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Attention, Information and Epistemic Perception

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Abstract

The article outlines a theory grounded in the Attentional Constitution Principle, which proposes that the faculty of attention is constitutive of humans' perceptual knowledge about individuals (i.e., agents or objects). In contrast to the non-biological epistemology of knowledge or the non-epistemological psychobiology of attention, the theory holds that the function of human attention is to serve perceptual knowledge and the acquisition of semantic information from causal (or environmental) information. In this account, attention is understood as a system that controls sensory-motor routines for satisfying epistemic or action requests. Support for the principle is found in premises stating that overt and covert forms of attention are necessary for establishing direct cognitive access to target individuals and extract relevant causal information relative to them. It follows from the argument that the use of attention is necessary for assessing the truth value of empirical beliefs and linguistic information reports that directly refer to perceived targets. Consequently, through integrated epistemic attention, humans can "navigate" the causal structure of the world to track individuals and truths. Concurrently, through pragmatic attention, humans can exert their power and perform actions on individuals as a function of their knowledge of the objective structure of the world.

Attention became a topic studied in experimental psychology by the end of the nineteenth century. With subsequent development of psychology, interdisciplinary research on attention became integral part of the cognitive and medical sciences.[1] Meanwhile, attention continues to raise a wide range of philosophical questions concerning, namely, sensorimotor control, perceptual reference, language understanding, social intentionality and the neural correlates of consciousness. The present article focuses on a question that may be fundamental to bridge the gap between epistemology and biology: what is the role of attention in the acquisition of knowledge?

To address this problem, I will outline a theory grounded in the Attentional Constitution Principle. This principle asserts that attention is constitutive of humans' perceptual knowledge about individuals (i.e., objects and persons). The proposed theory expands research on perception and demonstrative identification.[2] Its method is grounded in the thought that the epistemology of empirical beliefs should mesh with the psychobiology of attention in order to explain how human agents navigate and analyze their environment. In contrast to the non-biological epistemology of knowledge or the non-epistemological psychobiology of attention, this theory holds that the function of human attention is namely to serve perceptual knowledge through the extraction of causal information.

Section 1 formulates the Attentional Constitution Principle. Section 2 introduces distinct concepts of "information" of which use is relevant to the theory. Specifically, I distinguish causal information from the notions of semantic information and information processing. Section 3 introduces the argument from cognitive access to lend support to the central principle. The argument relies on premises (justified in sections 4 and 5) stating that overt and covert forms of attention are necessary for establishing direct cognitive access to target individuals and extract causal information relative to such individuals while they are perceived. It follows from this analysis that the use of attention is necessary for assessing the truth value of empirical beliefs and linguistic information reports about perceived individuals. The argument raises the challenge of discovering a theory whereby the *epistemic* use of attention is explained. Sections 5 and 6 suggest that the procedural theory of attention can explain the epistemic and pragmatic roles of attentional systems in the extraction of causal information. The procedural theory characterizes attention as a multi-component system that controls sensory-motor routines for solving action and epistemic requests and, thus, for seeking, extracting and using causal information available in the organism's environment.

1. The Attentional Constitution Principle of Singular Perceptual Knowledge

This article studies singular perception and singular action. I employ the term "singular" to refer to acts that are directed at individuals. Here, the term "individual" is used to denote a particular material thing that persists, changes or grows and is located in the spatio-temporal world. The article discusses two classes of individual: inanimate *objects* (e.g., artefacts) and intentional *agents* (e.g., human persons). Such objects or agents follow continuous paths in space and time, have cohesive parts, and have the power to affect other individuals. Not only can we perceive them standing at different locations, or moving to new locations, but we can also identify persisting individuals across changes in their appearance or location.

Individuals present a unique set of properties determining their fundamental ground of difference (i.e., the material ground determining their uniqueness, identity over time and singular causation).[3] This ground of difference is that which is to be known in singular knowledge and that which is causally relevant for guiding the performance of singular actions.

I borrow this use of the term “singular” from the philosophy of language and the semantic theory of singular terms, in which the fact that the human mind is directed at particular things (individuals) has been recognized as a key factor to address in order to explain the intentionality of the human mind.[4]

In the study of perceptual knowledge, the term “singular” is useful to stress that perceptions and actions are usually directed at individual things, in the sense that they use mechanisms that point toward, track over time or come into contact with particular persons or objects. This idea can be expressed in this principle:

> P1, dependence-on-tracking of true empirical beliefs and perceptual knowledge: The acquisition of perceptual knowledge of (of non-accidentally true empirical beliefs about) individuals depends on the tracking and perceptual-demonstrative identification of individuals.

P1 expresses a condition admitted in various versions by the realistic accounts of perceptual knowledge.[5] In philosophy, the notion of *perceptual-demonstrative identification* is traditionally understood as a mental act (a form[6] of intentionality) in which an individual is identified on the basis of its current perception. For instance, this kind of identification happens when, on the basis of your perceptual experience, you identify that “this is your mother.” In the phrase “perceptual-demonstrative identification,” the term “demonstrative” is used to indicate that this kind of identification frequently occurs with a thought that contains a demonstrative term, which is labeled “demonstrative thought” in philosophy.

Perceptual-demonstrative thoughts have a form such as “This is *F*,” in which “this” is a demonstrative term and “is *F*” is a predicate that refers to a concept or an attribute ascribed to the referent of the demonstrative term. Arguably, such thoughts are associated with the evaluation of propositions expressed by observations and information reports about what is perceived.

Demonstrative thoughts can identify, locate or describe the referents (or targets) of our perceptual experiences. For instance, if, at a crowded conference, your colleague points to a person and utters “This is Donald Broadbent,” your grasp of the meaning of the demonstrative proposition depends on your ability to visually pick out and identify the referent of the demonstrative.

The condition of *tracking* is mentioned in P1 because perceptual tracking seems to be a necessary condition of perceptual-demonstrative identification. This notion of tracking refers to the ability to identify and re-identify an individual (as remaining the same individual) over a certain period of time in spite of changes in its some intrinsic or relational properties (e.g., aging or changes in appearances and location). For instance, the demonstrative identification of Donald Broadbent (in the situation described above) requires you to succeed in visually tracking Donald Broadbent over a certain time and series of limited changes. (In section 5, I will distinguish perceptual tracking from more epistemic forms of tracking. The theory that I propose posits that attentional systems integrate different forms of tracking through the extraction of and storage of causal information about the identity and location of target individuals. This form of tracking can be termed “integrated tracking.”[7])

I accept the thought expressed by P1. I also believe it corresponds to a relatively widespread view in the philosophical epistemology of perceptual knowledge. Here I will focus on a more specific claim, which can be expressed in this principle:

> Principle of the Attentional Constitution of singular perceptual knowledge: Attentional systems are constitutive[8] of human agents' perceptual knowledge of individuals in their ecological environment.

Since there are close ties between perceptual knowledge of individuals and action planning, the claim can be associated with this more comprehensive thesis:

> Generalized Principle of the Attentional Constitution: Attentional systems are constitutive of the links between singular perceptions (i.e., perceptions directed at individuals) and singular actions (i.e., actions directed at individuals).

This principle can be paired with the thought that the attentional capacities in our hominin ancestors evolved to have the function to efficiently keep track of and act on individuals present in their environment such as prey or predator animals (or even tools (Arp, 2006)), and that this evolution was an adaptative response to environmental pressures. Before presenting an argument (sections 4 to 6) and a procedural theory (sections 6 and 7) to lend support to the Principle of Attentional Constitution, I will clarify the information-theoretic approach I propose to use (section 2) alongside a few basic problems relative to the concept of attention (section 3).

2. Causal and Semantic Notions of Information

Phenomenological descriptions of mental acts (e.g., Biran, 1988 [1804]; Hatfield, 1998; Husserl, 1995; Merleau-Ponty, 1945) may support some version of the Principle of Attentional Constitution. However, the justification of this principle is probably more forcefully achieved if we articulate phenomenology with an information-theoretic approach to attention. When the term "attention" is used in connection with perception in information-theoretic psychology, it frequently denotes the selection of information for further analysis. In neurobiology, this can be formulated in terms of selection of information for global availability[9] across neural networks of which modulation[10] correlates with conscious attentive perception.

This concept of attention *qua* mental selection is central in the descriptions of attention since, at least, the work of William James (1890) and other psychologists of the late nineteenth century.[11] However, a major step in the theoretical study of attention occurred with the description of mental selection in information-theoretic terms. This description originates in the research inspired by the mathematical theory of communication and carried out in England and the USA during and after the Second World War.[12] Information-theoretic approaches conceive of human persons, brains and minds as information-seeking or information-processing systems. This focus on information has introduced a number of innovations in the understanding of perception. For instance, the information-theoretic approach provided researchers with a framework departing from behaviorist theories (e.g., Neisser, 1967; Posner, 1994) and the atomistic theories of sense-data or sensations (e.g., Gibson, 1966: 266; Hatfield, 1991; Miller & Johnson-Laird, 1976: 29). This has proven to be a useful move to study the cognitive and active dimensions of human perception.

Information-theoretic approaches in biological psychology[13], philosophy[14] and other fields of cognitive science have become of remarkable diversity. As a result, the variety of information concepts can generate methodological intricacies. For instance, talks about information are ambiguous when they do not specify whether the concept of information in use refer to an objective (or mind-independent) property of physical facts or a subjective (or mind-dependent) construction of the mind. As an attempt to prevent conceptual slips, I will distinguish three classes of information-theoretic concepts.

A first class is relative to causal, environmental (Gibson, 1966) or material information (Bogdan, 1988) or natural meaning (Dretske, 1988; Grice, 1957; Millikan, 1984). I will use the concept of *causal information* to refer to an objective property of certain facts or structures of the material world, which is to have constant (or invariant) connections with other facts or structures of the world.[15] If a particular component A is constantly connected to component B (or, has the propensity to lead to B), A can be viewed as carrying causal information relative to B by virtue of its constant connection to B. One can therefore apprehend A as a *carrier* (or vehicle) of causal information relative to B of which specific characteristics may vary according to ontological kinds (Bogdan, 1988). Causal information refers to an objective connection between A and B of which existence is independent of, and prior to the knowledge that one may obtain about A or B.

Depending on specific ontological levels and terminologies, such connected components A and B may be apprehended as events, individuals, facts or situations. Their connections may be regarded as constant conjunctions, causal links or laws of nature. Specifically, the concept of causal information can be accommodated to a variety of ontological accounts of causation (e.g., causation *qua* singular causation[16], laws of nature, counterfactual dependencies, or statistical regularities). Although this concept of information is in the spirit of important points introduced by Fred Dretske (1981; 1994), the notion of causal information is distinct from Dretske's notion of information because the latter is primarily conceived of from the standpoint of Shannon's mathematical theory of communication (Shannon, 1948) and thus cannot be reduced to causation.

I will focus on the case in which the basic carriers of causal information are material individuals such as material objects, biological organisms and human persons. Here I will assume that the fundamental ground of difference of an individual depends on the singular causal powers of that individual and that such powers carry causal information about numerous other facts. Consider the case of human persons. Objective facts involving human individuals carry causal information about other facts because the former are constantly connected to the latter. For example, the fact that you are a living adult human person carries causal information about numerous facts relative to your biological organism such as the causal facts that you were born, that your body is made of cells or that your cells contain DNA. You remain a carrier of this causal information whether or not you cognitively access the specifics of that causal information which is carried by your organism and your DNA. Such causal information is an objective property of the fundamental material ground of difference of your own particular biological organism.

One can conceive of human folk and scientific knowledge as the extraction and analysis of distinct sorts of information (e.g., Bogdan, 1988; Dretske, 1981; Israel, 1988; Israel & Perry, 1990). An argument that supports this information-theoretic approach is that human subjects continuously communicate their knowledge through what one can term, after Israel and Perry (1990), “information reports.”

Information reports are sentences about what certain causal facts indicate about other facts. Information reports are omnipresent in the communication about forensic evidence, archeological or historical archives, or clinical medical knowledge among many other forms of empirical inquiries grounded in the scrutiny of material individuals. For instance, given the regular connection between the fact that a human agent manipulates an object and the fact that finger prints are left on the surfaces of the object, a human finger print on a knife carries causal information relative to the fact that the knife has been manipulated by a particular human individual. This can be expressed in these information reports:

(1) This finger print indicates that somebody has manipulated the knife.

(2) The fact that this finger print has these specific patterns indicates that Jack has manipulated the knife.

Such reports have a specific structure (Barwise & Perry, 1999 [1983]; Israel, 1988; Israel & Perry, 1990). The referent of the noun phrase in (1) refers to the carrier of causal information (or a part thereof). The noun phrase used to describe the carrier of causal information can be the referent of a demonstrative phrase. The proposition introduced by the 'that'-clause, which refers to the fact that is indicated by the primary carrier of causal information, can be thought of as the "informational content" of the linguistic report (Israel & Perry, 1990).

Information reports are paradigm cases of the building of singular knowledge through the conversion of causal information into semantic contents, or semantic information. One can thus use the concept of *semantic information* (or intentional information), which is distinct from causal information, for referring to the property of that which has the function to carry intentional content or meaning. Semantic information can thus be understood in teleological terms—i.e., through an analysis of the functions of the carrier of semantic information— and comes in different varieties of natural or conventional carriers of semantic information (e.g., Bogdan, 1988; Dretske, 1988, 1995b; Millikan, 1984). Numerous theories in cognitive science view phenomena such as experiences, emotions, thoughts, information reports or cultural contents either as possessing or processing semantic information. This use raises the problem of specifying the ways minds convert causal information into semantic information, or extract semantic information from causal information.

