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Psychological Agency

Guidance of Visual Attention

A dissertation submitted in partial satisfaction of the

requirements for the degree of Doctor of Philosophy

in Philosophy

by

Denis Buehler

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ABSTRACT OF THE DISSERTATION

Psychological Agency

Guidance of Visual Attention

by

Denis Buehler

Doctor of Philosophy in Philosophy

Unversity of California, Los Angeles, 2014

Professor Tyler Burge, Chair

My dissertation contributes to the study of agency by furthering our understanding of individuals' guidance of their acts. When individuals guide a shift of visual attention, their central executive system assigns priority to locations on the priority map. The central executive system is a psychological system for intermodal, often amodal, non-modular processing. The priority map is a representational state with geometrically structured content, representing the field of vision. This representational state helps direct attention shifts to their destination. I argue that, when an individual

(with a psychology relevantly similar to that of actual primates) guides her shifts of visual attention, then her central executive system's control over those shifts actually constitutes her guidance.

The dissertation of Denis Buehler is approved.

Pamela Hieronymi

Michael Rescorla

Tyler Burge, Committee Chair

University of California, Los Angeles

2014

Meinen Eltern

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- "Incomplete Understanding of Complex Numbers. Girolamo Cardano – A Case Study in the Acquisition of Mathematical Concepts." *Concept Acquisition and the Role of Language, Workshop with Susan Carey*, Durham University 27/28th May 2013

- "How is Epistemic Reasoning Possible?" *Konstanzer Kant Kurs with Quassim Cassam,* 2007

- "Understanding Understanding Reasoning." *Goettinger Philosophisches Kolloquium IX*, 2005

Chapter 1

Active Shifts of Visual Attention

In the first section of this chapter I introduce the dissertation's topic: individuals' guidance of their agency. In the second section I explain why I focus on individuals' guidance of visual attention shifts. I point out why such shifts lend themselves especially well to a case study of guidance. This type of agency bears on other important philosophical issues. Section three presents some methodological considerations. I close, in section four, by giving an outline of the dissertation's argument and a short summary of each chapter.

1.1

The Guidance of Agency

In central exercises of agency, individuals guide their acts. The ant guides the movements of its legs when he scurries across the desert toward a source of food. A bird guides the flapping of its wings and the orientation of its torso when changing the direction of his flight. The cat guides a jab with its paw when it tries to snatch a mouse off the wall. A macaque guides its thinking when it tries to picture a way of getting a treat out of a box. Humans sometimes guide their facial expression and the production of sounds from their mouths when they are having a conversation.

The ant does not guide the movements of its legs when a scientist stimulates it to move by applying an electrical charge. The bird does not normally guide the contraction of its lungs when breathing. Nor does the cat guide the blinking of its eyes. The macaque does not guide its thought of food when a pang of hunger seizes it. Humans do not guide their screech when a mouse on the wall startles them. None of these episodes are the animals' acts.

Much recent action theory focuses on sophisticated forms of agency. Action theorists ask about the nature of intentional action. They wonder about agency flowing from reasoning, deliberation, and reflection. Of course, nothing is wrong with such a focus, in and of itself. These forms of agency are central to human and morally responsible action. But this focus tends to distract theorists of high-level human action from other forms of agency. The focus disservices a general interest in the kind *agency* by being too narrow. It distorts our understanding of human agency by suggesting that human agency is mostly intellectual.

Harry Frankfurt cautioned against these pitfalls when he identified an explanation of individuals' guidance of their acts as *the* problem of action. Animals other than humans guide their actions. Individuals can guide their actions on the basis of intentions, reasoning, deliberation, and reflection. But they need not guide their actions on the basis of such states and episodes. Guidance unifies agency across species and activities. By identifying guidance as action theory's fundamental problem, Frankfurt appeals to one of our deepest intuitions about agency. An action, most fundamentally, has its source inside the agent, it comes from within her, and she is presently involved in it. Philosophers throughout history have expressed this intuition. Aristotle, for example, writes that "the soul is the cause of animate bodies as being in itself the origin of motion."[1] Kant claims that the "active subject [would begin] its effects in the sensible world from itself."[2]

The intuition closely tracks our experience of our own agency. Intuitively, it is not clear that we always act as a result of an intention. We certainly do not always reason, deliberate, or reflect on how to act. We often act spontaneously, driven by impulse. We act absentmindedly. Even in those cases, however, we can make sense of the claim that we guide our acts. Sometimes, individuals will exercise less control over their actions because they act absentmindedly or without thinking about what to do. I may control my acts to a higher degree if I deliberate about what to do or reflect on the considerations that I want to give special weight to. I normally control my movements to a higher degree if I pay attention to what I am doing. No matter the degree of control an individual exercises over her act, she guides her act in all these cases.

1 DA II.4, 415b10/2; DA I.3, 406a2; NE 1111a24; MA 9, 703a1/3.

2 B567/9; see also Kant's *Lectures on Metaphysics*, Kant, I. 1997, 29:822 & 29:903.

In order to understand agency, then, we should try to understand individuals' guidance of their acts. But do individuals guide all their acts? I am not sure. I want to allow for the possibility of reflex actions. A person strapped to a wheel may move his head to avoid the knife that a knife-thrower flung at her. He may flinch even knowing that he thereby increases the chances of getting hit. His head-movement does not merely happen to him. It seems to be his action. But does he guide this action? Maybe not. His perceptual and motor systems, on the basis of overlearned or instinctive motor routines, seem to take over. The systems may, in some sense, guide the movement. But the individual does not seem to guide it.[3] I acknowledge that there may be actions that are not guided by an individual. Nevertheless, I agree with Frankfurt in thinking that individuals' guidance is central to understanding agency in general. In what follows, I focus on instances of guided agency.

1.2

Visual Attention

At the heart of what follows lies a case study on active shifts of visual attention. Individuals sometimes guide their visual attention shifts. The jumping spider fixates visual attention on her prey in the foliage of a tree. She then plots her own route across the jungle floor and up into the trees by guiding attention along possible paths. A

[3] The example is Sean Foran's. See Burge, T. 2010, 334/5 & Fn. 61 & 62.

monkey searching for a berry shifts visual attention from one branch of the bush to another. From there he guides visual attention to the next bush until he finds his food. You study Ilya Repin's painting 'They Did Not Expect Him.' Wondering whether the depicted family is wealthy, you guide visual attention from one family member to the next. You fixate their living room's furniture and direct attention along the walls, estimating the value of the pictures and the piano.[4]

At other times, individuals' attention shifts, but the individuals do not guide these shifts. They are passive shifts. The monkey may notice a light or the shape of a venomous snake from the corner of his eyes. Reflexively, his attention shifts to the new stimulus. The light and the snake capture his attention. Or suppose that you concentrate on a recording of *Contrapunctus X* from the *Art of Fugue*, trying to discern the main subject in its different permutations. You do not close your eyes while listening. As a matter of fact, your eyes move. Your visual attention shifts with your eyes. Empirical research on eye movements reveals a default pattern in your attention shifts. You do not guide these shifts. They are passive occurrences.

