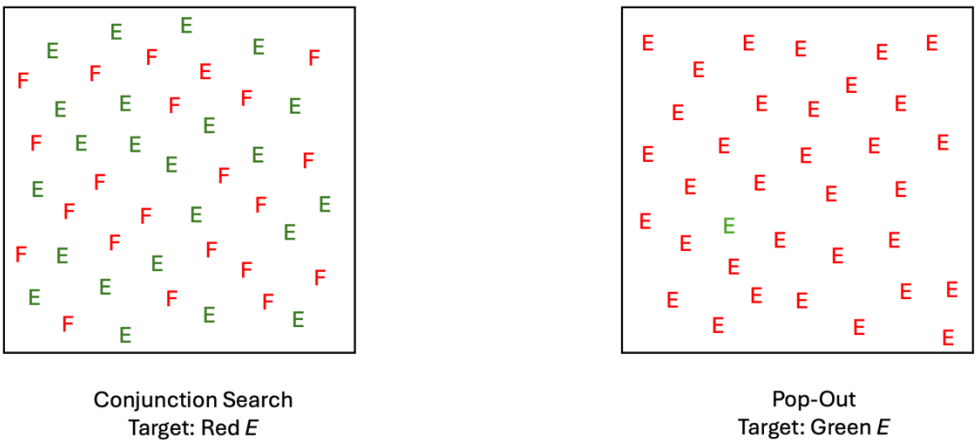

Figure 3
Left box shows conjunction visual search; look for the red "E." Right box shows pop out; look for the green "E."

In the 1970s, Posner developed a paradigm for studying visual spatial attention using cues (Posner et al., 1978). In a typical implementation, subjects maintain a fixation between two task-relevant locations where a target requiring response can appear. Before the target appears, subjects receive a cue. A *valid* cue indicates the target's upcoming location; an *invalid* cue indicates the other, incorrect, location. Cue validity, the proportion of valid versus invalid cues, is manipulated (e.g., 80/20 valid to invalid). Some cues are *direct*, appearing at or near the target location, and others are *indirect*, often symbolic, such as an arrow at fixation that points to a location (Figure 4). Relative to a neutral, uninformative cue, performance is better with valid cues and worse with invalid cues (for discussion, see Wright & Ward, 2008).

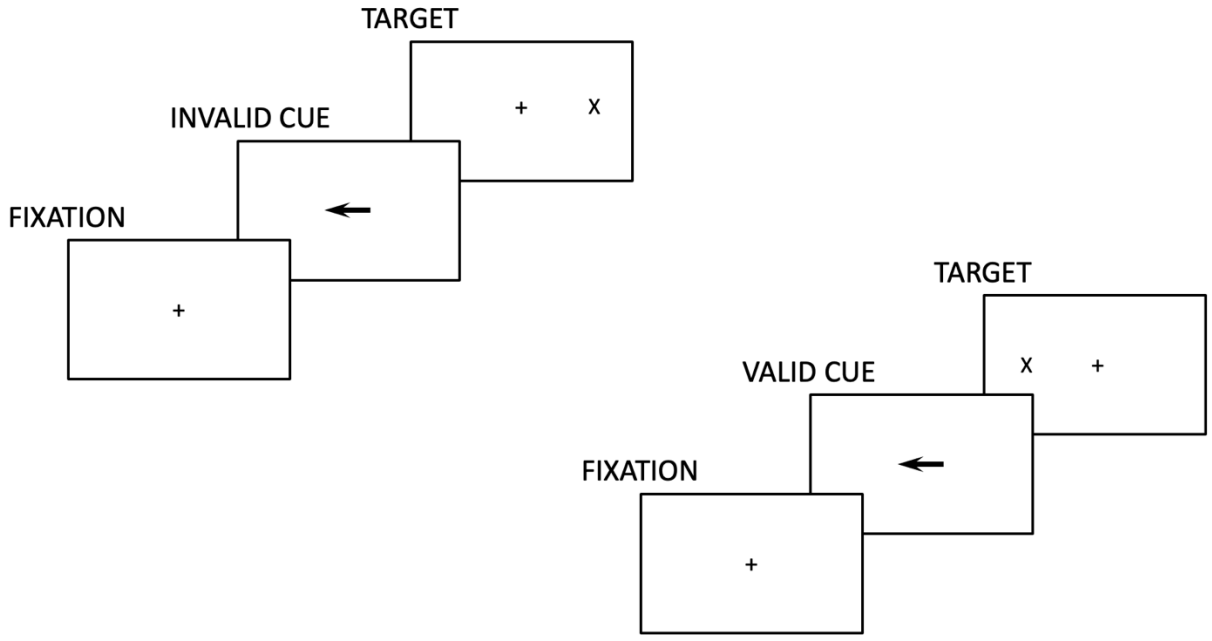

Figure 4
Left figure: An invalid, symbolic cue (the arrow) indicates the incorrect location. Right figure: A valid cue points to the correct target location.