A third class of information-theoretic notions includes the formal concepts of information, which have been initially introduced as mathematical tools for measuring the performance of communicating devices. The classical notion in this category was introduced by the mathematical theory of communication of Shannon (1948) and Shannon & Weaver (1949). In the latter, information is a measure of one's freedom of choice when one selects a message (the logarithm of the number of available choices or of probabilities).

The conceptual relations of the different classes of information-theoretic concepts are notoriously knotty. A number of thinkers have expressed concerns about the risk to conflate the colloquial notion of semantic information with the formal concepts of the mathematical theory of communication (see, e.g., Bar-Hillel, 1955; Partridge, 1981; Wicken, 1987). In addition, the project of grounding the theory of meaning and intentionality in the mathematical theory of communication, which has tempted Dretske (1981) among others (see, e.g., Adams, 2003), remains contentious (Dretske, 1994). Similar concerns have been expressed about the project of using the concept of information to describe genetic coding (Godfrey-Smith, 1999, 2000a, 2000b; Griffiths, 2001; Maynard Smith, 2000). Moreover, methodological debates on the concept of information are also found in psychology. For instance, there is a striking contrast between Donald Broadbent's (1958; 1971; 1982) and James Gibson's (1966; 1979) information-theoretic frameworks.

In his seminal book *Perception and Communication* (Broadbent, 1958), Broadbent borrows the term "information" with a constellation of other notions from the mathematical theory of communication (e.g., "information source", "channel", "signal", "noise" and "capacity"). However, it seems fair to view Broadbent's approach (Broadbent, 1958, 1971, 1982) as a global strategy to empirically analyze psychological activities relative to semantic information (or content) rather than an attempt to develop Shannon's mathematical theory of information or the theory of causal information. The key concepts originating from Broadbent's school in psychology is the notions of information processing and of processing levels (e.g., Kosslyn, 1994; Newell, 1990; Smith & Broadbent, 1981), which are theoretical concepts used to analyze semantic processing of information. (Through the concept of information processing, attention can be defined as analysis for further detailed processing (Kosslyn, 1994: 73; Treisman, 1969, 1988).) The notion of information processing performed by psychological faculties is primarily used to model the functional architecture of the mind/brain activities that are underpinning the possibility of semantic information. Its use is aimed at naturalizing semantic information.

In contrast to Broadbent (1958), Gibson (1966; 1979) develops an approach to perception that explicitly departs from the mathematical theory of communication and focuses on what Gibson terms “environmental information,” which is a concept roughly equivalent to the concept of causal information. He holds that “the information for perception is not transmitted” and “does not consist of signals, and does not entail a sender and a receiver” (Gibson, 1979: 63). Gibson’s concept of *environmental information* refers to invariant regularities, structures or specificities, which are present in the organism’s environment and which can be extracted in perception and action. These invariant regularities are found in a variety of “ambient arrays” of energy, such as the ambient optical array (Gibson, 1979: 65-91) or the acoustic array, which are fully objective and described by physical laws.[17] He maintains that “when we say that information is conveyed by light, or by sound, odor, or mechanical energy, we do not mean that the source is literally conveyed as a copy or replica” because “the sound of a bell is not the bell and the odor of cheese is not cheese” (Gibson, 1966: 187) and the perspective projection of the faces of an individual is not the individual itself. However, in all these cases “a property of the stimulus is univocally related to a property of the object by virtue of physical laws” (Gibson, 1966: 187) and this is what Gibson labels environmental information.

Gibson's environmental information is therefore a form of causal information. It describes the invariant or lawlike structure of the physical world. For instance, in light structured by the environment, "the information lies in the *structure* of ambient light, that is, in its having an *arrangement* or being an *array*" (Gibson, 1966: 208); see also Gibson (1979: 47-64). The ecological psychology of perception develops the idea that, in perceptual exploration, the organism "picks up" causal information (Gibson, 1966: 250-265) in the sense that it detects and explores the invariant structure of its environment.

There is a discrepancy between Broadbent's and Gibson's approaches to information. While Broadbent's information-processing view primarily accounts for the mental operations performed on semantic information (e.g., storage in memory systems), Gibson's ecological approach holds that the function of perception is to extract causal information. In spite of this apparent dilemma, I will suggest that the information-theoretic insight of each approach can be resolved by considering that attention is a key component of the translation of causal information into semantic information via the control of information-processing routines.

3. Common Assumptions about Attentional Systems and Information

The main thought I intend to convey in this article is that attention plays a key role in the acquisition of perceptual knowledge because of its role in the conversion of causal information into semantic information. Support for this thought is found, namely, in the theories that apprehend attentional as a faculty of selection for further information-processing. The early research on such an approach to attention has been primarily carried out in Broadbent's school,[18] which hypothesized that the need for selective attention arises from certain basic limited processing capacity in the brain. This conception was developed by Broadbent (1958; 1971; 1981; 1982) and other pioneers of cognitive psychology such as

George A. Miller (1956), Ulric Neisser (1967), Anne Treisman (1969), Neville Moray (1969) and Michael Posner (1978).

On this view, the selective character of attentional operations is a consequence of global information-processing limitations. This approach is usually combined with closely related assumptions, which have been critically pinpointed by cognitive scientists such as Allport (1993: 184) and others (e.g., Desimone & Duncan, 1995; Gibson, 1966, 1979; Neisser & Becklen, 1975). The defining assumptions of the early models of information-processing (I follow Allport's analysis with a few changes) are, primarily, these statements about computational resources and control:

> A1: The concept of "attention" refers to a processing resource, which is limited in quantity and must be allocated selectively. This conception originates in Broadbent's notion of attention as a "selective filter" that feeds a "limited capacity channel".[19]

> A2: Attention is a necessary condition for certain kinds of processes, which are "controlled" processes; attention is not necessary for other kinds of processes, which are "automatic" processes.[20]

In addition, these early models usually endorse a set of assumptions about the problem of the unity and variety of attention, which can be expressed as follows:

> A3: As a limited processing resource, attention is unitary.

If one reject the unity of attention, the attempt to characterize cognitive processes in terms of those that (discretely) do, or do not require attention becomes an ambiguous enterprise. In spite of giving some credence to A3, the early theories usually recognize that division or scission of attention was possible, and thus tend to accept this statement:

> A4: Attention is a unitary resource that can, in some circumstances, be "divided," but such a division demands a specific effort (it costs more resources).[21]

It cannot be taken for granted that the propositions A1 to A4 are compatible, as the ostensible tension between A3 and A4 may illustrate. Although such propositions pertain to controversial debates, they have oriented psychological research toward a series of traditional questions (Allport, 1993: 184; Findlay & Gilchrist, 2003). A first question is the problem of the spatial or temporal "location" of selection: what is the *locus* (or place, stage) of attentional selection? Does the intervention of attention take place in or at an *early* or *late* stage in the (temporal or sequential) ordering of information processing? The debate opposing psychological theories of the early and late selection presupposes the idea that there is a specific location in which, or where, the "unitary" attention intervenes. Another problem, raised by A2, is this: what are the processes which do, or do not, require attention?

There are reasons to approach propositions A1 to A4 with caution. Consider A3 as an example. There might be good reason to describe the phenomenology of attentive perceptual experience as being unitary. However, A3 is neither a phenomenological claim, nor a reductive claim about phenomenology. It is a psychological claim about the functional architecture of attention and the human mind/brain. It propounds that there is a single attention mechanism in the brain, which is independent of other cognitive systems such as sensory-motor control and memory. As such, A3 is debatable. Alternative approaches hold that "the" faculty of "attention" depends on *multiple selection* systems, and show that attention is reducible to the performance of a variety of sensory-motor and cognitive systems that can carry out a variety of mental procedures, acts or routines.

The aim of the basic research strategy in biological psychology is to analyze the faculty of attention in terms of functional units, and thus in terms of *multiple* mechanisms or systems (e.g., Parasuraman, 1998; Parasuraman & Davies, 1984; Posner, 1994).[22] For instance, in a statement that reflects a common approach in psychology and neurobiology, R. Parasuraman affirms that "attention is not a single entity but the name given to a finite set of brain processes that can interact, mutually and with other brain processes, in the performance of different perceptual, cognitive, and motor tasks" (Parasuraman, 1998: 3). Although there is no completely established taxonomy of attention, Parasuraman proposes the relative independence of three components of the attention faculty, which are selection, vigilance, and control. Given its focus on naturalistic approaches to attention, the present article uses phrases such as "attentional systems" or "systems of attention" to convey the idea that, at least in naturalistic accounts, the theoretical understanding of the faculty of attention requires the examination of a varied hierarchy of functional units or mechanisms.

This admission of the plurality of attentional systems opens the path to a wide range of questions. These questions originate in the attempt to understand attention systems as a *hierarchy* of selection and control procedures that shape tracking and action. Such control procedures may include the agent's endogenous selection of intentions and goals, of individuals to be tracked or of features to be analyzed. They may also include the selection operated by mechanisms that can prioritize the perception of salient unexpected events, which are usually termed "exogenous attention" to indicate that they are not deliberately or endogenously controlled by the attentive agent. The distinction between endogenous and exogenous factors in the control of attention is another fundamental assumption, which can be expressed as follows:

> A5: The faculty of attention can be controlled by endogenous or exogenous mechanisms.

The assumption distinguishes endogenous and exogenous shifts of attention (A5 should not be conflated with A2). It has long been described by phenomenological analyses that attention can undergo involuntary shifts (see Hatfield, 1998: 10). This has led to the distinction between “automatic” or “reflex” and “voluntary” or “willed” attention within various lexical idioms.[23] The distinction supports the naturalist stance about the plurality of attentional systems because endogenous and exogenous controls may be distinct with respect to their phenomenology, psychological mechanisms and neural correlates.

Another assumption, which can serve as a guide for the study of attention systems, can be expressed as follows:

A6: The faculty of attention encompasses “overt” and “covert” forms of selection.

In psychology[24], the concept of *overt attention* refers to gestures and actions associated with observable activities of attentive tracking such as listening, touching, smelling, tasting or looking. Paradigmatically, overt attention coincides with the displacement or adjustment of a sensory organ to explore target individuals in the organism’s environment. As pinpointed out by Gibson (1966), each perceptual system (i.e., the basic orienting system, the auditory system, the haptic system, the taste-smell system and the visual system) uses specific modes of overt attention. With respect to the visual system, overt attention is the activity of looking at individuals, which is performed by observable eye movements (patterns of saccades and fixations). Eye fixations are usually tightly bound to cognitive operations under progress (see section 7).[25] In contrast to overt attention, the concept of *covert attention* refers to the internal and cognitive consequences of the selection that are not so readily observable (see section 6).

4. An Argument from Cognitive Access in Support of the Attentional Constitution Principle

While the information-processing approach has provided a fundamental impetus to a functional description of the faculty of attention, a theory grounded in the assumptions A1 to A4 does not explain how humans acquire knowledge on individuals from the extraction of causal information. To provide such an explanation alongside a foundation for the Attentional Constitution Principle, I will propose an argument from cognitive access and outline a more appropriate theory of attention.

The argument from cognitive access in support of the principle runs as follows: humans' empirical beliefs and perceptual knowledge about target individuals depend on having direct cognitive access to such individuals in order to track and identify them through direct perceptual acquaintance (see P1 in section 1). The act of directing attention at a target individual is a necessary condition of having direct cognitive access to this individual (for the orienting of attention at a target provides access to causal information relative to such target). Therefore, attention is a necessary condition of the perceptual knowledge of individuals.

The crux insight of the argument is that selection by perceptual attention institutes direct cognitive access to targets of *de re* epistemic attitudes such as perceptual identification, demonstrative thoughts and empirical beliefs. Such a cognitive access is made possible by specific information-processing procedures performed by attentional systems. Only such attentional procedures can retrieve causal information available in the organism's environment.

To be consistent with naturalist constraints, this argument must be grounded in a biologically plausible account of attention and cognitive access. For this, I propose to ground the argument in the distinction between overt and covert attention (see A6, section 3). On that basis, the argument from cognitive access can be expressed as follows:

> P2: Perceptual tracking and perceptual-demonstrative identification of an individual *i* necessarily require a direct cognitive access to *i*'s properties (i.e., some of *i*'s intrinsic or relational properties that carry causal information).

> P3: To obtain direct cognitive access to *i*'s properties, an intentional agent must perform search actions and acts of *overt attention* (or, overt attentive tracking) in order to introduce and maintain *i* into at least one of her/his sensory fields and track *i*.

> P4: To obtain direct cognitive access to *i*'s properties, an intentional agent must track *i* and select *i* by *covert attention* to analyze some of *i*'s properties and assess propositions (e.g., expressed by information reports) about *i*.

From the fact that demonstrative identification depends on direct cognitive access (premise P2), and that direct cognitive access depends on acts of overt (premises P3) and covert attention (premise P4), one can conclude that:

> P5: Acts of overt and covert attention are necessary conditions of the perceptual tracking and demonstrative identification of an individual *i*.