We distinguish attention shifts that individuals guide from those that occur passively, just as we normally recognize when individuals guide their bodily actions. In what follows, I try to illuminate the nature of guidance in general through a case study of the guidance of visual attention shifts. Why focus on visual attention? One main reason is methodological. I will elaborate on it in the next sub-section. The other main

[4] Cf. Yarbus, A. 1963.

reason is that active shifts of visual attention connect with a range of important philosophical issues, beyond the nature of individuals' guidance of action. These connections have so far mostly been overlooked. I want to sketch three of these connections in what follows: connections with psychological agency more generally, agential control over bodily action, and epistemic agency.[5]

First, guided shifts of visual attention constitute a form of psychological agency. They are acts that we perform with our minds alone. It is not part of these acts' natures that they involve bodily events. To Aristotle, Descartes, and Kant, a capacity to engage in psychological agency was essential to being a rational (or human) being. Contemporary action theory has only recently engaged with the topic.[6] Psychological agency has posed a problem for traditional action theories. Maybe the most influential action theory, stemming from work by G.E.M. Anscombe, Donald Davidson, and John Searle, has it, roughly, that an event is an action just in case the event has been caused by an intention to perform that action. This type of theory faces difficulties in accounting for a salient kind of psychological act.

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5 I believe, as will come out in the body of the dissertation, that by investigating active shifts of visual attention we can also learn something about the nature and constitution of psychological individuals. Attention shifts connect with investigations of the nature of attention, its relation to visual perception, the cut between perception and cognition, and the nature of consciousness.

6 See, for example, the essays in O'Brien, L. & Soteriou, M. (eds.) 2009.

Suppose that an individual actively judges that the sun is out. On the theory just sketched, an intention to judge that the sun is out[7] should cause that judgment. Suppose that the individual deliberates about whether the sun is out. She reasons: the sun looks to be out; there is no reason to think someone is trying to trick me; surely, the sun is out. Her judgment is governed by epistemic norms. The individual would be epistemically irrational if she judged that the sun is out because so judging makes her feel better. When she is fully convinced, by her reasons, that the sun is out, she *therein* judges that the sun is out. Being fully convinced that one's considerations show that *p* and not judging that *p* is pathological. It may not be possible at all. Individuals' reasons for intending to perform some action just are their reasons for so acting. So if the individual is fully epistemically rational, her reasons for intending to judge that the sun is out just are the reasons that she takes to show that the sun is out. So in forming the intention to judge that the sun is out the individual either is less than fully rational. Or she already so judges, thereby making the intention redundant. So the influential view about action either makes it impossible for individuals to actively judge a content and be fully rational in doing so. Or the view postulates explanatorily redundant states and events.[8]

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[7] Here and throughout I mark expressions of psychological states' representational contents by underlining them.

[8] The argument is modeled after Hieronymi, P. 2006. For a contrary position, see Setiya, K. 2008. Cf. also the essays in O'Brien, L. & Soteriou, M. (eds.) 2009. Similar considerations have led epistemologists to doubt that a deontological conception of epistemic warrant is possible. Cf. Feldman, R. 2000.

I suggest that my account of the guidance of visual attention shifts may be transferred to active occurrences such as judgments and inferences. So, in offering an account of the agency that individual exercise when they guide shifts of visual attention, we may contribute to overcoming the difficulties of traditional action theory in explaining psychological agency more generally.

Second, guided shifts of visual attention constitute a form of agential control that individuals exercise over their bodily actions. Suppose that an individual carries out her intention to walk home. The individual will normally exercise greater control over her bodily action when she pays attention to what she is doing. She may scan her surroundings for obstacles or other participants in traffic that she might collide with. When she traverses a stretch on the sidewalk where the pavement is cracked, guiding her visual attention in the right way can prevent her from stumbling or slipping. This form of agential control over bodily action is present in many animals – monkeys, cats, and pigeons – other than humans.

Recent discussions of agential control by Harry Frankfurt, David Velleman, and Michael Bratman have entirely focused on intellectual forms of control.[9] According to these theories, very roughly, an individual controls her action just in case she reflects on her motives, desires, or intentions to act. Monkeys, cats, and pigeons do not reflect on their motives. The individual from the earlier example does not control her walking

9 Frankfurt, H. 1988; Velleman, D. J. 2000; Bratman, M. 2007; but see also Fischer, J. & Ravizza, M. 1998 and Watson, G. 2004.

through reflection on her motives. These animals exercise agential control by deploying visual attention in the right way.

Exercising agential control by relevantly paying attention is plausibly an important aspect of acting non-negligently. We cannot act fully well, from a moral perspective, without guiding visual attention so as to control our actions. Guided shifts of visual attention constitute a central form of agential control that recent action theory has overlooked.[10]

Third, consideration of visual attention as a factor in perceptual belief formation will plausibly be relevant to understanding epistemic norms governing such belief. Where an individual attends will partly determine what parts of a visual scene her visual system processes. Visual attention also seems to enable certain exploratory procedures for acquiring knowledge. If I am unsure about an object's shape I can re-check, maybe from different angles, by moving my attention in relevant ways.

Since individuals can actively guide their visual attention shifts, there may be epistemic norms that require individuals to guide attention in certain ways. Suppose that an individual glances at an unusually crowded, dimly lit scene in order to determine how many red items the scene contains. The insufficient perspicuity of red items together with the lighting conditions may undermine perception's reliability in determining the number of red items at a glance. There may be an epistemic norm that requires the individual to shift attention across the scene, and search for red items, in

10 Cf. my "Core Agential Control."

order to determine their number.

A study of guided visual attention shifts will contribute to a better understanding of all three topics.

1.3

Methodology

Another reason for choosing visual attention shifts for a case study of individuals' guidance is methodological. In the dissertation I develop an account of individuals' guidance of visual attention from a discussion of its empirical psychological study. There are very few, if any, other forms of agency, about which the empirical sciences provide a similar wealth of knowledge. This wealth has a quantitative dimension. Visual attention and its shifts have been studied for a fairly long time now. Empirical science provides a large amount of detail about visual attention and about how it shifts. The wealth has a qualitative dimension. While much of empirical psychology is still in its early stages, the study of visual attention shifts seems to have matured and begins to produce more firmly established results. For both reasons, guided visual attention shifts lend themselves especially well for a case study based on empirical psychology.

Why is this methodology advisable? As I will elaborate later, empirical science provides vast amounts of detail about visual attention shifts and their interconnections with other psychological processes. A priori reflection does not, and possibly cannot, provide this knowledge. By studying the nature of individuals' guidance on the basis of such empirical knowledge, we make this detail bear on our understanding of the nature of guidance. Furthermore, by illuminating the nature of guidance through empirical studies of guided processes, we set limiting conditions on a priori accounts of agency. Indeed, we will see that plausibly, much a priori theorizing in action theory is in conflict with our empirical knowledge about guided shifts of visual attention. Reflection on agency should be informed by what is empirically known about agency.[11]

Philosophical inquiry should not ignore empirical results pertaining to philosophical issues. It should draw on and reflect upon pertinent empirical sciences. This approach strikes me as obviously correct. Anti-Individualism about mental content supports the approach. Anti-Individualism is the position according to which the natures of many of our mental states, including the contents they have, depend on our relations to a wider environment.[12] A priori reflection on the meaning of water probably would not have led to a discovery of its nature, if it consists in being H_2O. Similarly, the content of my thoughts involving agency and guidance may depend on my relation to natures in the actual world. The content of my thoughts may depend on my relation to the actual natures of agency and guidance. Anti-Individualism has shown that in many cases, a priori reflection is a poor guide to fully understanding the content of our own

11 Cf. the introduction to Burge, T. 2007 and Burge, T. 2010, chapters 2, 3, and 11.

12 Cf. Burge, T. 2010, 61ff.

thoughts. Natures in the world are often not accessible to a priori reflection, but require empirical study.