Attention in memory has become an important topic. One *working memory* paradigm is *retro-cueing*, developed independently by the labs of Lamme and Nobre (Griffin & Nobre, 2003; Landman et al., 2003; compare Sperling, 1960). Retro-cues are similar to spatial cues, except the latter is delivered after stimulus offset, cueing what is remembered rather than perceived (for an overview, see Souza & Oberauer, 2016).

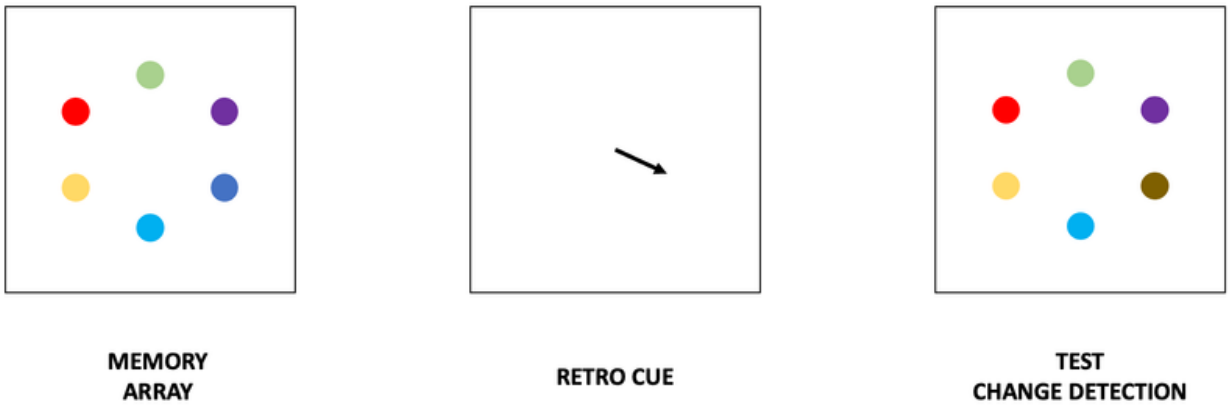

Figure 5
In retro-cueing, the subject must remember the array of colored circles. During the *delay period* (middle box), a retro-cue (here, an arrow) points to the location of one of the past circles (left box), cueing a memory of that target. A test array is presented where a change in color might occur. Subjects must report whether a change has occurred (here, yes). As in spatial cueing, valid retro-cues improve performance. Drawn after figure 1 in Souza and Oberauer (2016).

In the last half-century, work has probed attention in humans across developmental stages (Erel & Levy, 2016; Johnson, 2019). Attention has been investigated across species, including nonhuman primates (Cohen & Maunsell, 2011), rodents, birds, and bees (Eckstein et al., 2013; Sridharan et al., 2014; Wang & Krauzlis, 2018). A variety of neural recording modalities have been deployed to probe brain activity during attention. Attention is one of the most well-studied psychological phenomena. So, what is it?

Core concepts

What is attention?

A theory of attention should state what attention is. Everyone agrees that attention is selective, but not every selective process is attention. Photoreceptors on the retina select light of specific wavelengths for further processing, but retinal selection isn't attention. James's description of attention narrows the type of selection, namely selection *for guiding behavior*: a person attending to a target is mentally selecting it to respond to it in some way such as to reach for it or commit it to memory. Notably, this *functional structure* is built into experimental paradigms used to study attention. Specifically, experiments implement the following *empirical sufficient condition*: if a subject mentally selects a target to perform *an experimental task*, then the subject attends to that target. Such mental selection *suffices* for attention (Wu, 2024).

This condition is incorporated into laboratory tasks. Generally, subjects are instructed to select particular targets to inform a specific response such as a button press or movement. In this way, attention is set by instruction and monitored by the experimenter. In dichotic listening, subjects *auditorily select specific words in order to repeat them*, therefore, auditorily attend to them (Figure 1). In visual search, they *visually select*

stimuli to decide if they are targets, and if so, *they visually select that target to report* (Figure 3). In spatial cueing, they *visually monitor cued locations to report whether a target is present* (Figure 4). These cases set visual attention. In retro-cueing, subjects *visually select an array to encode in memory*, and when presented with a test, they *cognitively select, recall, a relevant part of the remembered array to compare with the visual array, and make a report* (Figure 5). The former involves visual attention, the latter memory-based (or cognitive) attention. Given that each paradigm exemplifies the same functional structure, cognitive science implicitly operates with a *common conception* of attention. There is functional unity across scientific studies, for each investigates attention as the subject's mentally selecting targets to respond to within a task.