Arguably, given P5 and P1 (see section 1), which states that human perceptual knowledge depends on perceptual tracking and demonstrative identification (of which form is schematically "This *i* is *F*"), it is possible to conclude that the Attentional Constitution Principle is true. Attentional systems are constitutive of agents' perceptual knowledge of individuals. This reasoning concludes that attention is a necessary condition of perceptual knowledge because of its necessary contribution to the assessment of propositions (expressed by information reports or beliefs) grounded in the perceptual-demonstrative identification "This *i* is *F*."

Proposition P2 expresses a commonly received epistemological thought. Perceptual-demonstrative identification of an object is usually defined—in a sense related to Russell's notion of knowledge by acquaintance (Russell, 1910-11)—as an identification whose success depends on the actual perception of the individual to be identified. Such perceptual identification may be performed, by excellence, through its localization and analysis in the visual field, or in some other sensory field.[26] According this tradition, perceptual-demonstrative identification cannot occur in the absence of veridical perception of the target individual, and to perceive in a veridical manner an individual requires having direct perceptual access to some of its properties. This direct access possesses a cognitive value because it determines the cognitive significance of the representation of the target individual (e.g., Campbell, 2002: 84-113). In perceptual-demonstrative identification, perceptual access serves the epistemic goals of the agent. (e.g., to verify an empirical belief expressed in information reports such as (1) and (2) in section 2).

Premises P3 and P4, and my comments on P2, refer to the establishment of a proper direct cognitive access to a target individual. How are we to understand this notion? In the present article, I will follow the common understanding of cognitive access in terms of global availability for mental acts such as recognition, reasoning and the rational guidance of action and speech.[27] I am using the term "direct" to restrict the discussion to perception and the perceptual retrieval of causal information.[28] Hence, in this use, we can declare that a human agent *a* has direct cognitive access to an individual *i* when, in virtue of *a*'s current perception of *i*, some properties of the *i* and their related causal information are available to *a*'s mind/brain for use in identification, localization, reasoning and the rational guidance of *a*'s action and speech.

Two kinds of analyzes may appear as conflicting accounts of this perceptual access. As a first kind, the conceptualist[29] and intentionalist[30] accounts stress the roles of conceptual capacities for individuating the target of perception. For instance, a few of them emphasize the role of sortal concepts in the spatio-temporal delineation of the demonstrative's referent.[31] In another kind of analysis, the explanation of cognitive access is conducted in an analysis of the non conceptual mechanisms or contents that allow the perceiver to be "anchored" onto the target via sensory-motor skills.[32]

If an account of cognitive access for identification is restricted to only one of the two types of explanation, it may be at risk of circularity with regard to the analysis of access. For access might thus be conceived as a purely conceptual/descriptive process without grounding in external individual or a purely sensory-motor anchoring without grounding in conceptual thought.[33] I suggest that the interest to study overt tracking and covert attention in this context is that the faculty of attention is likely to explain the missing link between the two explanations. It should help us have a better understanding of how conceptual and non-conceptual abilities interact to determine direct cognitive access. Thus, to preclude any circularity in the analysis, in the argument from cognitive access, attention is viewed as a mediating faculty of control that articulates the conceptual and non-conceptual conditions of the cognitive access to individuals.

5. Cognitive Access and the Tracker's Goal-Directed Movements (Justification of P3)

Let us focus on proposition P3, which asserts that the perceptual and cognitive access to an individual is dependent on *overt* attention. The statement can be justified on the ground that (i) the preparation and initiation of cognitive access is dependent on a wide spectrum of spatial actions and motor behavior needed for tracking a target (for reaching the situation where searched causal information can be made available), and that (ii) such actions can be viewed as sequences of information-seeking acts of overt attentive tracking.

Consider the case of a person who is looking for another individual *i* (e.g., a partner, a lost artifact, a building), to act upon *i* or verify an information report about *i*. Term the former agent the *tracker* and the latter the *target*. By the former definition of “direct cognitive access,” if, as a tracker, one intends to obtain direct cognitive access to *i*, one must put oneself in a situation of directly perceiving *i* and extract causal information relative to *i*. Assuming the existence of the target, a tracker can be presented with, roughly, two cases.

The first case can be termed *sustained perceptual absence*: the target *i* is apart or very distant from the tracker’s perceptual fields and cannot be perceived at the moment. The second case can be termed *perceptual proximity*: the target *i* is either present within the tracker’s perceptual fields or present in the region surrounding the tracker’s body—i.e., its peri-personal space (Maravita, Spence, & Driver, 2003).

In a situation of sustained perceptual absence of the target, in which the tracker maintains the intention to obtain direct cognitive access to *i*, the tracker must move its body (and, thus, the sensors thereof) in order to track down *i*’s present location until *i* is reached, found or caught. This spatial search may require small scale spatial actions (e.g., performing a saccade) or large-scale spatial actions (e.g., displacements in case of migrations or pilgrimages). These spatial actions can be described in different frames of reference.

For example, in the case of a pilgrimage, the pilgrim, as tracker, may have to move across lengthy territories before finally reaching a particular holy target. In this example, a useful description of the tracker’s move to *i*’s location may be made according to allocentric reference frames—e.g., by means of a map. The initial phase of the tracker's search corresponds to bodily movements initiated toward a still imperceptible target. Prior to a successful end of the search, the tracker's behavior is not grounded in the direct perception of *i*—although it may use, of course, the perceptual tracking of clues relative *i*'s location (e.g., the perception of maps or of signs that carry causal or semantic information relative to the target location). Thus, this kind of search can be termed *epistemic tracking* (Bullot, 2006; Bullot & Rysiew, 2007) because it aims at re-instating the perception of a target via epistemic means, which may use memories, reasoning and communication about the target's identify and location.

Notice that, epistemic tracking is organized to prepare cognitive access associated to the direct perceptual-attentive tracking of *i*. Although, in epistemic tracking, the tracker's target may not at all be available in the tracker's peri-personal space. Still, there may be concrete, perceptual clues or signs within that space (e.g., Bullot & Droulez, 2008; Sutton, 2006) that might eventually lead the tracker to a location where the target *i* can be directly perceived. In this case, some of the evidence that leads the tracker to its target is still perceptual (and therefore not just epistemic in a non-perceptual sense) although the target *i* itself is not directly perceived or within the tracker's peri-personal space.

Consider now the case of clear perceptual proximity with the target. To prepare cognitive access to *i*, when the tracker is sufficiently close to *i*'s location and *i* is available within its perceptual fields, the tracker must perform another class of bodily movements, which are the typical tracking actions described by the concept of overt attention (see A6, section 3). It includes movements such as the displacement and orientation of the sensory organs (e.g., eyes, hands, ears) in order to focus on the properties of the target. Furthermore, beside them, the preparation and optimization of the direct cognitive access imply the inhibition or modification of competing movements. For example, when the tracker arrives in the target's proximity, the tracker may suspend its locomotion or change its way of breathing. The description of these preparatory movements has been developed in the theories of sensory-motor consequences of attention since the end of the nineteenth century.[34]

William James, for instance, analyzes the overt and organic phenomena that accompany the procedures that seek for causal information through the attentional tracking of a target. He noticed that when we look or listen we accommodate our eyes and ears involuntarily, and we turn our head and body as well. Similarly, when we taste or smell we adjust the tongue, lips and respiration to the target. He concludes that in all these acts of overt attention "besides making involuntary muscular contractions of a positive sort, we inhibit others which might interfere with the result—we close the eyes in tasting, suspend the respiration in listening, etc." (James, 1890: 435).

We can conclude from all these examples that various classes of tracking actions and attentional movements prepare perceptual access to a target (and to related causal information) and, consequently, prepare the target's perceptual tracking and demonstrative identification. This appears to be a sufficient reason to admit P3.

6. Cognitive Access, Epistemic Attention and the Procedural Theory (Justification of P4)

This section is a justification of proposition P4, which states that an agent must track and select an individual *i* by covert attention in order to obtain direct cognitive access to *i*'s properties. Here the rationale is that the description of overt attentive tracking is not sufficient to explain the direct cognitive access to an individual because the description of overt attention do not fully account for the epistemic uses of attentional acts.

In spite of their complementary[35] status, overt and covert attention must be kept distinct. For instance, the description of overt and goal-directed attentional behavior in vision is mainly the description of eye movements. There is an emerging consensus[36] to acknowledge that, in an unconstrained context, the description of eye movements cannot unambiguously reveal the covert cognitive tasks performed by the tracker. For instance, the fact that a tracker is looking in the direction of an individual *i* does not necessarily imply that the tracker is currently paying attention to *i* to identify *i*. Empirical evidence supports this point, and, subsequently, the distinction between overt and covert attention.

The seminal psychological argument for the distinction originates from a series of experiments conducted by Michael Posner and collaborators (Posner, 1978, 1980; Posner, Nissen, & Ogden, 1978; Posner, Snyder, & Davidson, 1980). They have found convincing evidence that human trackers can shift covert visual attention independently of their eye movements (i.e., overt visual attention). Specifically, they demonstrated that reaction times to visual targets selected by covert attention were faster for spatial locations that had been previously cued in a context of unchanged fixation. These experiments are usually interpreted as evidence that covert and overt attention can be uncoupled in vision.

In addition, other experimental findings indicate that directing the eyes at an individual does not imply the identification or memorization of this individual. As described in perceptual phenomena such as “attentional blink” (Shapiro, 2001; Shapiro & Terry, 1998), “change blindness” (O'Regan, Rensink, & Clark, 1999; Simons & Rensink, 2005a, 2005b) or “inattentional blindness” (Mack & Rock, 1998), a sensory organ can be directed precisely towards a target without this target being consciously noticed, identified or recalled. For instance, the concept of inattentional blindness (Mack & Rock, 1998) refers to the failure to detect the presence of an entirely visible stimulus (such as a red square or a mobile bar) presented in the region of fixation. To study this phenomenon, Mack and Rock used a paradigm based on the principle of situating the subjects in a position where they would neither pay attention to, nor would expect to see, an individual thing—termed “critical stimulus”—but, nonetheless, would look at the region within which this thing is presented. Inattentional blindness illustrates a case in which directing the gaze towards a target does not imply the target’s identification—or, more weakly, does not imply the capacity to submit a verbal report on its identity.

Taken together, these findings suggest that overt attentional behavior and covert attentional information-processing are two distinct but (jointly) necessary conditions of direct cognitive access. Overt attentional selection, such as the action of looking at *i*, does not necessarily imply an epistemic analysis of *i*’s properties aimed at identifying or locating *i*. Therefore, the nature of covert mental procedures must be elucidated in order to account for the epistemic dimension of the access to *i*’s properties. However, what is the nature of covert acts of attentional selection, and how do they relate to overt attentional tracking? To answer this question, I will introduce the concept of epistemic attention.

In the remainder of this article, the phrase *(perceptual*[37]*) epistemic attention* will refer to the capacities to identify or locate individuals that are currently perceived, and to disclose facts about them through the extraction of causal information from their perceived properties. In this usage of the term “epistemic,” I conform to a tradition in the epistemology of perception, represented namely by Dretske’s concepts “epistemic seeing” (Dretske, 1969) and “meaningful perception” (Dretske, 1995a).[38] In contrast to the epistemic tracking carried out when the target is not perceived, by definition, an act of perceptual epistemic attention requires the analysis of some properties of a perceived individual. Thus, perceptual epistemic attention can only be performed while the target individual is being tracked within a sensory field. How shall we analyze the acts of epistemic perceptual attention?

Given its definition, the central requirement for epistemic attention is this: to qualify as "epistemic," an attentional system must be necessary to the acquisition of knowledge. Thus, in perception, epistemic attention must contribute to the ability of the tracker to form non-accidental true beliefs (e.g., Nozick, 1981) and information reports (Israel, 1988; Israel & Perry, 1990) about perceived individuals. Consequently, epistemic attention must bestow the tracker an ability (i) to flexibly assess the truth value of perceptual and demonstrative beliefs and (ii) to revise, or update, such beliefs as a function of information made available through perceptual analysis of the target's properties.

When assessed with regard to this epistemological constraint, the early models of selective attention—those which accept A1, A2 and A4—appear limited. Their explanatory scope is too narrow because they do not account for anything like an ability to assess whether a perceptual-demonstrative proposition is true or false. Models associated with this tradition—such as "attention-as-a-filter," "visual-attention-as-a-spotlight"[39] or "attention-as-a-spatial-window"[40]—restrict their descriptions to early stages of perceptual selection, which would not qualify as vehicles of truth-assessable mental states or truth-assessing mental processes. Furthermore, they may not view attention as a system of which function is to extract causal information.

There is also another substantive reason why the early models fail. To explain perceptual verifications or falsifications, you need to analyze the control of sensory-motor procedures used to perform perceptual verifications, such as directing your eyes toward *i* to verify whether *i* is *F*. Arguably, to account for procedures of perceptual verifications, one must have an account for the *executive control* of sensory-motor systems as performance systems for verification procedures. However, as a matter of historical fact, early cognitive models of selective attention were developed in relative independence from the theories of motor control. The executive control for epistemic/cognitive purposes is not an important theme of the early theories of the "locus" of attention selection. For instance, Broadbent's (1958: 297-301) early-selection theory identifies attention to a selective filter that feeds a single limited-capacity information channel and would not directly control the system's effectors—see the information-flow diagram in Broadbent (1958: 299). As a result, this kind of model does not offer predictions about the control of sensory-motor systems for epistemic purposes.