Wherein are visual attention shifts especially well understood? I pointed out earlier that our empirical knowledge about visual attention shifts exceeds that in other parts of psychology. We know more detail about the relevant psychological processes than about those in other areas of psychology. The knowledge is more firmly established. This situation is due partly to the close relation of visual attention shifts to vision science. Vision science is the most mature branch of empirical psychology. Vision science has reached a degree of mathematization and agreement between researchers that is otherwise unparalleled in psychology. Visual attention and its shifts are closely related to the study of vision in general. They have hence attracted the interest and the methodological sophistication of vision scientists. On the other hand, visual attention and its shifts lie at the intersection of many different psychological sub-disciplines. A case study on guided shifts of visual attention can draw on resources not only from vision science, but from studies of eye-movements, working memory, long-term memory, problem-solving and thinking, motor science, neuroscience, and, of course, the study of attention in different modalities.

Two peculiarities of empirical results are pertinent to the study of attention shifts. First, many models of visual attention shifts derive from studies of individuals' eye movements. The relevant eye movements – saccades, or shifts of the center of the fovea – are overt shifts of attention. We know, however, that attention can shift covertly. Thus individuals can fixate their fovea on a cross at the center of a display, while covertly attending to a stimulus at the display's left margin. So, eye movements and attention shifts can come apart. Psychologists debate the exact nature of their relation. They debate, for example, whether the same neural mechanisms undergird both covert and overt shifts of attention. They debate whether shifts of covert attention always precede eye movements and function, in part, to guide the latter. Psychologists agree, however, that studies of overt attention yield computational models for covert attention shifts. My use of data about eye movements relies only on this consensus.[13]

Second, the proposal that I will argue for involves the functioning of a system for controlling cognitive processes – the central executive system. Psychologists that investigate memory systems carry out many studies of this system. It may seem surprising that psychologists of memory should carry out the investigation of a system for the control of cognitive processes. This situation has a historical explanation. In the early days of cognitive science, psychologists interested in cognitive processing studied the memory systems required for such processing because they could more easily devise empirical paradigms for their study. Theorizing about the central executive system grew from these studies. Researchers on the central executive system and working memory were very clear, from the outset, that the executive component of working memory is

[13] Cf. Findlay, J. & Gilchrist, I. 2003, Chapter 3; Wright, R. & Ward, L. 2008, Chapter 6; Carrasco, M. 2011.

not, itself, a memory storage. Much of its investigation is still carried out in departments that focus on the study of working memory.[14]

1.4

Dissertation Summary

I conclude by providing an overview of the dissertation's argument and a brief summary of each chapter. The dissertation offers an extended argument for the claim that

> When an individual (with a psychology relevantly similar to that of actual primates) guides her shifts of visual attention, then her central executive system's control over those shifts actually constitutes her guidance.

To arrive at this conclusion, I first, in Chapter 2, introduce the central executive system as a psychological system for intermodal, often amodal, non-modular processing that figures in genuine psychological explanations.

Next, in Chapter 3, I scrutinize the psychology of different ways in which visual attention can be shifted. I show that individuals' guidance of their attention shifts correlates with their central executive system's control over these shifts.

[14] Cf. Baddeley, A. D. 2007; Baddeley, A. D. 2012; Cowan, N. 1995; Cowan, N. 2005.

In Chapter 4, I argue that both non-conceptual, map-like goal-representing states and conceptual goal-representing states or intentions can help guide active attention shifts.[15] What unifies individuals' guidance of such shifts is that they are controlled by the central executive system – whether on the basis of conceptual or non-conceptual states.

Finally, in Chapter 5, I explain why central executive control plausibly constitutes the guidance of individuals with psychologies relevantly like those of actual primates. Central executive control implements the guidance of attention shifts that primates in the actual world exercise. More importantly, central executive control helps us understand the nature of individuals' guidance, at least for those animals. I call conditions that have these two features *actually constitutive* conditions.

I conclude that my proposal not merely furthers our understanding of individuals' guidance. Central executive control actually constitutes guidance, whether the animal relies on reflective, conceptual, or non-conceptual competencies. Central executive control hence constitutes guidance across different species. The proposal refutes claims of recent action theories to the effect that causation by a belief-desire pair, an intention, or reflection is necessary and constitutive of individuals' agency.

I now turn to a more detailed summary of each chapter.

In Chapter 2 I present and explain the central executive system. It is an intermodal, non-modular psychological system that functions to control cognitive

[15] Goal-representing states are states that represent individuals' goals.

processes through the exercise of specific executive functions. One important function of the system is to enable goal-represented activities, or activities guided by individuals' goal-representing states. The central executive system controls cognitive processes by allocating central resources to them. It allocates resources by performing *executive functions*. Executive functions are specific competencies for the control of cognitive processes. The set of executive functions constitutes the primary, functional characteristic of the central executive system. I introduce three basic, well-understood, executive functions: Switching of mental set, Maintenance of relevant memories, and Inhibition of prepotent responses and interfering stimuli. *Switching* of mental set consists in the process of abandoning one cognitive process, and initiating another. *Maintenance* of relevant representations in memory consists in the activation and holding active of relevant long-term memories. Maintenance includes the encoding of incoming task-relevant information into working memory. *Inhibition* consists in the exercise of a competency to suppress dominant, automatic, or prepotent responses and distracting or interfering stimuli and information.

Philosophers and psychologists have expressed doubts about the validity of the central executive system as an explanatory construct. Prominent critics are Daniel Dennett and Alan Allport. They launch two main lines of objection against appeals to the central executive system. One consists in the claim that there is no central executive system. The other consists in the claim that appeals to the central executive system do not yield genuine explanation.

Proponents of the first line of objection typically assume, *first*, that empirical results have shown that the central executive system cannot be identified with any narrowly circumscribed, precisely identifiable region or mechanism in the brain. *Second*, they assume that a coherent, principled account of the central executive system requires identifying it with a narrowly circumscribed, precisely identifiable region or mechanism in the brain. They conclude that the central executive system does not exist.

I discuss and explain pertinent research in neuropsychology suggesting that while, indeed, activity of the central executive system is implemented by activation of many different areas in the brain, the prefrontal cortex nevertheless is the primary neuroanatomical realizer of the central executive system.

But more importantly, the objectors rely on the claim that a coherent, principled account of a central executive system requires identifying it with a narrowly circumscribed, precisely identifiable region or mechanism in the brain. This claim is mistaken. Psychological theorizing yields genuine explanations in absence of its reduction to brain mechanisms. Vision science, an immensely successful explanatory enterprise, largely explains without such reduction. We can thus legitimately expect that psychological competencies and systems can be individuated on the basis of on the basis of behavioral and computational investigations alone.

The second line of objection consists in the claim that no genuine psychological explanations derive from appeals to the central executive system. Some objectors claim that a behaviorally or functionally characterized central executive system is, or would have to be, an over-endowed homunculus. Such explanation, goes the reasoning, would be worthless.