The theoretical concept of attention has four notable dimensions that help the theorist differentiate types of attention: There is *what* subjects attend to, the *target* of attention. They also attend in different *ways*, the different *modes* of attention, and they deploy attention for different *purposes* associated with various *responses*. Finally, *subjects* are the ones who attend. The scientific concept of attention captures these four dimensions in its structure: *S* for the subject, *m* for mode, *T* for target, and *R* for the response guided by attention. That is, the scientific concept has four "variables" as captured in this statement: subject *S* *m*-attends to *T* to respond *R*. Figure 6 shows the parallel between the concept *attention* and two types of attention in historical paradigms by using suitable values for *S*, *m*, *T*, and *R*:

Concept	*S*	*m*	**attends to**	*T*	**to** perform *R*
Examples	*John*	*auditorily*	attends to	*a verbal stream*	to *verbally repeat*
	Mary	*visually*	attends to	*a letter*	to *decide if a target*

Figure 6

The concept of attention captures four dimensions: *who* is attending (S: subject), *how* one is attending (m: mode), *what* is attended to (T: target of attention), and for what *purpose*, namely the response (R: response informed by attention). These variables have concrete values in dichotic listening and visual search. Further cases are given in Table 1.

The concept organizes kinds of attention.

Kinds of attention

For over a century, scientists have complained that there are too many claims about what attention is. Can some order be imposed on this chaos? The common conception of attention, elaborated along the four dimensions, unifies many of these answers.

Consider the modality (m) and target (T) dimensions. A familiar division divides perception-based forms of attention from memory-based forms (often called *external* versus *internal* attention; Chun et al., 2011). There are various perceptual modes such as visual, auditory, tactile, olfactory, and gustatory attention. There are also

memory-based modes: attention based on short-term memory such as working memory and on long-term memory such as recalling a past event (episodic memory) or a fact (semantic memory).

Figure 7 shows a non-exhaustive list of theoretically salient mappings between modes and targets.

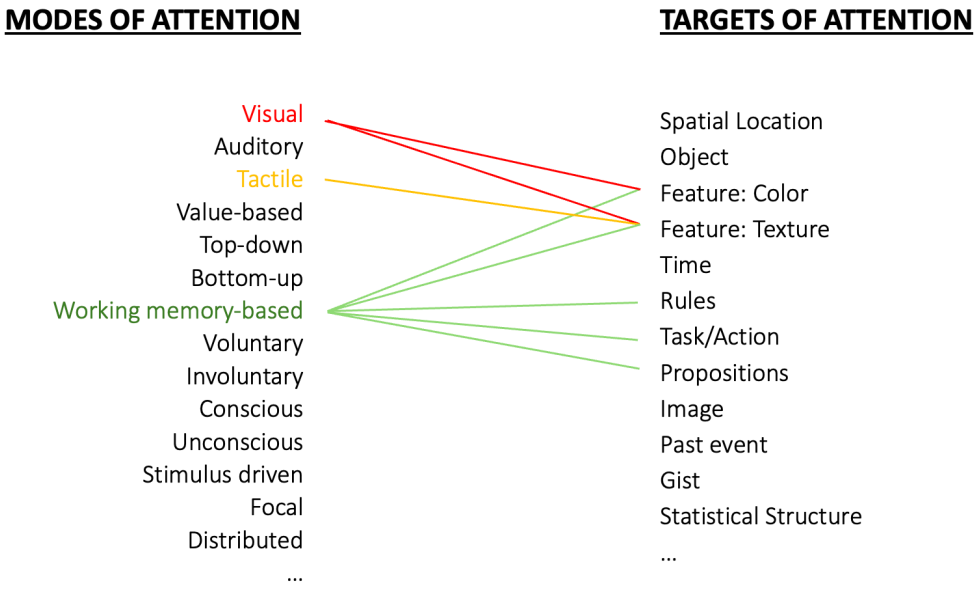

Figure 7
Different modes of attention mapped to different targets (list not complete). Colored lines indicate some possible combination of mode with target.

Most modes can take multiple types of target, and the same target can be selected by different modes. For example, visual attention can select locations, objects, and features. Some of these can be also tactually attended to, say a feature such as texture (roughness can be seen and felt). Some modalities are complex, such as *conscious*, *top-down*, *visual attention*, or *visual working memory-based* attention. The concept makes clear how each type of attention is related to or is different from others.