Can one provide a biologically plausible conception of attention that account for the perceptual verification or falsification of propositions expressed by empirical beliefs and information reports? My proposal is that a positive answer is possible within the framework of the "procedural/executive" theory of attention (e.g., Ballard et al., 1997; Campbell, 2002; Carlson & Sohn, 2000; Cavanagh, 2004; Gray, 2000; Logan, 1985; Miller & Johnson-Laird, 1976; Posner, 1994; Tomasello, Carpenter, & Liszkowski, 2007), which has different foundational principles from that of early models of attention.

The *procedural* [41], or *executive* theory I propose hypothesizes that attention-driven perceptual processing corresponds to strategies[42] built by each tracker for satisfying requests about individuals. Specifically, perceptual epistemic attention uses perceptual analyzers to generate semantic information about perceived individuals from the cognitive processing of causal information. The semantic information-processing guides the acquisition of singular perceptual representations and the performance of singular actions. (Singular representations are sometimes termed "object files" or singular, event "files." [43]) Consistently with the Attentional Constitution Principle (section 1), attention is identified with procedures constitutive of singular perceptions and singular actions. Although this account incorporates the semantic concept of information-processing, it does not restrict attention to the mere process of filtering out information as suggested by the attention-as-a-filter model (Broadbent, 1958).

The core principles of this procedural theory (PT) of attention can be formulated as follows:[44]

> PT1: The faculty of *attention* encompasses a set of executive and cognitive systems whose function is to perform singular perceptions (e.g., tracking and identifying a currently-perceived individual through the use of a mental file) and singular actions (e.g., acting on a presently-available individual).

As a component of the faculty of attention, one can isolate the faculty of perceptual epistemic attention as follows:

> PT1’: The faculty of *perceptual epistemic attention* is a system of executive and cognitive procedures that can implement exploratory strategies in order (i) to extract semantic information from causal information, (ii) to track and identify individuals in perception and (iii) to assess the truth value of information reports and empirical beliefs about such individuals and their relations.

In PT1’, the reference to the ability to assess the truth value of propositions expressed by reports and empirical beliefs is what justifies the use of the adjective “epistemic.” Perceptual epistemic attention is at the root of epistemic perception understood as the ability to perceive facts, form perceptual-demonstrative beliefs and express linguistic information reports. The nature of attentional control can be specified as follows:

> PT2: Perceptual epistemic attention is a control system that builds *attentional exploratory strategies*, which are hierarchical procedures of information-processing

> that combine (i) instructions that can be termed “epistemic requests” and “action requests” and (ii) specialized information-seeking operations termed “perceptual routines”, “motor routines” or “sensory-motor routines” that allow the tracker to solve or satisfy the epistemic and action requests (as a function of specific context- or task-dependent combinations).

An *epistemic request* is a control procedure—i.e., an instruction or command—that instructs a sensory-motor system or perceptual analyzer to extract semantic information about a perceptually tracked individual(s) from available causal information. As component of a way to come to believe particular perceptual-demonstrative proposition, the aim of an epistemic request is to solve a specific problem about perceived individuals. A paradigmatic example of the resolving of an epistemic request is the evaluation of perceptual predicates embedded in a demonstrative proposition.

Think about this task: imagine that a human person must act as a tracker and place a dozen eggs, which are dispersed on a table crowded with other kinds of objects, inside a box. To perform the task, the tracker must iterate and solve an epistemic request that may be expressed in public language by the question “Is this an egg?” The procedural theory proposes that human trackers solves this request by assessing whether a perceptual predicate—which one may note “EGG(*i*)”—is satisfied by the objects they are serially looking at. Thus, the ability to verify perceptual-demonstrative propositions depends on an ability to assess the truth-value of mental structures built from perceptual predicates ascribed to individuals. An examples of such predicates is OVOID(*i*), which is satisfied when the target individual *i* is egg-shaped. OVOID(*i*) is procedurally assessed as a satisfied by the current target of attention if the tracker’s perceptual epistemic attention can extract from the analysis from *i*’s faces the fact that *i* is egg-shaped. Perceptual predicates can relate to any other perceivable aspect of the target, such as its spatial relations with neighboring individuals—for instance, ABOVE(*i*, *k*) is satisfied when *i* is above *k*; COLLINEAR(*i*, *k*) is satisfied when *i* and *k* are collinear and so forth.[45]

Similarly, in the action domain, to account for the fact that the trackers' actions are singular (i.e., are directed at individuals), an action request can be represented under the form of an action-predicate assigned to an individual. An *action request* is a procedure that controls motor routines through the use of a repertoire of action predicates, which may be initiated in the context of the performance of a hierarchy of actions. An action predicate can be represented as "GRASP-A(*i*)", in which the structure "GRASP-A( )" refers to a sensory-motor mechanism that can control the grasping of the individual *i* (in argument position).[46]

Requests presuppose the activity of a control system that can assess the semantic information obtained from the performance of a command. Their study relates to the cognitive aspects of sensory-motor control.[47]

An additional key concept in PT2 is the notion of routines. Epistemic and action requests can be solved through the uses of a variety of sensory-motor and cognitive routines. The concept of *routines* refers to hierarchical information-processing systems of elementary mental analyzers or sensory-motor operations that must be carried out to resolve epistemic or action requests—the notion of "perceptual analyzers" has been introduced by Treisman (1969). Routines are structured and hierarchical abilities, of which iterated use for retrieving information in familiar tasks does not impose extreme demands on the tracker's capacities. The routines constitute the basic elements of the repertory of the practical aptitudes of a tracker, and these elements are regarded as stable once acquired after training. The development of some routines is likely to be driven by innate mechanisms. The routines are selected during the action according to the demands of the ongoing task and are controlled by hierarchical structures of goals.

This concept of routine is to be understood with regard to the theories of the sensory-motor capacities.[48] It presents a kinship relation to other notions such as sensorimotor primitives[49], functional routines[50], sensorimotor contingencies[51], scripts and micro-scripts[52], or procedures of haptic exploration[53]—of which aim is to understand the formation and structure of the skills that allow trackers to carry out epistemic perceptions and actions.

The procedural theory can be summarized by this hypothesis of tracking by epistemic attention:

> H: A human tracker must carry out exploratory strategies of epistemic attention (i.e., assemble epistemic and action requests with relevant routines) directed at an individual *i* in order to seek for task-relevant information, build a singular representation of *i* and verify or falsify empirical beliefs and linguistic information reports about *i*.

If H is correct, it provides a relatively new way to justify P3 and P4, and, subsequently, the Attentional Constitution Principle. Direct cognitive access to an individual (cf. P3 and P4) depends on overt (P3) and covert (P4) attention. On the procedural theory, the cognitive and epistemic processes of covert attention are analyzed as procedures performed by epistemic perceptual attention: cycles of hierarchically-organized requests and routines, which are constitutive of the tracker's perceptual verifications. Specific perceptual and conceptual routines explain the extraction of task-relevant causal information related to targets' properties such as shape, color or acoustic activities. The procedural theory predicts that human agents, as epistemic and perceptual trackers, have routinely recourse to probing behaviors and perceptual verification about causal information and individuals in their environment.

In contrast to the non-biological epistemology of knowledge or the non-epistemological psychobiology of attention, the procedural theory can address epistemological problem in a conceptual framework that is consistent with a naturalist philosophy and a biological investigation. One further advantage of this theory is that it can accommodate the seminal insights of both Broadbent's and Gibson's schools (see section 2). Broadbent's school insists that one must account of semantic information in terms activities of functional information-processing units of the perceiver's brain. The procedural theory addresses this point in its account of information-processing routines. Gibson's school states that perceptual knowledge derives from exploratory actions performed by perceptual systems that seek for and pick out (causal) information in the environment. The procedural theory addresses this point in its account of the epistemic exploratory procedures. The procedural theory can thus reconcile the two approaches in its suggestion that the attentional control of sensorimotor systems and perceptual analyzers provide human trackers with direct cognitive access to individuals *qua* carriers of causal information, and with means for extracting semantic information from causal information.

7. Biology and the Procedural/Executive Theory of Epistemic Attention

One may object that the procedural theory of epistemic attention cannot be grounded in biology. This concern can be set aside for at least two reasons. First, the theory raises specific biological questions. Second, it leads to hypotheses that can be (and have been) assessed via methods of experimental psychobiology.

To establish the first point, it should suffice to mention a few prevalent questions. A popular issue belongs to neurophysiology: what are the neural bases of executive attention? The question is now integral part of the biological sciences of attentional control, which use of a variety of methods for specifying the neural correlates of attentive experience and the role of the prefrontal cortex in executive control (e.g., Duncan, 2001; Prabhakaran, Narayanan, Zhao, & Gabrieli, 2000). For instance, Posner and his collaborators (Bush, Luu, & Posner, 2000; Posner, 1994; Posner & DiGirolamo, 1998; Posner & Raichle, 1994) suggest that the neural bases of the executive attention involve frontal structures, including the anterior cingulated, that act on different brain areas and account for attention as a control system.

Furthermore, the procedural theory also raises the biological question of determining the evolution of human attention systems in phylogeny and ontogeny. The ontogenetic development of attention systems is studied through specific experimental methods in developmental psychology and neuroscience. Some studies have investigated the relation of attentional systems to heritable traits (e.g., Fan, Fossella, Sommer, Wu, & Posner, 2003; Rueda, Rothbart, McCandliss, Saccomanno, & Posner, 2005).

With respect to phylogeny, the problem of understanding the effects of evolutionary pressure on the evolution of attentional systems remains, to the best of my knowledge, to be further investigated. The attentional systems specific to some of humans' ancestors may have been primarily selected to keep track of individual agents and objects. Specifically, a reliable attentional ability for tracking animate individuals is advantageous in terms of ecological fitness because it provides the tracker with efficient ways to hunt preys and to detect predators (e.g., New, Cosmides, & Tooby, 2007). The attentional tracking of animate individuals is also crucial for understanding the biological bases of social cognition since this kind of tracking is a requirement of learning social hierarchy, participating in collective actions and learning language by means of joint attention (e.g., Bruner, 1983; Tomasello, 1995; Tomasello et al., 2005).

Second, the procedural theory can be, and has already been developed and assessed with the methods of experimental psychobiology and neuroscience. This point can also be illustrated with behavioral research on the deployment of executive attention in the interactive tasks of daily human life. A good example of this kind is the experimental research associated with the "deictic theory of vision" proposed by D. Ballard and collaborators (Ballard, 1997; Ballard, Hayhoe, Li, & Whitehead, 1992; Ballard et al., 1997). The core thesis of the deictic theory is that the eyes are used deictically. Their use of the term "deictic" refers to the ability of certain sensory-motor mechanisms and actions to serve as means of direct cognitive access to (causal) information available in the organism's environment.

Ballard et al. (1997: 726-30) term such a mechanism of direct cognitive access "pointers." They argue that the use of pointers is essential to the performance of cognitive and epistemic procedures. Eye fixation is conceived as eye pointing directed at a referent (a target for the cognitive access to causal information in the tracker's environment), and illustrates the use of pointers in the sensory-motor domain. In addition, selection by covert attention is a neural pointer that interplays with eye fixations (Ballard et al., 1997: 725-26). Eye fixations are known to be particularly important when vision interfaces with cognitively, or epistemically controlled action.[54] This deictic theory is a procedural theory, in the sense defined by principles PT1 and PT2 (section 6), of singular perceptions and actions. With its enhanced visual resolution that occurs through foveal vision, the fixation on an external individual serves singular perception. Moreover, a fixation presents this advantage to allow "the brain's internal representations to be implicitly referred to an external point" (Ballard et al., 1997: 724), which can serve in the control of singular actions.

The deictic theory rests on the concept of deictic strategies. Fixations are parts of more overarching hierarchical structures termed "deictic strategies" or "do-it-where-I'm-looking" strategies (Ballard et al., 1997: 725). In a way consistent with PT2, the deictic theory stipulates that a *deictic strategy* is a sequential combination of routines, which use discreet deictic pointers to solve epistemic requests and activate action requests. The paradigm example of a pointer in the sensory-motor domain is eye fixations. Fixations serve singular cognition and action because they provide direct cognitive access to the referent of the pointing and an addressing mechanism to control motor routines directed at the same referent. Furthermore, Ballard et al. (1997: 729-30, 735-7) distinguish two basic routines combined in deictic strategies to serve the tracking of individuals through the performance of singular perceptions and actions: the "identification routine" (e.g., trying to identify the target of an eye pointing) and the "location routine" (e.g., trying to locate in the environment the target of a pointer in memory). Therefore, in a summary consistent with the procedural hypothesis H, a deictic strategy employs eye fixations to select the individuals which must be targets of identification or location routines in order to solve epistemic request and fulfill action requests. In agreement with PT2, the binding of each fixation's referent with properties or motor instructions is usefully represented in a predicative form that ties a target individual with a general category or concept (in the case of singular perceptual knowledge) or a motor instruction (in the case of singular action).