I refute this line of objection by discussing some recent results from the psychology of the central executive system. These results have largely bypassed philosophical attention. I present several studies by Akira Miyake and others in which behavioral data are used to identify, distinguish, and provide experimental paradigms for, basic executive functions. Progress in identifying such executive functions is progress in delineating and exploring a psychological system – the central executive system. It allows integrating research on this system with research in other areas of psychology and on the brain. All these findings constitute part of our best explanations of individuals' cognitive processes. They constitute genuine explanatory progress.

I also discuss the worry that the central executive system is a homunculus. I reject the claim be referring to empirical research suggesting that central executive processes do sometimes not carry the marks of individuals' processes. And I explain how, even if the charge were accurate, this would not make explanations in terms of the central executive system any less genuine.

I conclude that the central executive system is a valid explanatory construct.

In Chapter 3, I develop a proposal for the nature of individuals' guidance of their visual attention shifts from a close scrutiny of these shifts' psychology. I start by presenting salient examples of attention shifts guided by their agents. I contrast them with passive attention shifts that occur without individuals' guidance. When individuals engage in a visual search or when they focus their visual attention on some location or object, they guide their attention from one location or object to the next. In contrast, when a physically salient stimulus captures attention or when attention shifts in default ways, then the individual does not guide the shifts.

Next, I explain and illustrate some of the psychology of these shifts. An initially plausible proposal has it that guided and non-guided shifts are caused by the endogenous and exogenous attentional system, respectively. The exogenous system functions to respond reflexively to physically salient stimuli. Shifts effected by the endogenous system are typically accessed and penetrated by individuals' central states. Psychologists often classify shifts by the exogenous system as passive, and those by the endogenous system as active. A look at the psychology of attention shifts in capture and default state confirms that the exogenous system effects them. The endogenous system is responsible for the focusing of attention.

But the proposal is overly simple, as a closer scrutiny of shifts during visual search shows. The two attentional systems typically interact. When the exogenous system modulates an attention shift without overriding the individual's guidance, it draws attention. Also, not all endogenous factors are plausibly guiders of actions. A range of long-term memory systems and adaptation factors, commonly considered to be endogenous, do not plausibly constitute the individual's guidance.

I show that at the level of psychological processes, the central executive system's control of attention most closely correlates with individuals' guidance. I discuss empirical evidence for different ways in which the central executive system impacts attention shifts during visual search. I propose that central executive control is partly constitutive of individuals' guidance. A better understanding of the psychology of guided shifts provides a deeper understanding of the notion individual's guidance.

In Chapter 4, I introduce the priority map as another crucial factor in shifts of visual attention. I discuss its role in shifts of visual attention that individuals actively guide. The priority map helps direct all shifts of visual attention. I argue that the priority map is a representational state with geometric, non-conceptual, rather than propositional structure.

An influential tradition in action theory, stemming from G.E.M. Anscombe and Donald Davidson, emphasizes the role of practical reasoning for the constitution of action. Propositional thoughts that can enter into propositional practical reasoning constitutively guide actions, according to this tradition. These thoughts are conceptual intentions. The tradition ignores the importance of other, non-conceptual capacities for guiding action. The tradition ignores actions of animals that do not have conceptual capacities.

I argue that non-conceptual priority maps ultimately help guide even attention shifts caused by a conceptual intention. I suggest that, indeed, *no* conceptual intention is needed even for humans to actively shift visual attention. My discussion illustrates a concrete instance of psychological agency explained in terms of individuals' non-conceptual competencies. Such shifts of attention provide a model for thinking about non-propositional psychological agency in humans and other animals.

In order to do so, I first introduce the distinction between propositional, conceptual and geometric, non-conceptual psychological states. I illustrate how all major models of visual attention shifts commit to these shifts' being guided by a priority map with geometric structure.

Zenon Pylyshyn has launched several criticism of claims that specific representational states have non-conceptual or geometric content. I reject such criticisms for the priority map by showing that the priority map's geometric structure essentially shapes explanations in terms of relevant computational models of attention shifts. I adduce further results from behavioral studies and neuroscience that support the claim that the priority map has non-conceptual, and indeed geometric, structure. Priority maps are non-conceptual representational states. Their use in psychological explanations weighs against philosophical positions according to which all representational states have propositional structure.

After addressing Pylyshyn's objections, I discuss a position according to which it is granted that the priority map itself has non-conceptual structure. Guided shifts, however, involve activity of the central executive system. The position holds that the central executive system imports conceptual structure into the guiding state. I argue that there is no support for this position. It is reasonably to suppose that active shifts of attention are normally partly guided by non-conceptual states.

I end my discussion by reflecting on the role of conceptual intentions in attention shifts. The traditional view, stemming from Anscombe and Davidson, has it that, constitutively, all actions are guided by a conceptual intention. Of course, it is true that many active shifts of attention are caused by a conceptual intention. But in all these cases, the conceptual intention relies on the non-conceptual priority map for its guidance. I discuss different ways in which conceptual intentions and the priority map interact. I point out that the priority map can guide active shifts of visual attention in absence of conceptual intentions. Active shifts of visual attention provide a model for non-conceptual psychological agency more generally.

In the dissertation's final chapter, Chapter 5, I explain how my proposal helps solve Frankfurt's problem of action. I provide support for the claim that central executive control not merely correlates with individuals' guidance of visual attention, but indeed actually constitutes their guidance. I reflect on the proposal's scope and its contribution to the investigation of agency more generally.

When individuals guide their attention shifts, then, actually constitutively, in psychologies sufficiently like those of actual primates, the central executive system controls these shifts. In order to understand what agency is, Frankfurt once claimed, we have to, first, understand what constitutes purposive processes. Second, we must understand under what conditions such processes can be attributed to the whole individual, as opposed to her sub-systems alone. I explain that the interactions between central executive system and attentional system described in the course of the dissertation often constitute purposive processes. I suggest that central executive control may be one of the marks of the distinction between individual-level and sub-individual processes.

Constitutive conditions are necessary, sufficient, or necessary and sufficient for being something of a kind or with a nature. They are in principle relevant to explaining, understanding, and illuminating a kind or nature. In this sense, my proposal probably does not specify constitutive conditions. It is not necessary for guidance in general. Possibly it is not even necessary for guidance by the kinds of individuals whose psychologies I discuss. Central executive control is a condition on guidance of attention shifts by primates in the actual world, however. I qualify my proposal accordingly. It does not provide constitutive conditions, but actually constitutive conditions on psychologies relevantly like those of actual primates.

Central executive control deserves to be called actually *constitutive*, because it helps illuminate, explain, and understand the nature of guidance more generally. By reflecting on our notions guidance and individual I extract several features of these notions that central executive control plausibly implements. The proposal helps understand individuals' guidance by connecting it with law-like explanations in empirical psychology. First, scientific explanation provides detail about how guidance actually works, how it is realized in actual psychologies. Second, scientific explanation connects guidance, through its implementation by the central executive system, to empirical research on many other phenomena. Third, connecting individuals' guidance with law-like explanation in psychology places a constraint on, and corrects, alleged results of a priori reasoning about the notion. My proposal helps solve Frankfurt's problem by specifying conditions that implement individuals' guidance and help explain its nature.