Table 1 uses the concept to capture some kinds of attention along with their "folk" descriptions.

Table 1

The left column gives examples of attention as a target of empirical investigation, and the right column gives ordinary descriptions of such attention.

S m-selects T for R	Ordinary descriptions
S *auditorily* selects verbal *stream* to *parrot*	S listens to the voice to understand it

S *visually* selects a stimulus to decide if target	S looks for a target in a clutter
S *visually* selects location L to ready response	S keeps an eye out for a target over *there*
S *mnemonically* selects an encoded object to ready response	S recalls the target to answer a question
S *top-down* selects an object to encode in memory	S deliberately remembers an object
S *consciously* selects a thought to reason from	S ponders, reasons, thinks
S *bottom-up visually* selects a loud flash to turn towards	S orients towards unexpected explosion
S *consciously, automatically* selects a thought to follow	S mind wanders

Top-down, bottom-up, and historical modes

There are many proposed modes, and how they are related remains an open question. Consider two common values for modality*: top-down* versus *bottom-up* attention. This is similar to other theoretical distinctions such as voluntary versus involuntary, endogenous versus exogenous, controlled versus automatic, and goal-driven versus stimulus-driven attention. The top-down and bottom-up distinction assumes a psychological structure that has a top-bottom organization with, say, cognition at the top, perception at the bottom.

Since many experiments involve an instructed task or task rules being encoded in the agent's plan or intention, top-down attention is set by task instructions. Intention is then a common top-down factor manipulated through instructions. In contrast, bottom-up attention is driven by the perceived stimulus. An example is attention captured by a loud bang. Provisionally, take top-down attention as driven by an intended task and bottom-up attention by salient stimuli that grab attention.

This distinction, however, is *not* exhaustive (Awh et al., 2012). It leaves out many modes, and recent discussion has focused on the *historical* effects on attention. Past experience influences present attention. Roughly, while an intention or flash of light affects attention *synchronically*, that is, at the time of attention, historical effects affect attention *diachronically*, that is, rooted in past events. For example, past learning that a large reward is associated with certain targets can bias future attention toward them. This is value-based attention (Anderson, 2016).

While the three-part expansion is a conceptual advance, it is still not exhaustive. Emotion doesn't fit these categories, but they influence attention. For example, fear strongly directs attention to what triggers it. Perhaps, theoretical and experimental clarity is best served by being as specific as possible regarding the mode of attention that is being studied.

Automatic versus controlled attention

Another important distinction is between automatic and controlled modes of attention (Schneider & Shiffrin, 1977). Automatic attention is common and, perhaps by definition, thoughtless. It is also socially significant. Intuitively, automatic attention is attention one doesn't think about. Most attention is automatic. Consider eye movements, called *overt* visual attention. A common eye movement is a *saccade*, a ballistic movement that occurs one to three times a second in humans. Many think that *covert* visual attention, attention independent of eye movement, programs overt attention. Saccades can be controlled. When someone is directed to look at their feet, their saccadic movement to the feet is intended. Still, most saccades are automatic. Subjects aren't aware of most of their saccades, and they do not, thankfully, have to intentionally plan them. For example, what words or locations were the targets of your last three saccades? You probably only have an educated guess.

Automatic attention occurs not just in perception but also in thought, such as mind wandering (Irving & Glasser, 2019). Thoughts drift here and there during a boring lecture. Such cognitive attention is not controlled but shaped by various internal biases (see "bias and biased competition"). Automatic attention has socially significant effects. Think of being at a party where you are talking to someone, and their eyes continue to flick over your shoulder. You might feel offended because it seems they are not paying attention to you, perhaps more interested in finding someone else. Yet, they might have no idea that they are doing this, their saccades automatic and thoughtless.

Specific patterns of automatic eye movement are a signature of expertise, as when accomplished batters hit a fast moving ball (Land & McLeod, 2000; Mann et al., 2013) or radiologists search for anomalies in a chest x-ray (Donovan & Litchfield, 2013). Automatic attention also figures in habits, including habits of attention (Jiang & Sisk, 2019). Understanding automatic attention will be an important part of understanding skill and expertise as well as numerous socially significant cases (Wu, 2023, chapter five).

Bias and biased competition

An influential theory of attention is *biased competition* (Desimone & Duncan, 1995). Many modes of attention are tied to *biases* on attention. *Bias*, a theoretical concept, refers to internal causal factors that explain attentional selection during action. Attention is needed because there is too much information in the world. Coherent action requires selection in the face of possible information overload (Broadbent, 1958; Carrasco, 2011).