To assess the principles of the deictic theory, Ballard and his colleagues (Ballard et al., 1992; Ballard et al., 1997) used an artificial manipulative task carried out by mouse-controlled modifications of a computer screen display. In this "block assembly" task, the subjects acted on elements presented in computer display of colored blocks and had the task of assembling a copy of the Model (a top left area of the screen with a few colored blocks) in the Workspace (bottom left area of the screen). The experimental set up allowed the authors to keep a detailed record of both the manipulative actions and the eye scanning of the subject carrying out the task. The data collected from the block assembly task supported a deictic characterization of the underlying cognitive operations. Blocks were invariably *fixated* before they were operated on. Furthermore, there was clear evidence that the preferred strategy involved making minimal demands on any internalized memory.

In the block assembly task, as has been found in other tasks, many more saccades were made than what would seem necessary. The most common sequence observed in the block assembly task was eye-to-model, eye-to-resource, pick-from-resource, eye-to-model, eye-to-construction, drop-at-construction. It is referred to as a “Model-Pickup-Model-Drop” or “MPMD” strategy. (1) The first eye-to-model shift would be to acquire the color information of the next block to be assembled, then a suitable block is found in the resource space. (2) The second look at the model informs, or confirms, the location of this block in the model, which is then added to the construction. This second look could be avoided if the location information is also stored on the first look.[55]

It is possible to describe this MPMD deictic strategy in terms of a sequence of demonstrative thoughts, such as: “What is the color of the next square to be moved?” (epistemic request about an individual’s color); “This is a green square.” (demonstrative proposition about information obtained by a fixation and a color-recognition routine); “Pick a green square in this area up.” (action request); “What is the location of the green square in the model?” (epistemic request about the relative location of the element in the model); “It is located at the bottom right location" (demonstrative proposition supported by a location routine).

Another group of studies that accords with the procedural theory has been published by Michael Land and his collaborators. Land used a head-mounted video-based eye tracking system, which enabled a record to be built up of the fixation positions adopted by an observer during a variety of actions. Tasks studied have ranged through driving (Land & Lee, 1994), table tennis (Land & Furneaux, 1997), piano playing (Land & Furneaux, 1997) and making tea (Land, Mennie, & Rusted, 1999). The results, obtained during cognitively-controlled actions, demonstrate the strength of the principle that the gaze is directed to the points of the scene where causal information is to be extracted (Land et al., 1999: 1328).

The aim of Land's analysis of tea making (Land et al., 1999) was to determine the pattern of fixations during the performance of a well-learned task in a natural setting, and to classify the types of monitoring action that are associated with eyes movements. They used a head-mounted eye-movement video camera, which provided a continuous view of the scene ahead, with a dot indicating foveal direction with an accuracy of about 1 degree. A second video camera recorded the subject's activities from across the room. The authors analyzed the actions performed during the task as a control hierarchy in which the largest units describe the goals and subgoals of the operation. The hierarchy comprises these levels: (L1) main goal: "make the tea"; (L2) subordinate goals: "put the kettle on", "make the tea", "prepare the cups"; (L3) intermediate actions: "fill the kettle", "warm the pot"; (L4) basic actions, object-related actions: "find the kettle *k*", "lift the kettle *k*", "remove the lid *l* of *k*", "transport *k* to sink" and so forth; (L5) eye fixations "fixate *k* at time *t*".

To analyze the fourth level, the authors introduced the concept of "object-related action" units which they regard as the basic elements of an action sequence. These units, with very rare exceptions, are carried out sequentially and involve engagement of all sensory-motor activity on the relevant individual object or set of individuals. The eyes move to the object before the manipulation starts. In general the eyes anticipate the action by about 0.6 sec. During a single object-related action, saccades move the gaze around the object, but when shifting between one object-related action and another, very large saccades can occur. The eye movements could, with only occasional exceptions, be placed into one of the following categories of procedures: "locate *x*" (locate an object to be used later in the task), which may be represented with a deictic perceptual and action predicate such as LOCATE(*x*); "direct *x*" or DIRECT(*x*, *l*) (directing the hand or object in the hand to a new location); "guide *x*" or GUIDE(*k*, *l*) (guiding the approach of one object to another such as lid and kettle); "check *x*" or CHECK(*w*, *k*) (checking the state or property of an object such as water level in a pot). The description on these control functions is consistent with the procedural theory, in which they are described as epistemic requests (about the location or identity of certain individuals) or action requests of which aim is to control the action performed on a contextually relevant individual.

8. Conclusive remarks

The article has formulated the Attentional Constitution Principle. It has introduced the argument from cognitive access to support this principle and introduce the procedural theory of epistemic attention. The procedural theory grants attention with an eminent epistemic status due to its role in the perceptual tracking and demonstrative identification of individuals. It conceives of attention as a system that controls sensory-motor routines for satisfying action and epistemic requests—and, thus, for seeking or extracting semantic information from causal information available in the organism's environment. Hence, through the deployment of epistemic attention in singular perception, human attentive trackers can "navigate" the informational structure of the world to follow individuals and discover truths about them. Concurrently, through executive attention, trackers can perform singular actions on individuals as a function of their dynamical knowledge of the informational structure of the world.

9. Works cited

Adams, F. (2003). The informational turn in philosophy. *Minds and Machines, 13*, 471-501.

Allport, A. (1993). Attention and control: have we been asking the wrong questions. A critical review of the last twenty five years. In D. E. Meyer & S. Kornblum (Eds.), *Attention and Performance XIV* (pp. 183-218). Cambridge, MA: MIT Press.

Allport, A., Styles, E. A., & Hsieh, S. (1994). Shifting intentional set: Exploring the dynamic control of tasks. In C. Ulmità & M. Moscovitch (Eds.), *Attention and Performance XV: Conscious and Nonconscious Processing* (pp. 421-452). Cambridge, MA: MIT Press.

Arp, R. (2006). The environments of our Hominin ancestors, tool usage, and scenario visualization. *Biology and Philosophy, 21*, 95-117.

Baars, B. J. (1988). *A Cognitive Theory of Consciousness*. Cambridge: Cambridge University Press.

Ballard, D. H. (1997). *An Introduction to Natural Computation*. Cambridge, MA: MIT Press.

Ballard, D. H., Hayhoe, M. M., Li, F., & Whitehead, S. D. (1992). Hand-eye coordination during sequential tasks. *Philosophical Transactions: Biological Sciences, 337*(1281), 331-338.

Ballard, D. H., Hayhoe, M. M., Pook, P. K., & Rao, R. P. N. (1997). Deictic codes for the embodiment of cognition. *Behavioral and Brain Sciences, 20*(4), 723-767.

Bar-Hillel, Y. (1955). An examination of information theory. *Philosophy of Science, 22*(2), 86-105.

Barwise, J., & Perry, J. (1999 [1983]). *Situations and Attitudes*. Stanford: CSLI Publications.

Binet, A. (1894). Les sensations, les perceptions, l'attention, *Introduction à la Psychologie Expérimentale* (pp. 23-45). Paris: Félix Alcan.

Biran, M. d. (1988 [1804]). *Mémoire sur la décomposition de la pensée (Œuvres, Tome III)*. Paris: J. Vrin.

Block, N. (1995). On a confusion about a function of consciousness. *The Behavioral and Brain Sciences, 18*(2), 227-247.

Block, N. (2001). Paradox and cross purposes in recent work on consciousness. *Cognition, 79*, 197-219.

Bogdan, R. J. (1988). Information and semantic cognition: An ontological account. *Mind & Language, 3*(2), 81-122.

Bower, G. H., Black, J. B., & Turner, T. J. (1979). Scripts in memory for text. *Cognitive Psychology, 11*(2), 177-220.

Braun, J., Koch, C., & Davis, J. L. (Eds.). (2001). *Visual Attention and Cortical Circuits*. Cambridge, MA: MIT Press.

Brefczynski, J. A., & DeYoe, E. A. (1999). A physiological correlate of the 'spotlight' of visual attention. *Nature Neuroscience, 2*(4), 370-374.

Broadbent, D. E. (1958). *Perception and Communication*. London: Pergamon Press.

Broadbent, D. E. (1971). *Decision and Stress*. London: Academic Press.

Broadbent, D. E. (1981). Selective and control processes. *Cognition, 10*(1-3), 53-58.

Broadbent, D. E. (1982). Task combination and selective intake of information. *Acta Psychologica, 50*(3), 253-290.

Bruner, J. S. (1983). *Child's Talk: Learning to Use the Language*. Oxford: Oxford University Press.

Bullot, N. J. (2006). The principle of ontological commitment in pre- and postmortem multiple agent tracking. *Behavioral and Brain Sciences, 29*, 466-468.

Bullot, N. J., Casati, R., & Dokic, J. (2005). L'identification des objets et celle des lieux sont-elles interdépendantes? In C. Thinus-Blanc & J. Bullier (Eds.), *Agir dans l'espace* (pp. 13-32). Paris: Editions de la Maison des Sciences de l'Homme.

Bullot, N. J., & Droulez, J. (2008). Keeping track of invisible individuals while exploring a spatial layout with partial cues: Location-based and deictic direction-based strategies. *Philosophical Psychology, 21*(1), 15-46.

Bullot, N. J., & Rysiew, P. (2007). A study in the cognition of individuals' identity: Solving the problem of singular cognition in object and agent tracking. *Consciousness and Cognition, 16*, 276-293.

Bush, G., Luu, P., & Posner, M. I. (2000). Cognitive and emotional influences in anterior cingulate cortex. *Trends in Cognitive Sciences, 4*, 215 - 222.

Campbell, J. (1993). The role of physical objects in spatial thinking. In N. Eilan & R. McCarthy & B. Brewer (Eds.), *Spatial Representation* (pp. 65-95). Oxford: Basil Blackwell.

Campbell, J. (2002). *Reference and Consciousness*. Oxford: Clarendon Press.

Campbell, J. (2004). Reference as attention. *Philosophical Studies, 120*, 265-276.

Carlson, R. A., & Sohn, M.-H. (2000). Cognitive control of multistep routines: Information processing and conscious intentions. In S. Monsell & J. Driver (Eds.), *Control of Cognitive Processes* (pp. 443-464). Cambridge, MA: MIT Press.

Cavanagh, P. (2004). Attention routines and the architecture of selection. In M. I. Posner (Ed.), *Cognitive Neuroscience of Attention* (pp. 13-28). New York: Guilford Press.

Cherry, E. C. (1953). Some experiments on the recognition of speech with one and two ears. *Journal of the Acoustical Society of America, 25*, 975-979.

Clark, A. (2000). *A Theory of Sentience*. Oxford: Clarendon Press.

Clark, A. (2004a). Feature-placing and proto-objects. *Philosophical Psychology, 17*(4), 443-469.

Clark, A. (2004b). Sensing, objects, and awareness: Reply to commentators. *Philosophical Psychology, 17*(4), 553-579.

Cowan, N. (1995). *Attention and Memory: An Integrated Framework*. Oxford: Oxford University Press.

Craik, K. J. W. (1947). Theory of the human operator in control systems, 1. The operator as an engineering system. *British Journal of Psychology, 38*, 56-61.

Cussins, A. (2003a). Content, conceptual content, and nonconceptual content (1990). In Y. H. Gunther (Ed.), *Essays on Nonconceptual Content* (pp. 133-163). Cambridge: MA: MIT Press.

Cussins, A. (2003b). Postscript: Experience, thought, and activity (2002). In Y. H. Gunther (Ed.), *Essays on Nonconceptual Content* (pp. 147-159). Cambridge: MA: MIT Press.

Dehaene, S., Changeux, J.-P., Naccache, L., Sackur, J., & Sergent, C. (2006). Conscious, preconscious, and subliminal processing: a testable taxonomy. *Trends in Cognitive Sciences, 10*(5), 204-211.

Dehaene, S., & Naccache, L. (2001). Towards a cognitive neuroscience of consciousness: basic evidence and a workspace framework. *Cognition, 79*, 1-37.

Desimone, R., & Duncan, J. (1995). Neural mechanisms of selective visual attention. *Annual Review of Neuroscience, 18*, 193-222.

Devitt, M. (1974). Singular terms. *The Journal of Philosophy, 71*(7), 183-205.

Donnellan, K. S. (1966). Reference and definite descriptions. *The Philosophical Review, 75*(3), 281-304.

Dretske, F. I. (1967). Can events move? *Mind, 76*, 479-492.

Dretske, F. I. (1969). *Seeing and Knowing*. Chicago: The University of Chicago Press.

Dretske, F. I. (1981). *Knowledge and the Flow of Information*. Cambridge, MA: MIT Press.

Dretske, F. I. (1988). *Explaining Behavior, Reasons in a World of Causes*. Cambridge, MA: MIT Press.

Dretske, F. I. (1994). The explanatory role of information. *Philosophical Transactions: Physical Sciences and Engineering, 349*(1689), 59-69.

Dretske, F. I. (1995a). Meaningful perception. In S. M. Kosslyn & D. N. Osherson (Eds.), *An Invitation to Cognitive Science: Visual Cognition, Second Edition* (pp. 331-352). Cambridge, MA: MIT Press.

Dretske, F. I. (1995b). *Naturalizing the Mind*. Cambridge, MA: MIT Press.

Dretske, F. I. (2000). *Perception, Knowledge, and Belief*. Cambridge, MA: Cambridge University Press.