I discuss and reject four objections against my proposal. One line of objection maintains that the central executive system tacitly imports agential events into my account of guidance and agency. A second line of objection claims that central executive control does not, even in actual primates, implement individuals' guidance of attention shifts. A third line claims that I must have misidentified the true constitutor of agency because all action, at least in humans, must have its source in individuals' Reason. But central executive together with the priority map does not form part of Reason. A fourth line maintains that reflection on empirical science could not possibly yield understanding of a nature.

After addressing these objections, I formulate a conjecture as to how central executive control might help illuminate individuals' guidance of other psychological acts, and even motor action. I point out several ways in which my proposal constitutes progress in understanding agency.

Chapter 2

The Central Executive System

In this chapter I introduce the central executive system. I defend the notion of a central executive system against objections both from psychology and from philosophy. In later chapters, I propose that central executive control partly constitutes individuals' guidance of attention shifts.

In section one I present and explain the central executive system. It is an intermodal, non-modular psychological system that functions to control cognitive processes through the exercise of specific executive functions. In section two I describe and refute a first objection against the notion of a central executive system. This objection relies on the claim that there is no specific part of the brain that realizes the central executive system. From this claim the objector infers that there is no such system. I reject the key premises and the conclusion of this argument. Section three contains a discussion of another set of objections. According to these objections, the central executive system does not and cannot yield genuine predictions and explanations. Sometimes, objectors claim that the notion has no explanatory value because the central executive system is an over-endowed homunculus. I address both the general claim about the explanatory value of the central executive system and the specific charge that this system is an over-endowed homunculus. In both sections one and two I illustrate ways in which the central executive system does generate genuine explanations and predictions in psychology.

I conclude that the central executive system is a valid psychological notion.

2.1
The Central Executive System

The central executive system is a psychological system that functions to control cognitive processes. It initiates, sustains, and terminates them. It organizes processing and storage resources for carrying out cognitive processes. It coordinates their simultaneous or sequential execution. The central executive system controls a cognitive process by flexibly allocating central processing and storage resources for its completion.[16]

Suppose that an individual adds the numbers 123,145 and 224,187. The central executive system can initiate the addition by allocating central processing resources to it. The central executive system can terminate the addition by allocating resources away

[16] The conception of the central executive system I expound here is grounded in psychology. I do not commit to the details of specific psychological account of the central executive system.

from it, to some other cognitive process. The amount of resources that the central executive allocates to the addition determines its speed and accuracy.

Adding the numbers 123,145 and 224,187 requires a competency to add integers. Adding requires maintaining the numbers 123,145 and 224,187 in memory. When the individual adds the numbers, she has to carry 1 from the column of the units to the column of the tens. She has to carry 1 from the column of the tens to that of the hundreds. She must maintain in memory both the 2 in the column of the units, the 3 in the column of the tens, and the numbers to be carried. The central executive system organizes these memory states for the completion of the addition. The central executive system activates memories relevant to the current cognitive process. And it encodes or maintains new information for the completion of the process.

The central executive system sustains the addition by continuously allocating at least some minimal amount of central resources to this process. The central executive system sustains the addition by suppressing interference from task-irrelevant stimuli and competing cognitive processes. The individual may be looking at the neon landscape of Hollywood Boulevard. Blinking lights attract her attention. The central executive system inhibits the lights' influence on the individuals' addition. The system suppresses the impulse of reading the advertisements before adding the numbers.

In these different ways, the central executive system organizes the individual's resources for attaining the goal of adding 123,145 and 224,187.

Suppose that the individual simultaneously engages in a conversation. The central executive system coordinates the execution of the two tasks by switching from processes pertaining to one task to those pertaining to the other. The central executive system may cue the tasks, causing the execution first of the conversation, then of the addition. The central executive system may distribute central resources among the tasks. It may allocate some of its resources to the addition, others to the comprehension of the interlocutor's utterances. In doing, so, the system enables the simultaneous completion of both tasks.

Psychology traditionally studies the central executive system through its relations with working memory. Working memory holds states active during the execution of cognitive processes. It is a short-term memory system with limited storage capacity. Working memory comprises several sub-components.[17] These sub-components are devoted to storing different types of information. For example, one widely acknowledged component stores speech-based and purely acoustic information.

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[17] The precise nature of working memory is a matter of ongoing debate. Researchers disagree about the amount of information working memory can store and about what determines this amount. According to tradition, working memory has the capacity of storing four to seven 'chunks' of information. Cf. Baddeley, A. 2012, 15 & 20. Cowan, N. 2005, 75ff & 80ff.; Cowan, N. 1995. More recent research conceptualizes working memory as a flexible resource. How many objects, items, or chunks of information working memory can store depends, according to these researchers, on the amount of detail and the degree of fidelity of the stored representations. Cf. Alvarez, G. & Cavanagh, P. 2004; Brady, T., Konkle, T. & Alvarez, G. 2011.

Another prominent component holds visuo-spatial information deriving from individuals' perceptual systems.[18] [19]

Most basically, however, the central executive system functions to allocate central processing resources to cognitive processes. Such resources are connected with, but different from, working memory. While working memory provides and maintains information for processing, the central executive system's allocation of resources enables processing. It also determines the amount that can be performed by the system at a given time. It determines the speed and accuracy of a cognitive process. It determines the number of cognitive processes that can be performed concurrently.

These resources, allocated by the central executive system, are central partly because they are used for non-modular intermodal processing. The states in working memory are central partly because they are often affected by intermodal processing, and are available for non-modular processing.

A representational state with input from different modalities often depends on processing that goes through working memory and depends on allocations governed by

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18 Baddeley calls the speech-based acoustic storage the 'phonological loop' and the visuo-spatial store the 'visuo-spatial sketchpad.' Cf. Baddeley, A. D. 2007, chapters 2 & 3 on the phonological loop and chapters 4 & 5 on the sketchpad. Cf. also Baddeley, A. 2012, 7.

19 While psychology emphasizes the connection between the central executive system and working memory, psychology also acknowledges the central executive system's ability to activate long-term memory. Long-term memory is a memory system of basically unlimited capacity. Representational states in long-term memory exhibit a lower degree of activation. Just like working memory, long-term memory comprises many different sub-components. Psychologists often assume that representations in long-term memory must be activated for them to influence current processing. Often, representations in working memory *are* activated long-term memories. Often, representations in working memory are encoded into long-term memory, once current processing no longer requires them. Cf. Squire, L. 2004; Baddeley, A. D. 2007; Brady, T., Konkle, T., Alvarez, G. & Oliva, A. 2008; Brady, T., Konkle, T. & Alvarez, G. 2011.

the central executive system.[20] For example, a belief might be formed on the basis of information from both vision and touch. States in working memory are often affected intermodally. One of the functions of visuo-spatial working memory is to store visual information. Many states in this system are nevertheless formed on the basis of information from several modalities. My visuo-spatial memory of the predator's location, for example, may derive from an earlier visual perception of her approach, and from subsequently registering a rustle in the close-by bushes. States in working memory are often affected by intermodal processing, because one function of working memory is to serve as an interface for integrating information from different modalities and psychological capacities.