Begin intuitively at the level of behavior, and consider the fable attributed to the philosopher Jean Buridan. A hungry donkey approaches two qualitatively identical bales of hay. Unfortunately, the donkey has walked perfectly down the middle between them, so they are at the same distance, one to the left, the other to the right. Given qualitative identity, there is no basis for prioritizing one over the other. Neither is closer, larger, or more tasty in appearance and so on. Yet, if the donkey fails to select one bale to deal with (eat), it starves to death.

Similar less dramatic cases occur in life: Should one vacation in the city or country? Should one choose chocolate or vanilla? Should one go to the gas station on the left or on the right? And so on. Agents face a *selection problem*: there are many available targets, so which should one act on?

Given too many (two!) options, the donkey faces behavioral competition (Figure 8). The donkey cannot simultaneously act on both bales. One of the two available actions must be executed if the donkey is to eat. Each bale competes for response, each corresponding action for expression. This behavioral competition must be resolved in that there must be a winner…otherwise with inaction, death awaits.

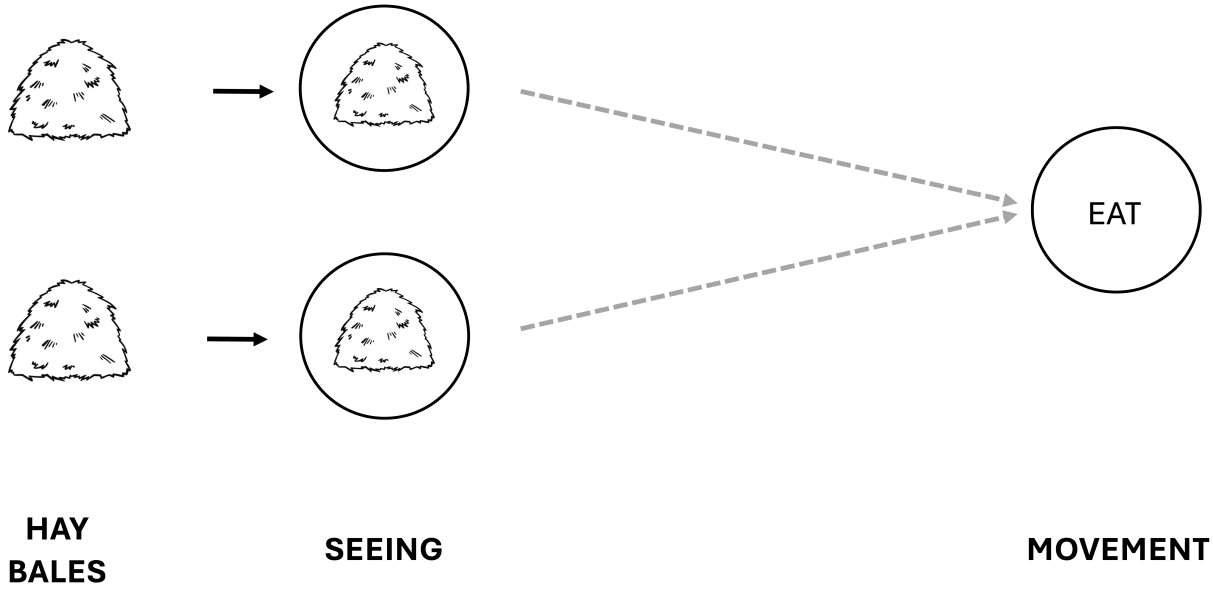

Figure 8
The donkey sees two bales of hay, each an input into the visual system that enables the donkey's seeing both. Each bale can inform producing a movement towards it, but until this competition among targets and motor response is resolved, the behaviors are merely possible (dotted lines).

An internal bias can resolve competition. For example, if the donkey arbitrarily decides to eat the hay on the left, its intention biases it to move to the left. One bale, and one action, wins the competition. Alternatively, by luck, the sun suddenly shines on just one of the bales, which grabs the donkey's attention, pulling it towards the brighter bale. Such attentional capture can be explained by a *saliency map*, an internal representation of space that ranks locations in respect of a value of salience defined by local feature differences; here, the suddenly brighter bale (Itti et al., 1998). The saliency map biases competition of spatial location given the features therein. Intention (task representation) and saliency maps are two distinct internal biases that can resolve competition, thereby setting attention. Intentions are a top-down bias, while saliency maps are a bottom-up bias. There are many biases, and recent work postulates integrating these to form a *priority map* of space (Bisley & Mirpour, 2019; Shomstein et al., 2023; Todd & Manaligod, 2018).

Biased competition at the behavioral level must reflect the resolution of processing competition at the brain level. Just as multiple items compete for an agent's attention, those stimuli also compete for neural processing resources. For the animal to act, it must resolve behavioral competition. This means that its brain must resolve the correlated neural competition, for the animal will move towards a target only if its brain selectively processes said target to program a response (Figure 9).