Driver, J., & Baylis, G. C. (1989). Movement and visual attention: The spotlight metaphor breaks down. *Journal of Experimental Psychology : Human Perception and Performance, 15*(3), 448-456.

Driver, J., & Spence, C. (1998). Attention and the crossmodal construction of space. *Trends in Cognitive Sciences, 2*(7), 254-262.

Driver, J., & Spence, C. (2004). Crossmodal spatial attention: Evidence from human performance. In C. Spence & J. Driver (Eds.), *Crossmodal Space and Crossmodal Attention* (pp. 180-220). Oxford: Oxford University Press.

Duncan, J. (1984). Selective attention and the organization of visual information. *Journal of Experimental Psychology : General, 119*, 501-517.

Duncan, J. (1996). Cooperating brain systems in selective perception and action. In T. Inui & J. L. McClelland (Eds.), *Attention and Performance XVI* (pp. 549-578). Cambridge, MA: MIT Press.

Duncan, J. (2001). An adaptative coding model of neural function in prefrontal cortex. *Nature Reviews Neuroscience, 2*, 820-829.

Ellis, B. (2000). Causal laws and singular causation. *Philosophy and Phenomenological Research, 61*(2), 329-351.

Eriksen, B. A., & Eriksen, C. W. (1974). Effect of noise letters upon the visual identification of a target letter in a nonsearch task. *Perception & Psychophysics, 16*, 143-149.

Eriksen, C. W., & St. James, J. D. (1986). Visual attention within and around the field of focal attention: a zoom lens model. *Perception & Psychophysics, 40*, 225-240.

Evans, G. (1982). *The Varieties of Reference*. Oxford: Oxford University Press.

Fan, J., Fossella, J., Sommer, T., Wu, Y., & Posner, M. I. (2003). Mapping the genetic variation of executive attention onto brain activity. *Proceedings of the National Academy of Sciences, USA, 100*(12), 7406-7411.

Findlay, J. M., & Gilchrist, I. D. (2003). *Active Vision: The Psychology of Looking and Seeing*. Oxford: Oxford University Press.

Folk, C. L., & Gibson, B. S. (Eds.). (2001). *Attraction, Distraction and Action: Multiples Perspectives on Attentional Capture*. Amsterdam: Elsevier.

Frege, G. (1892). Über Sinn und Bedeutung. *Zeitschrift für Philosophie und philosophische Kritik, 100*, 25-50.

Gibson, J. J. (1966). *The Senses Considered as Perceptual Systems*. London: George Allen and Unwin.

Gibson, J. J. (1979). *The Ecological Approach to Visual Perception*. Hillsdale, NJ: Lawrence Erlbaum Associates.

Godfrey-Smith, P. (1999). Genes and codes: Lessons from the philosophy of mind? In V. G. Hardcastle (Ed.), *Where Biology Meets Psychology: Philosophical Essays* (pp. 305-331). Cambridge, MA: MIT Press.

Godfrey-Smith, P. (2000a). Information, arbitrariness, and selection: comments on Maynard Smith. *Philosophy of Science, 67*(2), 202-207.

Godfrey-Smith, P. (2000b). On the theoretical role of 'genetic coding'. *Philosophy of Science, 67*(2), 24-44.

Gopher, D. (1993). The skill of attention control: Acquisition and execution of attention strategies. In D. E. Meyer & S. Kornblum (Eds.), *Attention and Performance XIV* (pp. 299-322). Cambridge, MA: MIT Press.

Gopher, D., & Koriat, A. (1999). *Attention and Performance XVII*. Cambridge, MA: MIT Press.

Gray, W. D. (2000). The nature and processing of errors in interactive behavior. *Cognitive Science, 24*(2), 205-248.

Grice, H. P. (1957). Meaning. *The Philosophical Review, 66*(3), 377-388.

Grice, H. P. (1989). *Studies in the Way of Words*. Cambridge, London: Harvard University Press.

Griffiths, P. E. (2001). Genetic information: A metaphor in search of a theory. *Philosophy of Science, 68*, 394-412.

Gunther, Y. H. (Ed.). (2003). *Essays on Nonconceptual Content*. Cambridge: MA: MIT Press.

Handy, T. C., Hopfinger, J. B., & Mangun, G. R. (2001). Functional neuroimaging of attention. In R. Cabeza & A. Kingstone (Eds.), *Handbook of Functional Neuroimaging of Cognition* (pp. 75-108). Cambridge, MA: MIT Press.

Hatfield, G. (1991). Sensation and perception: Epistemological and psychological, *The Natural and the Normative: Theories of Spatial Perception from Kant to Helmholtz* (pp. 281-284). Cambridge, MA: MIT Press.

Hatfield, G. (1998). Attention in early scientific psychology. In R. D. Wright (Ed.), *Visual attention* (pp. 3-25). Oxford: Oxford University Press.

Hayhoe, M. M. (2000). Vision using routines: A functional account of vision. *Visual Cognition*, *7*(1/2/3), 43-64.

Helmholtz, H. v. (1856-1867). *Handbuch der physiologischen Optik*. Hamburg: L. Voss.

Helmholtz, H. v. (1924-1925a). *Treatise on Physiological Optics. V.2. Sensations of Vision (Translated from the 3rd German ed.)* (Southall, James P.C. ed.). Rochester, NY: The Optical Society of America.

Helmholtz, H. v. (1924-1925b). *Treatise on Physiological Optics. V.3. The Perceptions of Vision (Translated from the 3rd German ed.)* (Southall, James P.C. ed.). Rochester, NY: The Optical Society of America.

Hommel, B., Müsseler, J., Aschersleben, G., & Prinz, W. (2001). The Theory of Event Coding (TEC): A framework for perception and action planning. *Behavioral and Brain Sciences, 24*, 849-937.

Humphreys, G. W., Duncan, J., & Treisman, A. (Eds.). (1999). *Attention, Space and Action: Studies in Cognitive Neuroscience*. Oxford: Oxford University Press.

Hurford, J. R. (2003). The neural basis of predicate-argument structure. *Behavioral and Brain Sciences, 26*(3), 261-316.

Husserl, E. (1995). *Leçons sur la théorie de la signification* (J. English, Trans.). Paris: J. Vrin.

Israel, D. J. (1988). Commentary: Bogdan on information. *Mind & Language, 3*(2), 123-140.

Israel, D. J., & Perry, J. (1990). What is information? In P. Hanson (Ed.), *Information, Language and Cognition* (pp. 1-19). Vancouver, BC: University of British Columbia Press.

James, W. (1890). *The Principles of Psychology*. New York: Dover Publications.

Jones, M. R. (2001). Temporal expectancies, capture, and timing in auditory sequences. In C. L. Folk & B. S. Gibson (Eds.), *Attraction, Distraction and Action: Multiples Perspectives on Attentional Capture* (pp. 191-229). Amsterdam: Elsevier.

Just, M. A., & Carpenter, P. A. (1976). Eye fixations and cognitive processes. *Cognitive Psychology, 8*, 441-480.

Kahneman, D. (1973). *Attention and Effort*. Englewood Cliffs, NJ: Prentice-Hall.

Kahneman, D., Treisman, A., & Gibbs, B. J. (1992). The reviewing of object files: Object-specific integration of information. *Cognitive Psychology*, *24*(2), 175-219.

Kaplan, D. (1989a). Afterthoughts. In J. Almog & J. Perry & H. Wettstein (Eds.), *Themes from Kaplan* (pp. 556-614). Oxford: Oxford University Press.

Kaplan, D. (1989b). Demonstratives [1977]. In J. Almog & J. Perry & H. K. Wettstein (Eds.), *Themes from Kaplan* (pp. 481-563). Oxford: Oxford University Press.

Kastner, S., & Ungerleider, L. G. (2000). Mechanisms of visual attention in the human cortex. *Annual Review of Neuroscience, 23*, 315-341.

Kirsh, D., & Maglio, P. (1995). On distinguishing epistemic from pragmatic action. *Cognitive Science, 18*, 513-549.

Klahr, D., & Wallace, J. G. (1970). An information processing analysis of some piagetian experimental tasks. *Cognitive Psychology, 1*(4), 358-387.

Klatzky, R. L., & Lederman, S. J. (1999). The haptic glance: a route to rapid object identification and manipulation. In D. Gopher & A. Koriat (Eds.), *Attention and Performance XVII* (pp. 165-196). Cambridge, MA: MIT Press.

Kosslyn, S. M. (1994). *Image and Brain: The Resolution of the Imagery Debate*. Cambridge, MA: MIT Press.

Kowler, E. (1995). Eye Movements. In S. M. Kosslyn & D. N. Osherson (Eds.), *Visual Cognition* (pp. 215-265). Cambridge, MA: MIT Press.

Kripke, S. (1980). *Naming and Necessity*. Cambridge, MA: Harvard University Press.

Land, M. F., & Furneaux, S. (1997). The knowledge base of the oculomotor system. *Philosophical Transactions: Biological Sciences, 352*(1358).

Land, M. F., & Lee, D. (1994). Where we look when we steer. *Nature, 369*, 742-743.

Land, M. F., Mennie, N., & Rusted, J. (1999). The role of vision and eye movements in the control of activities of daily living. *Perception, 28*, 1311-1328.

Lederman, S., Klatzky, R., Chataway, C., & Summers, C. (1990). Visual mediation and the haptic recognition of two dimensional pictures of common objects. *Perception & Psychophysics, 47*(1), 54-64.

Logan, G. D. (1985). Executive control of thought and action. *Acta Psychologica*, *60*(2-3), 193-210.

Mack, A., & Rock, I. (1998). Inattentional blindness: perception without attention. In R. D. Wright (Ed.), *Visual attention* (pp. 55-76). Oxford: Oxford University Press.

MacKay, D. M. (1951). Mindlike behaviour in artefacts. *The British Journal for the Philosophy of Science, 2*(6), 105-121.

MacKay, D. M. (1953). Mindlike behaviour in artefacts. *The British Journal for the Philosophy of Science*, *3*(12), 352-353.

Maravita, A., Spence, C., & Driver, J. (2003). Multisensory integration and the body schema: Close to hand and within reach. *Current Biology, 13*, R531-R539.

Maynard Smith, J. (2000). The concept of information in biology. *Philosophy of Science, 67*(2), 177-194.

McDowell, J. (1984). De Re Senses. *Philosophical Quarterly, 34*(136), 283-294.

McDowell, J. (1990). Peacocke and Evans on demonstrative content. *Mind*, *99*(394), 255-266.

McDowell, J. (1991). Intentionality *De Re*. In E. Lepore & R. Van Gulick (Eds.), *John Searle and His Critics* (pp. 215-225). Oxford, Cambridge: Blackwell.

McDowell, J. (1996). *Mind and World, Second Edition*. Harvard: Harvard University Press.

McGinn, C. (1981). The mechanism of reference. *Synthese, 49*, 157-186.

Merleau-Ponty, M. (1945). *Phénoménologie de la perception*. Paris: Gallimard.

Miller, G. A. (1956). The magical number seven, plus or minus two: some limits on our capacity for processing information. *Psychological Review, 63*, 81-97.

Miller, G. A. (1981). Trends and debates in cognitive psychology. *Cognition, 10*, 215-225.

Miller, G. A. (2003). The cognitive revolution: A historical perspective. *Trends in Cognitive Sciences, 7*(3), 141-144.

Miller, G. A., Galanter, E., & Pribram, K. H. (1960). *Plans and the Structure of Behavior*. New York: Henry Holt and Company.

Miller, G. A., & Johnson-Laird, P. N. (1976). *Language and Perception*. Cambridge, MA: Harvard University Press.

Millikan, R. G. (1984). *Language, Thought, and Other Biological Categories*. Cambridge, MA: MIT Press.

Minsky, M., & Papert, S. (1969). *Perceptrons*. Cambridge, MA: MIT Press.

Monsell, S., & Driver, J. (Eds.). (2000). *Control of Cognitive Processes*. Cambridge, MA: MIT Press.

Moray, N. (1969). *Attention: Selective Processes in Vision and Hearing*. London: Hutchinson Educational.

Neisser, U. (1967). *Cognitive Psychology*. New York: Appleton-Century-Crofts.

Neisser, U., & Becklen, R. (1975). Selective looking: Attending to visually specified events. *Cognitive Psychology, 7*, 480-494.

New, J., Cosmides, L., & Tooby, J. (2007). Category-specific attention for animals reflects ancestral priorities, not expertise. *Proceedings of the National Academy of Sciences, USA, 104*(42), 16598-16603.

Newell, A. (1990). *Unified Theories of Cognition, The William James Lectures, 1987*. Cambridge, MA: Harvard University Press.

Nozick, R. (1981). *Philosophical Explanations*. Cambridge, MA: Harvard University Press.

O'Craven, K. M., Rosen, B. R., Kwong, K. K., Treisman, A., & Savoy, R. L. (1997). Voluntary attention modulates fMRI activity in human MT-MST. *Neuron, 18*, 591-598.

O'Regan, J. K. (1992). Solving the "real" mysteries of visual perception: The world as an outside memory. *Canadian Journal of Psychology, 46*(3), 461-488.

O'Regan, J. K., & Noë, A. (2001). A sensorimotor account of vision and visual consciousness. *Behavioral and Brain Sciences, 24*(5), 939-1031.