Modular processes are fast, automatic, driven by a very limited range of inputs, relatively encapsulated, and inaccessible to consciousness.[21] A process is encapsulated if it takes a very confined range of inputs and is not influenced by information outside this range. Processes in perceptual systems are relatively modular. They are relatively encapsulated from information in other systems and especially higher faculties. For example, suppose that a computation of surface lightness in the early visual system relies exclusively on information about luminance contours. This information stems

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[20] Burge, T. 2010; Burge, T. 2010a; and especially Burge, T. 2010b, 47ff.; cf. also Carey, S. 2009. Note that it is not obvious that all intermodal states and events are non-modular states and events. It is at least in principle possible for intermodal propositional inference to be modular. Cf. the discussion in Burge, T. 2010b, 49f., Stanovich, K. & West, R. 2000, and Stanovich, K. 2010.

[21] Fodor, J. 1983, 47ff.; Fodor, J. 2001, 55.

directly from the registration of light intensities at the retina. The individuals' beliefs about lightness properties of the seen object in that case do not influence the visual system's computations. Such a computation of lightness is a modular process. Processes involving representational states are non-modular when a wide range of states from different psychological capacities enter into them. Suppose that an individual forms a perceptual belief that the apple in front of her is edible. To form the belief, suppose that she relies on her visual perception, competency with the concept apple, and background beliefs about the edibility of apples. Different psychological capacities contribute to the belief's formation. Then the formation is a non-modular process. States in working memory often result from the integration of information from different psychological faculties, such as beliefs and perceptual sources. States in working memory often enter into non-modular processes. After all, one function of working memory is to provide an interface for different perceptual and other psychological capacities.

The central executive system allocates resources and manages storage by performing *executive functions*. Executive functions are specific competencies for the control of cognitive processes. The set of executive functions constitutes the primary, functional characteristic of the central executive system. Executive functions are signature competencies that characterize the functioning of the executive system.

One of the primary aims of this area of psychology is to determine which executive functions there are. Psychology aims to determine their nature and number. It tries to determine which executive functions are basic.

Switching of mental set, maintenance of relevant memories, and inhibition of prepotent responses and interfering stimuli are the most frequently recognized executive functions. These functions are fairly precisely defined. A set of well-studied, relatively simple tasks requires exercising these functions and allows their investigation. I will follow the science in focusing on these three executive functions.[22]

Switching of mental set consists in the process of abandoning one cognitive process, and initiating another. A mental set is the suite of psychological states and events required for completing a cognitive process.

One sample paradigm for switching is the Local-Global Task. In it, individuals are presented with a *Navon*-figure on a computer screen. *Navon*-figures are geometric figures composed of other geometric figures. The 'global' figure in such a task might be a triangle. Its three sides might be composed of 'local' squares. Individuals count the number of lines in either the local or global figure, depending on the color of the *Navon*-figure. Individuals might be instructed to focus on the 'global' triangle if its color is green, and on the 'local' squares, if the color of the configuration is red.

In this task, the central executive system implements the individuals' goal of counting lines in the global triangle. The central executive system then switches set by activating the goal, and associated memories and competencies, of counting lines in the local squares.

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[22] Miyake, A. & Shah, P. (eds.) 1999; Jurado, M. & Roselli, M. 2007; Anderson, V., Jacobs, R. & Anderson, P. (eds.) 2008; Baddeley, A. D. 2007.

Maintenance of relevant representations in memory consists is the activation and holding active of relevant long-term memories. Maintenance includes the encoding of incoming task-relevant information into working memory. Both component processes subserve ongoing cognitive activity.

A paradigm for studying maintenance is the Tone Monitoring Task. Here, individuals are presented with a series of 25 tones for 500 ms each. Tones are of three different pitches – high (880 Hz), medium (440 Hz), and low (220 Hz). Individuals respond as soon as the fourth tone of each particular pitch was presented. Thus individuals respond after, say, the fourth medium or high tone sounds. To do well on this task, individuals keep track of the number of times each particular pitch is presented. They count along and remember the number of repetitions per pitch. In a series "low, high, high, medium, low, medium, low, high, medium, *high*," individuals should respond to the italicized tone.

In this task, the central executive system maintains the number of occurrences for each pitch in working memory. The central executive system determines which memorized pitch's number a given sound is relevant to. The central executive system updates that number and encodes the new number into memory.

Inhibition consists in the exercise of a competency to suppress dominant, automatic, or prepotent responses and distracting or interfering stimuli and information.

In the Antisaccade Task, for example, individuals fixate attention at a point in the middle of a screen for a variable amount of time. A visual cue – a black square – is then presented to the left of the fixation point. Next, the target stimulus – an arrow inside an open square – appears on the side opposite the cue. Individuals indicate the direction of the arrow in the target-box.

Given the short appearance of the target, the central executive system must inhibit the reflexive orientation of attention to the cue. If the central executive system allocates sufficient resources to the process of finding the target, the central executive system can suppress the distractor's influence.

At the most basic level, the central executive system controls cognitive processes by allocating central resources to them. Switching, maintenance, and inhibition are ways in which the central executive system allocates central resources and memory storage to ongoing cognitive processes. Psychology studies the central executive system by studying these executive functions.

2.2

The Objection from Neural Mechanisms

There are two main lines of objection against appeals to the central executive system. One consists in the claim that there is no central executive system. The other consists in the claim that appeals to the central executive system does not yield genuine explanation. Both lines of objection have been called "*the* homunculus-problem." It has sometimes gone unnoticed that the two objections are not equivalent. In the present section, I discuss the first line of objection. In the following section, I discuss the second. The objections constrain the notion of a central executive system too narrowly. They rely on outdated scientific results. And they impose implausible requirements for genuine explanatory work in psychology. In both sections, I present some current psychological and neuroscientific research on the central executive system.

The first objection – originally stemming from work by Daniel Dennett and Alan Allport – consists in the claim that the central executive system does not exist. Proponents of this objection typically assume, *first*, that empirical results have shown that the central executive system cannot be identified with any narrowly circumscribed, precisely identifiable region or mechanism in the brain. *Second*, they assume that a coherent, principled account of the central executive system requires identifying it with a narrowly circumscribed, precisely identifiable region or mechanism in the brain. They conclude that the central executive system does not exist.[23] I discuss the two assumptions of this argument in the following two sub-sections.

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[23] See especially Allport, A. 1993; Allport, A. 2011; Dennett, D. 1994; Dennett, D. 2005; Stinson, C. 2009.

Allport, A. 1993, 202: "The results offered by … new techniques together with neuropsychological analyses of the effects of localized injury or disease on diverse executive functions, and neurophysiological data on nonhuman primates, make the idea of a general-purpose, functionally undifferentiated central executive … highly implausible."

Dennett, D. 1994, 275: "The frontal lobes of the cortex … are known to be involved in long-term control, and the scheduling and sequencing of behavior. … So it is tempting to install the Boss in the frontal lobes, and several models make moves in this direction. … [A]nyone who goes hunting for the frontal display screen where the Boss keeps track of the projects he is controlling is on a wild goose chase."

2.2.1 The Neuroanatomic Realization of the Central Executive System

Objectors argue for the first assumption on the basis of now outdated brain research. Alan Allport, in his 1993 article, supports the first assumption by surveying then current results from neuroscience. Different central executive processes correlate with neural activity in different parts of the brain. Allport points out, for example, that endogenous deployments of attention elicit neural activity spread over the parietal cortex, the frontal eye fields, the superior colliculus, and the lateral pulvinar nucleus of the thalamus.[24] Deductive reasoning and task-preparation coincide with activations of different areas in the prefrontal cortex.[25] Allport concludes that the central executive system could not be located at, or identified with, any narrowly circumscribed, precisely identifiable region or mechanism in the brain.