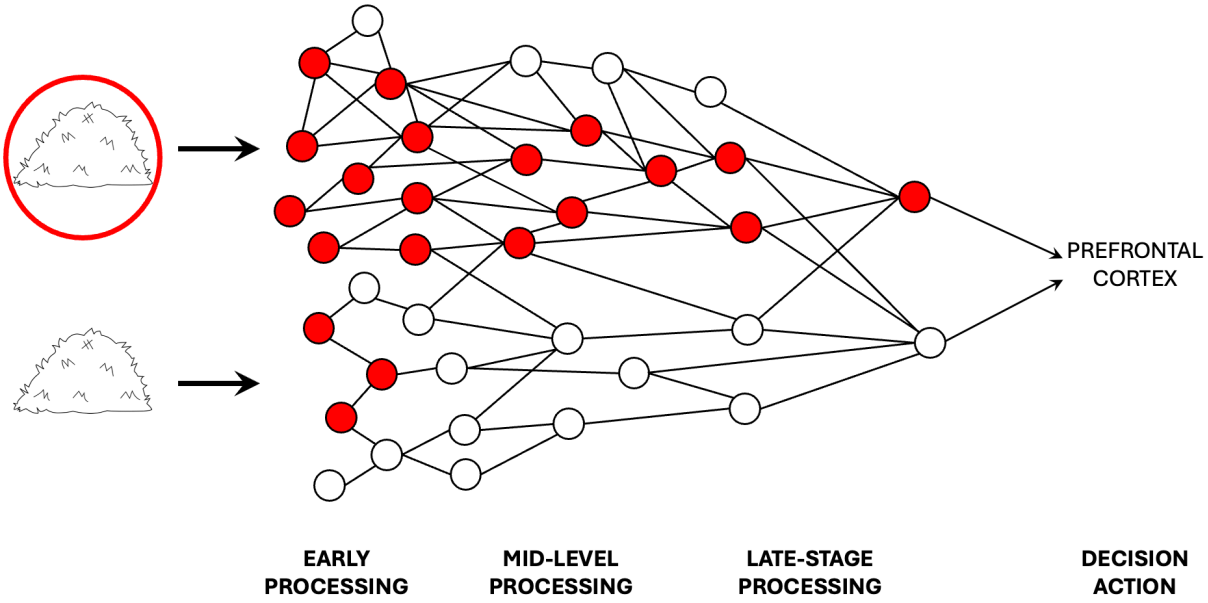

Figure 9
The resolution of neural competition in visual processing is depicted here. If the donkey decides to eat one of the bales, this decision *biases* neural competition for visual processing resources (biasing factor not shown). Red units indicate active processing. The selected bale, circled in red, is processed so that the donkey will move to it. The resolution of neural competition depicted here explains the resolution of behavioral competition (Figure 8). The donkey visually attends to the winning bale, and the unattended bale is not further processed. This figure is drawn after figure 1 in Serences and Yantis (2006).

The parallel between two selection problems, one faced by the agent, the other faced by its brain, suggests an explanation of the subject's paying attention to guide behavior by appealing to the brain's corresponding selective processing of the task-relevant target. What would such an explanation look like?

Explaining what attention is

How might cognitive science construct an answer to the following question: What is attention? Consider Marr's multilevel approach (Marr, 1982, chapter one). This account tells us what an explanation to the "What is X?" question looks like and what has to be filled in to complete an answer. The variable *X* takes psychological phenomena as values, say vision or attention. The structure of the explanation involves three

connected levels of analysis (there is nothing sacrosanct about *three* levels*;* researchers can add levels as needed). The "top" level gives the *computational theory* of the phenomenon, what the phenomenon is for, its function and goals. The *algorithmic level* specifies algorithms to compute the proposed function, and the *implementation level* identifies the physical (neural) implementation of those algorithms.

Drawing on this framework for inspiration, take the functional structure expressed by the common conception of attention as a substitute for a computational theory. From this, scientists can construct an explanation that focuses on dissecting performance in a concrete experimental paradigm. Experiments with that paradigm generate relevant data regarding the subject's selecting a target to inform task performance. Theorists then model the data, proposing algorithms to explain correlated processing. For example, the algorithms explain how specific inputs give rise to observed outputs under experimental conditions. These proposals in hand, one can measure neural activity during the subject's task performance to identify brain regions that implement the proposed algorithms (Figure 10).