O'Regan, J. K., Rensink, R. A., & Clark, J. J. (1999). Blindness to scene changes caused by "mudsplashes". *Nature, 398*(34).

Palmer, S. E. (1999). *Vision Science, Photon to Phenomenology*. Cambridge, MA: MIT Press.

Parasuraman, R. (Ed.). (1998). *The Attentive Brain*. Cambridge, MA: MIT Press.

Parasuraman, R., & Davies, D. R. (Eds.). (1984). *Varieties of Attention*. Orlando: Academic Press.

Partridge, D. (1981). Information theory and redundancy. *Philosophy of Science, 48*(2), 308-316.

Pashler, H. E. (1998). *The Psychology of Attention*. Cambridge, MA: MIT Press.

Peacocke, C. (1983). *Sense and Content: Experience, Thought, and their Relations*. Oxford: Oxford University Press.

Peacocke, C. (1991). Demonstrative content: a reply to John McDowell. *Mind, 100*, 123-133.

Peacocke, C. (1992). *A Study of Concepts*. Cambridge, MA: MIT Press.

Peacocke, C. (2001). Does perception have a nonconceptual content? *The Journal of Philosophy, 98*(5), 239-264.

Peacocke, C. (2003). Postscript: The relations between conceptual and nonconceptual content (2002). In Y. H. Gunther (Ed.), *Essays on Nonconceptual Content* (pp. 318-322). Cambridge: MA: MIT Press.

Peirce, C. S. (1931-35). *Collected Papers of Charles Sanders Peirce, Vols. I-VI*. Cambridge, MA: Harvard University Press.

Pettit, P., & McDowell, J. (Eds.). (1986). *Subject, Thought, and Context*. Oxford: Clarendon Press.

Posner, M. I. (1978). *Chronometric Exploration of Mind*. Hillsdale, NJ: Lawrence Erlbaum Associates.

Posner, M. I. (1980). Orienting of attention. *Quarterly Journal of Experimental Psychology, 32*, 3-25.

Posner, M. I. (1982). Cumulative develoment of attentional theory. *American Psychologist, 37*, 168-179.

Posner, M. I. (1994). Attention: The mechanisms of consciousness. *Proceedings of the National Academy of Sciences, USA, 91*, 7398-7403.

Posner, M. I., & DiGirolamo, G. J. (1998). Executive attention: conflict, target detection, and cognitive control. In R. Parasuraman (Ed.), *The Attentive Brain* (pp. 401-423). Cambridge, MA: MIT Press.

Posner, M. I., Nissen, M. J., & Ogden, M. C. (1978). Attended and unattended processing modes: the role of set for spatial location. In H. L. Pick & I. J. Saltzman (Eds.), *Modes of perceiving and processing information*. Hillsdale, NJ: Lawrence Erlbaum.

Posner, M. I., & Raichle, M. E. (1994). *Images of Mind*. New York: Scientific American Library.

Posner, M. I., Snyder, C. R. R., & Davidson, B. J. (1980). Attention and the detection of signals. *Journal of Experimental Psychology : General, 109*, 160-174.

Poulton, E. C. (1952). Perceptual anticipation in tracking with two-pointer and one-pointer displays. *British Journal of Psychology, 43*, 222-229.

Prabhakaran, V., Narayanan, K., Zhao, Z., & Gabrieli, J. D. E. (2000). Integration of diverse information in working memory within the frontal lobe. *Nature Neuroscience, 3*(1), 85-90.

Pylyshyn, Z. W. (1989). The role of location indexes in spatial perception: A sketch of the FINST spatial-index model. *Cognition, 32*(1), 65-97.

Pylyshyn, Z. W. (2001). Visual indexes, preconceptual objects, and situated vision. *Cognition, 80*, 127-158.

Pylyshyn, Z. W. (2003). *Seeing and Visualizing: It's Not What You Think*. Cambridge, MA: MIT Press.

Quinton, A. (1973). *The Nature of Things*. London & Boston: Routledge & Kegan Paul.

Quinton, A. (1979). Objects and events. *Mind, 88*(350), 197-214.

Reimer, M. (1992). Three views of demonstrative reference. *Synthese, 93*, 373-402.

Ribot, T. (1908 [1889]). *Psychologie de l'Attention (Dixième édition)*. Paris: Félix Alcan.

Rizzolatti, G., & Arbib, M. A. (1998). Language within our grasp. *Trends in Neurosciences, 21*, 188-194.

Rizzolatti, G., Riggio, L., & Sheliga, B. M. (1994). Space and selective attention. In C. Ulmità & M. Moscovitch (Eds.), *Attention and Performance XV: Conscious and Nonconscious Information Processing* (pp. 395-420). Cambridge, MA: MIT Press.

Rollins, M. (2003). Perceptual strategies and pictorial content. In H. Hecht & R. Schwartz & M. Atherton (Eds.), *Looking into Pictures: An Interdisciplinary Approach to Pictorial Space* (pp. 99-122). Cambridge, MA: MIT Press.

Rueda, M. R., Rothbart, M. K., McCandliss, B. D., Saccomanno, L., & Posner, M. I. (2005). From The Cover: Training, maturation, and genetic influences on the development of executive attention. *Proceedings of the National Academy of Sciences, USA, 102*(41), 14931-14936.

Russell, B. (1910-11). Knowledge by acquaintance and knowledge by description. *Proceedings of the Aristotelian Society, 11*, 108-128.

Russell, B. (1918). Knowledge by acquaintance and knowledge by description, *Mysticism and Logic and Other Essays*. London: Longmans, Green.

Russell, B. (1984 [1913]). *Theory of Knowledge: The 1913 Manuscript*. London: George Allen & Unwin.

Schank, R. C. (1996). Goal-based scenarios: Case-based reasoning meets learning by doing. In D. Leake (Ed.), *Case-Based Reasoning: Experiences, Lessons & Future Directions* (pp. 295-347): AAAI Press / The MIT Press.

Schank, R. C. (1999). *Dynamic Memory Revisited*. Cambridge: Cambridge University Press.

Sellars, R. W. (1944). Causation and perception. *The Philosophical Review, 53*(6), 534-556.

Sellars, R. W. (1959). Sensations as guides to perceiving. *Mind, 68*(269), 2-15.

Shallice, T. (1994). Multiple levels of control processes. In C. Ulmità & M. Moscovitch (Eds.), *Attention and Performance XV: Conscious and Nonconscious Information Processing* (pp. 395-420). Cambridge, MA: MIT Press.

Shannon, C. E. (1948). A mathematical theory of communication. *The Bell System Technical Journal, 27*, 379-423, 623-656.

Shannon, C. E., & Weaver, W. (1949). *The Mathematical Theory of Communication*. Urbana: University of Illinois Press.

Shapiro, K. L. (Ed.). (2001). *The Limits of Attention, Temporal Constraints in Human Information Processing*. Oxford: Oxford University Press.

Shapiro, K. L., & Terry, K. (1998). The attentional blink: The eyes have it (but so does the brain). In R. D. Wright (Ed.), *Visual attention* (pp. 306-329). Oxford: Oxford University Press.

Shiffrin, R. M. (1988). Attention. In R. C. Atkinson & R. J. Hernstein & G. Lindzey & R. D. Luce (Eds.), *Stevens' Handbook of Experimental Psychology. Vol. 2, Learning and cognition. 2nd. ed.* (pp. 739-811). New York: John Wiley.

Shiffrin, R. M. (1997). Attention, automatism, and consciousness. In J. D. Cohen & J. W. Schooler (Eds.), *Scientific Approaches to Consciousness* (pp. 49-64). Hillsdale, NJ: Erlbaum.

Shiffrin, R. M., & Schneider, W. (1977). Controlled and automatic human information processing: II. Perceptual learning, automatic attending and a general theory. *Psychological Review, 84*, 127-190.

Shoemaker, S. (1984). Identity, properties, and causality, *Identity, Cause and Mind* (pp. 234-260). Cambridge, MA: Cambridge University Press.

Siegel, S. (2002). The role of perception in demonstrative reference. *Philosophers' Imprint, 2*(1), 1-21.

Simon, H. A. (1975). The functional equivalence of problem solving skills. *Cognitive Psychology, 7*(2), 268-288.

Simons, D. J., & Rensink, R. A. (2005a). Change blindness, representations, and consciousness: Reply to Noë. *Trends in Cognitive Sciences, 9*(5), 219.

Simons, D. J., & Rensink, R. A. (2005b). Change blindness: past, present, and future. *Trends in Cognitive Sciences, 9*(1), 16-20.

Smith, A. P., & Broadbent, D. E. (1981). Noise and levels of processing. *Acta Psychologica, 47*(2), 129-142.

Somers, D. C., Dale, A. M., Seiffert, A. E., & Tootell, R. B. (1999). Functional MRI reveals spatially specific attentional modulation in human primary visual cortex. *Proc. Natl. Acad. Sci. USA, 96*, 1663-1668.

Spence, C. (2001). Crossmodal attentional capture: A controversy resolved? In C. L. Folk & B. S. Gibson (Eds.), *Attraction, Distraction and Action: Multiples Perspectives on Attentional Capture* (pp. 231-262). Amsterdam: Elsevier.

Stoffregen, T. A., & Bardy, B. G. (2001). On specification and the senses. *Behavioral and Brain Sciences, 24*(2), 195-261.

Strawson, P. F. (1956). Singular terms, ontology and identity. *Mind, 65*(260), 433-454.

Strawson, P. F. (1959). *Individuals: An Essay in Descriptive Metaphysics*. London: Methuen.

Sully, J. (1898). *Outlines of Psychology [1884]*. London: Longmans, Greens & Co.

Sutton, J. (2006). Distributed cognition: domains and dimensions. *Pragmatics & Cognition, 14*(2), 235-247.

Titchener, E. B. (1899). *An Outline of Psychology*. New York: The Macmillan Company.

Titchener, E. B. (1908). *Lectures on the Elementary Psychology of Feeling and Attention*. New York: The Macmillan Company.

Tomasello, M. (1995). Joint attention as social cognition. In C. Moore & P. J. Dunham (Eds.), *Joint Attention: Its Origins and Role in Development* (pp. 103-130). Hillsdale: Lawrence Erlbaum Associates.

Tomasello, M., Carpenter, M., Call, J., Behne, T., & Moll, H. (2005). Understanding and sharing intentions: The origins of cultural cognition. *Behavioral and Brain Sciences, 28*, 675-735.

Tomasello, M., Carpenter, M., & Liszkowski, U. (2007). A new look at infant pointing. *Child Development, 78*(3), 705-722.

Treisman, A. (1969). Strategies and models of selective attention. *Psychological Review, 76*(3), 282-299.

Treisman, A. (1988). Features and objects: The fourteenth Bartlett memorial lectures. *The Quarterly Journal of Experimental Psychology, 40*(2), 201-237.

Treisman, A. (1992). Perceiving and re-perceiving objects. *American Psychologist, 47*, 862-875.

Treisman, A., & Gelade, G. (1980). A feature-integration theory of attention. *Cognitive psychology, 12*, 97-136.

Triesch, J., Ballard, D. H., Hayhoe, M. M., & Sullivan, B. T. (2003). What you see is what you need. *Journal of Vision, 3*(86-94).

Ullman, S. (1984). Visual routines. *Cognition, 18*, 97-159.

Ullman, S. (1996). *High Level Vision*. Cambridge, MA: MIT Press.

Valdes-Sosa, M., Bobes, M. A., Rodriguez, V., & Pinilla, T. (1998). Switching attention without shifting the spotlight: object-based attentional modulation of brain potentials. *Journal of Cognitive Neuroscience, 10*(1), 137-151.

Viviani, P. (1990). Eye movements in visual search: Cognitive, perceptual, and motor control aspects. In E. Kowler (Ed.), *Eye Movements and their Role in Visual and Cognitive Processes*: Elsevier Science.

Wettstein, H. (1984). How to bridge the gap between meaning and reference. *Synthese, 58*, 63-84.

Wicken, J. S. (1987). Entropy and information: suggestions for common language. *Philosophy of Science, 54*(2), 176-193.

Wiggins, D. (1997). Sortal concepts: A reply to Xu. *Mind and Language, 12*(3/4), 413-421.

Wiggins, D. (2001). *Sameness and Substance Renewed*. Cambridge: Cambridge University Press.

Woodfield, A. (Ed.). (1982). *Thought and Object, Essays on Intentionality*. Oxford: Clarendon Press, Oxford University Press.

Wright, R. D. (Ed.). (1998). *Visual Attention*. New York, Oxford: Oxford University Press.

Wundt, W. M. (1897). *Outlines of Psychology* (C. H. Judd, Trans.). Leipzig: Wilhelm Engelmann.

Yarbus, A. L. (1967). *Eye Movements and Vision* (B. Haigh, Trans.). New York: Plenum Press.

[1] See, e.g., Posner & Raichle (1994), Parasuraman (1998), Wright (1998), Braun, Koch, & Davis (2001), Handy, Hopfinger, & Mangun (2001).

[2] The philosophical research on perceptual-demonstrative identification has originated in seminal writings by, namely, Peirce (1931-35), Russell (1918; 1984 [1913]: 39-40), Sellars (1944; 1959) and ulterior writers such as Dretske (1969; 1981; 2000), Evans (1982), Peacocke (1983; 1991; 1992) or Campbell (2002; 2004).