Allport is right to point out that no one brain location exhibits neural activity during processes that involve the central executive system. While current work in cognitive neuroscience supports this part of Allport's verdict, neuroscience also suggests

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Dennett, D. 2005, 133: "Since there is no single organizational summit to the brain … In an arena of opponent processes … the 'top' is distributed, not localized."

Dennett, D. 2005, 136: "It is … the accessibility [of specialized brain modules] to each other (and not to some imagined higher Executive or Central Ego) that could in principle explain the dramatic increases in cognitive competence that we associate with consciousness: the availability to deliberate reflection, the non-automaticity, in short, the open-mindedness that permits a conscious agent to consider anything in its purview in any way it chooses."

[24] Allport, A. 1993, 203; Goldberg, M. E. & Bruce, C. J. 1985; Posner, M. 1980; Goldberg, M. E. & Segraves, M. A. 1987.

[25] Allport, A. 1993, 200/1.

that there is *some* anatomical unity underlying the central executive system's functioning.

Since Patricia Goldman-Rakic's pioneering work, central executive control had been linked to the prefrontal cortex.[26] In the late 1980s technological advances in positron emission tomography coincided with the development of cognitive subtraction techniques. These techniques made it possible to associate variations of activity in specific brain regions with the execution of specific tasks.[27]

Positron emission tomography has fairly low temporal resolution (30 – 40 sec). On its basis alone, we cannot distinguish brain areas underlying different components of the central executive that are active within a single task phase. We cannot distinguish which areas of the prefrontal cortex underlie, say, the maintenance of a stimulus configuration in memory or the subsequent recognition that this configuration is present in a display. With the introduction of event related functional magnetic resonance imaging in the late 90s, this obstacle could be overcome. Functional magnetic resonance imaging allowed mapping central executive functions to activity in the prefrontal cortex with a temporal resolution of 2 to 4 sec.

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[26] Goldman-Rakic, P. 1987; See Buchsbaum, B. & D'Esposito, M. 2008, 245ff. for the development of the central executive system's neuroscientific study.

[27] For any set of hypothesized cognitive operations, one had to find a task involving all of them, and several tasks involving only subsets. Researchers reasoned that brain areas active during tasks engaging *all* cognitive operations in the set, but not in tasks engaging all cognitive operations but *one*, realize this one cognitive operation at the level of the brain.

Evolutionary speculation suggests that the prefrontal cortex evolved to enable goal-directed behavior. The prefrontal cortex enables the use of sensory information about the environment *for* goal-directed behavior, such as the maintenance of an image of a visual search's target. Parts of the brain different from the prefrontal cortex process the relevant sensory information. The prefrontal cortex accordingly should serve to modulate neural activity occurring elsewhere in the brain.[28] Sensory and motor representations, for example, are predominantly processed on the basis of neural activity in the unimodal association regions. Functional magnetic resonance imaging reveals co-activation of these regions along with prefrontal cortex, for instance, during goal-directed motor action.

For the prefrontal cortex to control activity in remote brain regions, it must be connected to these regions. Temporal imaging alone does not provide evidence for the interconnection and interaction of different brain regions. Only the development of multivariate methods for analyzing neuroimaging data have, during the 2000s, allowed the specification of neural networks that underlie the prefrontal cortex's modulation of neural activity.[29] Complex cognitive processes are not confined to specific brain regions functioning in isolation. Rather, they emerge from intricate neural connections between different parts of the brain.

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[28] Gazzaley, A. & D'Esposito, M. 2006, 5.

[29] Multivariate approaches evaluate covariance of activation across brain regions. Cf. Miller, B. & D'Esposito, M. 2005, 537; Gazzaley, A. & D'Esposito, M. 2006, 11.

Functional magnetic resonance imaging and positron emission tomography together allow a fairly precise specification of neural networks active during the performance of executive functions. They do not in and of themselves show that prefrontal-cortex activities are control processes. In recent years, neuroscientists have gathered evidence for this stronger claim. Gazzaley and D'Esposito,[30] for example, asked individuals to actively observe a display with the goal to memorize items in it. Gazzaley and D'Esposito found that when individuals pursued the goal of observing a display, activity in the prefrontal cortex and the relevant regions of the association cortex increased against a baseline of activity during passive viewing. The prefrontal cortex presumably enables individuals' goal-directed cognitive processes. These findings suggest that the prefrontal cortex controls modulations of neural activity in the association cortex. Other evidence for prefrontal-cortex control comes from disrupting prefrontal-cortex afferents and recording activity in distant brain regions while the subject is engaged in a control task. There have been several such studies in humans and animals. They show that the prefrontal cortex controls enhancement and suppression of neural activity in other areas. Cooling the prefrontal cortex in cats, for example, results in increased responses to sensory stimulation, suggesting the lack of inhibitory control by the prefrontal cortex. Cooling the prefrontal cortex in monkeys leads to diminution of neural activity in the inferotemporal cortex, associated with poorer performance in recalling items from working memory. In humans, combined lesion and event-related

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30 Gazzaley, A. & D'Esposito, M. 2007.198ff. & 205/6.

potential studies provide evidence that the prefrontal cortex enhances activity in the visual association cortex for the processing of visually attended stimuli.[31]

Allport is right to point out that activity of the central executive system causes activation of many different areas in the brain. Allport is wrong to assume that he has thus shown that no part of the brain realizes the central executive system.

Current neuroscientific theorizing can accommodate and explain the fact that neural activity realizing central executive functions spreads over many different parts of the brain. This theorizing relies on methods and data that were not available when Allport was writing. Central executive control is likely realized in the prefrontal cortex's modulation of neural activity in domain specific neural networks. Considerations about the evolutionary function of the prefrontal cortex support this verdict. So does evidence that the prefrontal cortex controls activation in brain regions devoted to the processing of specific sensory stimuli. Neuroscientific research suggests that the prefrontal cortex is the primary neuroanatomical realizer of the central executive system.

So there is now evidence for some unity in areas of the brain that realize the central executive system. There seems to be more to the suggestion that a specific brain region controls cognitive processes than was apparent when Allport was writing.[32] [33]

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[31] Funahashi, S. 2007, 228/9; See also Ruff, C. 2011; Stokes, M. & Duncan, J. 2014; Serences, J. & Kastner, S. 2014; Nobre, A. & Mesulam, M. 2014; Gottlieb, J. 2007; Gottlieb, J. 2014; Clark, K., Noudoost, B., Schafer, R. & Moore, T. 2014; Spence, C. 2014.

I conclude that the first premise of the objector's argument, according to which empirical evidence shows that no part of the brain realizes the central executive system, is false.

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32 In a later article, Allport seems to implicitly recognize the availability of this reply to his early argument. Cf. Allport, A. 2011, 39ff.