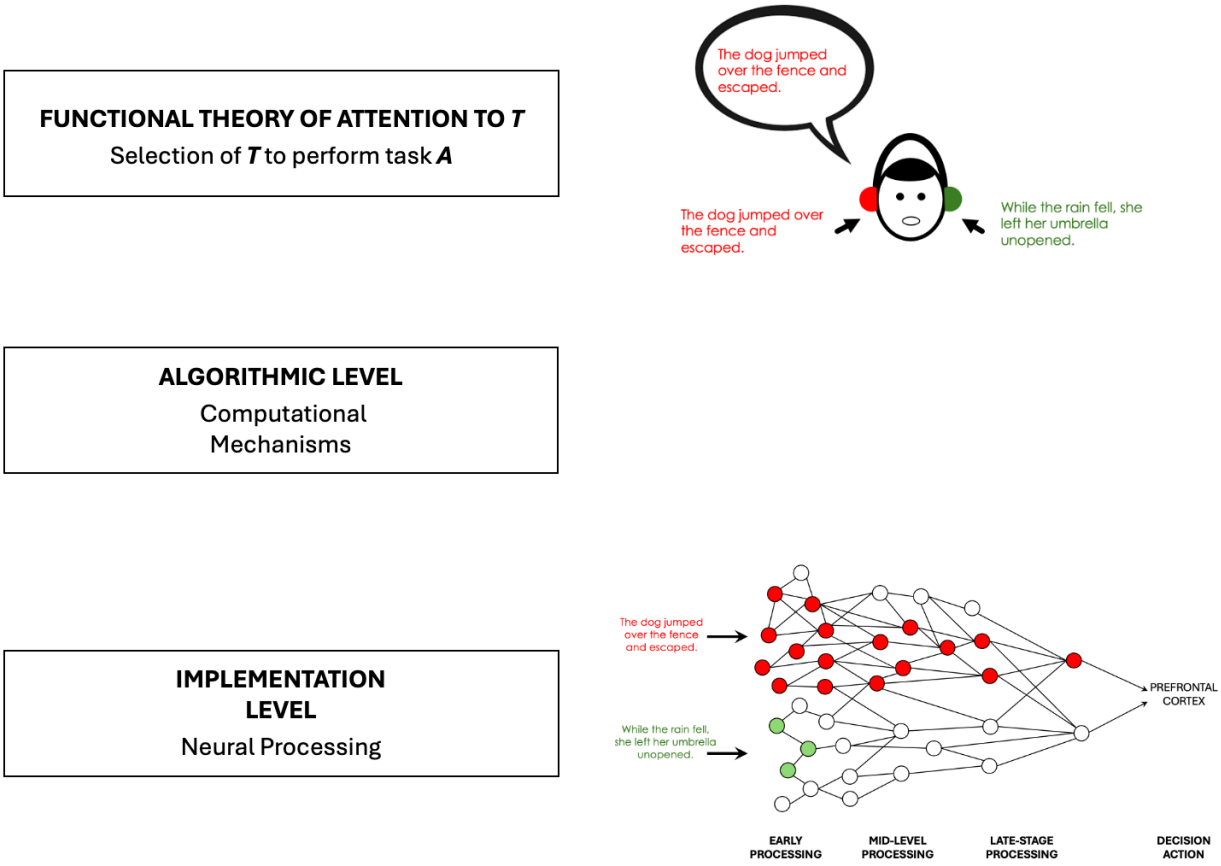

Figure 10

The multilevel explanatory structure is depicted here. This frame answers a question of the form, "What is *X*?" where *X* = attention. Focus on a concrete task *A* and fill in "implementation" levels. For example, one can begin with dichotic listening functionally characterized and invoke a biased competition model of auditory processing at the implementation as a heuristic. The precise algorithms are left open. This is a sketch for discussion purposes. Filling in details is the job of experiment and modeling.

Notice that the functional structure expressed in the common conception links these levels together, tied to a specific experimental task. After all, scientists collect data based on that task, construct models and algorithms given that data, and monitor correlated neural activity during task performance. In filling in each level of analysis, scientists contribute to explaining what attention in the task amounts to. For many tasks, the science of attention is capable of fleshing out different levels of analysis and, accordingly, is capable of explaining different kinds of attention (of *m*-attention to *T* for *R*).

Attention and resource

In everyday conversation, people talk about *paying more or less* attention. Attention is thought to come in degrees. Discussions of the *attention economy* assume that attention is a resource, a commodity that social media companies design apps to steal (Wu, 2017). Such claims are metaphorical. What does the science say?

Some cognitive scientists *equate* attention with a resource. For example, attention might be *effort* in which more or less effort just is more or less attention (Kahneman, 1973). There are two different claims that must be kept distinct:

1. *Identity*: attention literally is a resource *R*.
2. *Causality*: attention causally depends on *R* for its operations.