[3] The notion of a fundamental ground of difference of an individual has philosophical roots that go back at least to Spinoza or Leibniz. In recent philosophy of mind and language, it is analyzed, namely, by Evans (1982: 89-120, esp. 107) and Campbell (1993; 2002). We can link the idea that individuals have a fundamental ground of difference with the thought that material individuals possess singular causal powers (or singular causation, see e.g., Ellis, 2000; Shoemaker, 1984). In section 2, I link this singular causation to causal information and suggest, in section 6, that the function of epistemic attention is to extract causal information relative to the singular causation of individuals.

[4] For a discussion of the 'problem of singular cognition (or singular intentionality)' associated with this transfer to philosophy of perception, see Bullot & Rysiew (2007). For discussions of singular terms in philosophy of language, see, among others, Frege (1892), Strawson (1956), Devitt (1974), Kripke (1980) and Evans (1982).

[5] Sellars (1944; 1959), Strawson (1959), Quinton (1973; 1979), Dretske (1967; 1969; 1995b), Evans (1982), Campbell (1993; 2002), Peacocke (2001; 2003).

[6] This form of intentionality is also discussed in the philosophical literature in terms of "*de re* intentionality" by McDowell (1984; 1991) and other philosophers (Pettit & McDowell, 1986; Woodfield, 1982).

[7] A justification of the distinction between "perceptual-motor tracking" and "epistemic tracking" is proposed in Bullot (2006), Bullot & Rysiew (2007) and Bullot & Droulez (2008).

[8] How are we to understand this notion of constitutive relation? The strongest form of constitutive relation would be identity. In such a case, the thesis would mean that some attentional processes in perception are identical to some knowledge-acquisition processes; or, that the performance of some attention system is a necessary and sufficient condition of some perceptual knowledge. A weaker constitutive relation is a relation of

part-whole relationship. In this interpretation, the thesis would mean that some attentional systems are necessary parts of systems for the acquisition of perceptual knowledge. According to the Attentional Constitution Principle, in either in its weak or strong forms, the study of attention is required to explain the genesis of agents' perceptual knowledge and its relations to their actions.

[9] Dehaene & Naccache (2001), Dehaene et al. (2006).

[10] In neuroscience, the neural manifestations of attentional selection are often equated with "biasing signals" that can "modulate neural activity" (Kastner & Ungerleider, 2000); see, for other instances, Posner (1994), Somers, Dale, Seiffert, & Tootell (1999), O'Craven, Rosen, Kwong, Treisman, & Savoy (1997), Handy et al. (2001).

[11] See Helmholtz (1856-1867; 1924-1925a; 1924-1925b), Binet (1894), Ribot (1908 [1889]), James (1890), Titchener (1908), Sully (1898); Hatfield (1998) proposes a historical overview of the main characteristics of early psychological theories of attention.

[12] Miller (1981; 2003).

[13] See, for instance, Cherry (1953), Miller (1956), Broadbent (1958), Moray (1969).

[14] Dretske (1981; 1994), Adams (2003).

[15] The notion of causal information relates to the concept of "natural meaning" discussed by philosophers such as Peirce (1931-35), Grice (1989) and Dretske (1994). It is also analogous to James Gibson's (1966) notion of environmental information.

[16] See, e.g., Ellis (2000). Given of the prevalence of Humean views in metaphysics (Ellis, 2000), the claim that the presence of causal information in the physical world is independent of the human knowledge of causal information can be debated. However, this should not undermine the concept of causal information because a humean account can framed into the picture I am drawing—see, for instance, Israel & Perry (1990).

[17] Stoffregen & Bardy (2001) argue in support of the notion "global array."

[18] If needed, clear evidence in support of this observation is found in the numerous books on attention in cognitive psychology. See, for instance, Broadbent (1958; 1971), Posner (1978), Neisser (1967), Moray (1969), Kahneman (1973), Parasuraman & Davies (1984), Cowan (1995), Parasuraman (1998), Pashler (1998), Wright (1998), Braun, Koch, & Davis (2001).

[19] Broadbent (1958), Treisman (1969), Pashler (1998). Alternative models of attention selection are for instance, models of the competition among objects (Desimone & Duncan, 1995; Duncan, 1984, 1996; Humphreys, Duncan, & Treisman, 1999).

[20] Kahneman (1973), Posner (1978; 1982; 1994), Shiffrin (Shiffrin, 1997; Shiffrin & Schneider, 1977).

[21] Shiffrin (1988), Pashler (1998).

[22] Rizzolatti, Riggio, & Sheliga (1994), Parasuraman (1998: 3), Findlay & Gilchrist (2003: 40).

[23] For instance, James (1890: 416-17) distinguishes between "passive" and "reflex" attention on one hand and "active" and "voluntary" attention on the other. At the end of the nineteenth century, Wundt (1897: 217-18) or Titchener (1899) mention also a related distinction. Cognitive psychology uses the phrases "exogenous attention" and "endogenous attention" respectively—see, e.g., Folk & Gibson (Folk & Gibson, 2001), Driver & Spence (e.g., Driver & Spence, 1998; 2004: 189; Spence, 2001), Jones (2001).

[24] Posner (1980), Palmer (1999: 520), Spence (2001: 232), Findlay & Gilchrist (2003: 3-4, 35-54).

[25] Pioneer works on the cognitive function of eye movements are, namely, Yarbus (1967), Just & Carpenter (1976), and numerous other more recent contributions; see, e.g., Viviani (1990), Kowler (1995), O'Regan (1992), Ballard and Hayhoe (Ballard, Hayhoe, Pook, & Rao, 1997; Triesch, Ballard, Hayhoe, & Sullivan, 2003), or the review by Findlay & Gilchrist (2003).

[26] I am referring to the tradition focusing on the perceptual conditions of demonstrative identification, such as in Dretske (1969: 78-138), Evans (1982), Clark (2000; 2004a; 2004b), Rollins (2003: 106-7). The more general debate about the understanding of demonstratives' reference raises other issues that cannot be discussed in the present article, see Kaplan (1989a; 1989b), McGinn (1981), Wettstein (1984), Reimer (1992), Siegel (2002).

[27] For discussion of the notion of cognitive access in association with singular perception, see, namely, Evans on the "information link" (Evans, 1982), Baars (1988), Block (1995; 2001).

[28] I assume here that the prosthetic "perception" of a target through telecommunication as a form of indirect access.

[29] Two influential conceptualists are Wiggins (1997; 2001) and McDowell (1990; 1996).

[30] For instance, Donnellan (1966: 297) and Kaplan (1989a) defend an intentionalist account of demonstrative reference. Among others, Reimer (1992) and Siegel (2002) have challenged the strong intentionalist views.

[31] Wiggins (1997; 2001).

[32] Cussins (2003a; 2003b), Clark (2000; 2004a; 2004b), Gunther (2003) et Pylyshyn (2003).

[33] Strawson (1959) and Peacocke (1992 : 61-98) have considered the circularity which is inherent to a number of purely descriptivist or conceptualist approaches. Pylyshyn (2003 : 242-56) and Bullot, Casati and Dokic (2005) study how problems of circularity can affect the analysis of identification and attentional selection.

[34] In addition to James (1890: pp. 434-38), this reference to the motor and overt consequences of attentional selection is found in a number of other authors. Sully (1898: p. 82) describes attention as an active mode of consciousness that affect certain motor process. Ribot writes that the mechanism of attention "is primarily motor, i.e. [*attention*] always acts on muscles, mainly in the form of a stop" (Ribot, 1908 [1889]: p. 3). Similar assumptions are held in contemporary theories of vision such as the motor (or pre-motor) theories of visual attention, which describe spatial covert attention as a preparation of saccadic eye movements (e.g. Rizzolatti et al., 1994). A comprehensive classification of the possible acts of overt attention for each perceptual system can be found in Gibson (1966: 47-58).

[35] It is important to realize the complementary character of overt and covert attention: see, e.g., Posner (1980) and Findlay & Gilchrist (2003). It is a crucial assumption of the procedural theory presented in section 6.

[36] Viviani (1990), Ballard et al. (1997), Findlay & Gilchrist (2003).

[37] I will sometimes abbreviate "perceptual epistemic attention" by "epistemic attention."

[38] In the analysis below, an example of use of epistemic attention is the primary epistemic seeing in Dretske's sense (1969: 72-93) which refers to knowledge that "(this) *i* is *F*" based on direct perception by the perceiver of the fact that *i* satisfies a perceptual predicate *F* (and the perceiver is justified to think that *i* is *F* because he or she perceives the fact that *i* is *F*.) The perceptual re-identification of an object is another example (Strawson, 1959: 31-36; Treisman, 1992).

[39] Eriksen & Eriksen (1974), Broadbent (1982), Eriksen & St. James (1986), Brefczynski & DeYoe (1999); see also Driver & Baylis (1989) and Valdes-Sosa et al. (1998).

[40] Treiman (1988; 1980), Kosslyn (1994).

[41] According to the criteria mentioned in the text, one may consider as possible antecedent versions of the procedural theory the contributions of, namely, Miller, Galanter, & Pribram (1960) on plan; Miller and Johnson-Laird (1976) on the relations between perception and language and the evaluation of the perceptual predicates; Dretske (1969: 78-139) on epistemic primary seeing; Evans (1982) on demonstrative identification; Posner on executive attention (Posner, 1978, 1994; Posner & DiGirolamo, 1998); Ullman (1984) on visual routines; Ballard, Hayhoe and collaborators (Ballard et al., 1997) on the deictic strategies; Campbell (2002: 80, and chapters 2, 3, 4 et 5) on attention in reference; Pylyshyn (2003) on focal attention and visual reasoning. One may also include some theories of cognitive control (Allport, 1993; Allport, Styles, & Hsieh, 1994; Gopher, 1993; Logan, 1985; Shallice, 1994) and some theories of joint attention (Tomasello, Carpenter, Call, Behne, & Moll, 2005; Tomasello et al., 2007). Although they differ in many important aspects, the aforementioned works tend to analyze the contribution of perceptual attention to singular knowledge and singular actions, and to describe strategies or methods necessary for the acquisition of knowledge on individuals. In addition, such works may account the fact that acts of identification by perceptual attention can be of a greater or lesser sophistication (Campbell, 2002; Clark, 2000: 135; Millikan, 1984: 239-56), and can be revised and built from increments added to the singular knowledge already available to the tracker (Dretske, 1969: 78-139; Pylyshyn, 2001: 135-9).

[42] The notion of strategy and of perceptual strategies is used in the executive/procedural theories of attention and action planning; see, for instance, Miller et al. (1960), Simon (1975), Logan (1985), Gopher (1993) or Ballard et al. (1997).

[43] See, namely, Kahneman, Treisman, & Gibbs (1992), Hommel, Müsseler, Aschersleben, & Prinz (2001) and Bullot & Rysiew (2007) for reviews of the literature on mental singular (object, agent, event) files.

[44] The theses are ordered as a new formulation of the propositions A1 and A2, about the essential nature of attention (A1 and PT1) and its relation to control (A2 and PT2, PT2a-c).

[45] The notion of perceptual predicate is used, namely, by Minsky & Papert (1969), Miller & Johnson-Laird (1976), Ullman (1984; 1996), Pylyshyn (1989; 2003), Peacocke (1983; 1992), Clark (2000; 2004a) or Hurford (2003). There are, of course, different ways to view the neural or behavioral implementation of perceptual predicates and I remain neutral about this question. The point of the discussion is that something like perceptual predicates is needed to account for the epistemic dimension of perception, and it is likely that these predicates are assessed by attentional procedures.

[46] Cf. Rizzolatti & Arbib (1998: 192).

[47] Some directing ideas of control theory applied to cognitive science originate from electrical engineering (e.g., Craik, 1947; MacKay, 1951, 1953; Poulton, 1952). They have been developed in the theory of eye movements [see, e.g., Kowler (1995)] and other domains (see the next notes).

[48] The concept of routines has been used in cognitive psychology to analyze the architecture of practical skills (Gopher & Koriat, 1999; Gray, 2000; Kirsh & Maglio, 1995; Klahr & Wallace, 1970; Monsell & Driver, 2000; Schank, 1996). It refers to primitives used in sensory-motor and interactive abilities and perceptual abilities such as visual recognition and analysis (Ballard et al., 1997; Hayhoe, 2000; Kosslyn, 1994; Ullman, 1984) or haptic/tactile recognition (Klatzky & Lederman, 1999; Lederman, Klatzky, Chataway, & Summers, 1990). It has also been used in the analysis of understanding, reasoning and memory (Bower, Black, & Turner, 1979; Carlson & Sohn, 2000; Schank, 1996).

[49] Ballard et al. (1997).

[50] Ballard, Hayhoe et al. (Ballard et al., 1997: 735-7) ; Kosslyn (1994).

[51] O’Regan & Noë (2001).

[52] Schank (1996; 1999).

[53] Klatzky & Lederman (1999: 171-2, 174-7).

[54] As discussed in Findlay & Gilchrist (2003: chap. 2), visual control of non-cognitive aspects of action does not necessarily need eye pointing.

[55] On occasions, the second look was omitted, indicating that such use of memory was an option. However these sequences were much less common than the sequences in which a return was made to the model.