What makes these two claims different is that the first *equates* attention with *R*, and the second *distinguishes* them, attention tapping into a distinct phenomenon *R*. To show that one of these is the correct conclusion, a scientific argument is needed. Is there one?

Imagine someone says that attention *is* energy (cf. Kahneman, 1973). As energy goes up and down, since energy and attention are the same thing, attention must also go up and down. But is this right? An alternative is that attention is not literally energy but *uses* it. For example, a car's operation depends on gas, but it would be a mistake to conclude that the car *is* gas. Concluding that attention is resource *R* is not ridiculous, but what evidence might lead one to move beyond the causal claim, (2), to the stronger identity claim, (1)? The challenge is that *both* positions explain changes in measured dependent variables by appeal to the same construct, *R*. It is just that one says attention = R and the other only that it causally depends on *R*.

The distinction between identity and causality is obscured by frequent talk of an *attentional resource*. This term is *ambiguous* between the two positions. Does it suggest that the resource *is* attention or that it is just *used by* attention? Many scientists who have posited limited resources such as channel capacity or cognitive load to explain limitations in performance only endorse causality (Broadbent, 1958; Lavie, 2005). To be clear, the present point is not to deny that attention is literally a resource. Perhaps it is. If so, there should be a convincing scientific argument for it. Is there such an argument?

Attention and mechanism

Many scientists treat attention as a *psychological* or *neural mechanism*. Perhaps the most common expression of this is through the *spotlight* metaphor. If attention is a spotlight, it is not because subjects literally have a spotlight shooting from their eyes. Rather, the spotlight refers to an internal mechanism that alters representations or processing. For example, in feature integration theory, the spotlight mechanism in visual processing binds features into an object (Treisman, 1988). In biased competition, the bias that shifts neural competition enhances the neural processing of a target.

Call any "spotlight" mechanism *M*. Just as with claims about attention as a resource, there are different claims about attention as a mechanism *M*.

1. Identity: attention *is M*.
2. Implementation: attention is implemented by (results from) *M*.

The first holds that attention literally is a mechanism, the second that attention is different from and explained by a mechanism. Which is correct? Importantly, the question about identity is not about the use of words, as if the point was simply about language. That is, the question is not whether scientists should label *M* as "attention." Rather, since attention exists, the question is about the non-linguistic world, whether *M is* attention. Answering that question requires an empirical, not linguistic, argument. So, this leaves the question hanging: Are there compelling scientific arguments that support identity over implementation?

Questions, controversies, and new developments

While we have drawn on experimental practice to identify a common shared conception, controversies remain: Is attention a resource, and if so, what resource? Is it a mechanism, and if so, what mechanism? Are these options mistaken because attention is what *subjects* do, as per the common conception? Are there compelling arguments for or against these positions? What theoretical or methodological constraints might help decide the issue? Might evolutionary considerations help (Hommel et al., 2019; Krauzlis et al., 2014)?

What of challenges to human attention? For example, various disorders are tied to changes in attention, such as in attention deficit and hyperactivity disorder, autism [see Autism], obsessive compulsive disorder, schizophrenia, and various substance addictions. How is attention understood in each of these domains? What conception of attention is most fruitful for understanding these phenomena? Might understanding attention aid development of interventions?

What of attention and technology? Attention is said to be distracted or mined by social media, with companies stealing attention. How might empirical understanding of attention shed light on the interaction between attention and technology? Can empirical work lead to more effective strategies for resisting behavioral addiction in which apps capture our attention?

Broader connections

A growing area of research concerns the relation between perceptual attention and memory (Oberauer, 2019). For example, researchers have investigated the nature of perceptual attention and working memory. One thought is that perceptual attention is crucial for selective encoding (attention to working memory), while another is that working memory directs perceptual attention (working memory to attention; Kiyonaga & Egner 2013; van Ede & Nobre, 2023).

Attention is connected to consciousness, often treated as a gate for consciousness: you are conscious of only what you attend to. Take attention away, awareness goes away (Mack & Rock, 1998). Is attention really a gate necessary for conscious awareness? Alternatively, you can be conscious of more than what you attend to, with attention merely modifying consciousness (Carrasco et al., 2004; Tse, 2005). Can attention be unconscious (Kentridge, 2011)? Notable paradigms probing attention's relation to consciousness include inattentional

blindness (Simons & Chabris, 1999) and the attentional blink (Martens & Wyble, 2010; Zivony & Lamy, 2021). The empirical issues are, however, tricky (Wu, 2014, chapter five).

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