Stinson, too, acknowledges the relevance of this research to the first objection. She rejects the research by pointing out that "the patterns of connections found to exist between [the relevant brain-regions are] put forward as necessary properties of an attentional control system, not sufficient ones." She continues: "Identifying the only part of the brain that has a necessary property of an executive controller would only warrant the conclusion that this area is an executive controller if we had some prior reason for believing that there exists an executive controller somewhere in the brain." Cf. Stinson, C. 2009, 149.
Psychological, not neuroscientific, theorizing provides prior reason to believe in the central executive system's existence. Neuroscience supports the position that prefrontal cortex implements the central executive system's control.

33 The first assumption might be supported by claiming that cognitive processes are connectionist or parallel-distributed brain processes. According to this position, cognitive processes emerge from the activity of entire neural networks. Different neurons inhibit or enhance the activity of specific other neurons. Whether and to what extent different neurons inhibit or enhance others depends on the strengths of their activation and the strength of the connections between them. No part of a neural network is privileged as the control system for other parts of the network. Daniel Dennett (Dennett, D. 1994; Dennett, D. 2005) assumes that the brain has 'global' parallel-distributed structure. The neural network engendering cognitive processes is the entire brain. No part in the brain is in principle devoted to controlling others or indeed any specific function. According to this view we should in reject the claim that the central executive system exists.

Even the earliest connectionist models acknowledged hierarchical levels of processing. They accommodated bottom up and top down influences on information processing (Rumelhart, D., Hinton, G. & McClelland, J. 1986, 59). Dennett provides no reason for thinking that his more radical 'global' version of a parallel-distributed architecture is the right version. Connectionism as a general model of neural activity is consistent with the existence of a hierarchical structure of systems. Each of these systems might be implemented as a connectionist network. The influence of one such neural network on another might plausibly implement central executive control of one psychological system over another (Stokes, M. & Duncan, J. 2014). Some of the more sophisticated computational models of the central executive system are indeed connectionist models (O'Reilly, R. 2006).

The debate about the role of connectionist modeling for understanding cognitive processes is ongoing. Researchers tend to agree that connectionism provides a plausible model for brain processes. It is doubtful that connectionism provides the best model for cognitive processes (Fodor, J. & Pylyshyn, Z. 1988; Horgan, T. 1997; Garson, J. 2010). There is no reason for thinking that connectionist modeling can supersede psychological explanation in terms of psychological systems. Even in fully parallel connectionist architectures there might be different modes of functioning for that architecture. Different modes of functioning might be sufficient to support a distinction between the central executive system and other psychological systems.

Thanks to Calvin Normore for pressing me to address this objection.

2.2.2 Neuroscientific and Psychological Explanation

The second premise of the objector's argument is the claim that a coherent, principled account of a central executive system requires identifying it with a narrowly circumscribed, precisely identifiable region or mechanism in the brain.

What support might there be for such a requirement? According to Allport's 1993 critique of then current research on the central executive system, the second premise was assumed to be true by all relevant theories of the central executive system.[34] The premise was part of the classical computational picture of the mind. According to this picture, information processing is to be thought of in analogy with a computer. Input analyzers process sensory input in parallel fashion. Then a linearly ordered, uni-directional sequence of further processing ensues. Central executive processing is high-resource processing with limited capacity, beginning at some particular processing stage. An analogue of a central processing unit in a computer achieves central executive processing. This physically separate processor in the brain thus realizes the central executive system.

But even adherents of a computational picture of the mind no longer take the analogy between brains and computers this literally. Our general lack of understanding

[34] Allport A. 1993, 187.

of the relation between mind and brain invalidates this motivation for the second assumption.[35]

How might the central executive system be distinguished from other systems, if not as a narrowly circumscribed, precisely identifiable region or mechanism in the brain? The preceding sketch of the realization of the central executive system in the brain may hint at a neuroscientific answer to this question. The prefrontal cortex may turn out to be the primary source of central executive control in the brain. Again, we do not know enough about the brain to answer this question with certainty.

The objector's second premise may be driven by the contention that only explanation in terms of neural mechanisms is *genuine* explanation. The objector might reason that until we have a full specification of a neural mechanism for central executive control of cognitive processes, we have no genuine explanation in terms of the central executive system. Since we do not have such a specification at this point, appeals to the central executive systems are spurious.

The objector's claim about requirements for a coherent, principled account of a central executive system is mistaken. Psychological method does not support the view that only explanation in terms of brain mechanisms is valid explanation. Psychological explanation is mostly independent of explanations in terms of neural mechanism. Large parts of psychology continue to generate powerful theory on the basis of behavioral studies and computational modeling. Neither behavioral studies nor computational

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[35] Block, N. 1995c; Burge, T. 1993; Burge, T. 1995; Burge, T. 2010c.

modeling need appeal to structures of the brain. Our understanding of how psychological theory correlates with activity in the brain is often very poor. There is at this point no positive reason to think that all psychological explanations will ultimately be reduced to explanations in terms of brain mechanisms.

Even if the preceding sketch of the realization of the central executive system in the brain should turn out to be false, there are alternative ways of distinguishing a central executive system from other psychological systems. Behavioral data support the identification of distinct modes of functioning – the executive functions.[36] Earlier I have illustrated these modes of functioning and some of the behavioral data identifying them. I elaborate on the study of these modes of functioning in the next section. Identification of such modes of functioning helps systematize and explain distinctive sets of behavioral data. Postulating a psychological system such as the central executive system yields generalizations and predictions that explain the behavioral data. Such successful explanations in psychology provide evidence for the existence of the entities the explanations are in terms of.[37] Such successful explanations in psychology do not depend on whether they can be reduced to explanations in terms of brain activity.

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[36] Computational modeling provides a further way of specifying a psychological system or competency without relying on neuroscience.

[37] Psychologists are very clear on this point. See for example Anderson, P. 2008, 6: "Executive function is a psychological construct, but the concomitant neural systems (i.e. prefrontal cortex and related systems) provide important information about specific processes and the integration of these functions." Baddeley (Baddeley, A. D. 1996, 6) insists that his model is "principally a functional model that would exist and be useful even if there proved to be no simple mapping on to underlying neuro-anatomy."

Vision science may serve as an analogy.[38] Much of the success in vision science is due to behavioral studies and computational modeling. While there are attempts to integrate behavioral and computational studies in vision science with brain studies, the latter are much less advanced than the former, especially for later stages of visual processing. Integration of the different fields succeeds mostly for very low-level vision. Our understanding of higher-level visual functions, such as the processing of objects or object-categories, relies almost exclusively on behavioral and computational research. Nevertheless, vision science provides genuine, powerful explanations. We are committed to the existence of the competencies and systems that these explanations are in terms of. We can thus legitimately expect genuine explanation in psychology that is not given in terms of neural mechanisms. We can expect that psychological competencies and systems can be individuated on the basis of such psychological explanations.

So the objector's requirement that a coherent, principled account of a central executive system requires identifying it with a narrowly circumscribed, precisely identifiable region or mechanism in the brain is implausible. Psychology can provide such an account on the basis of behavioral and computational investigations alone.

The second premise of the objector's argument, too, should be rejected. The first line of objection against appeals to the central executive system fails.

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38 See, for example, Palmer, S. 1999, chapters 5ff.; Burge, T. 2010; Burge, T. 2010c.

2.3

The Objection from Explanation

The second objection consists in the claim that no genuine psychological explanations derive from appeals to the central executive system. Often this objection is motivated by an assumption that genuine explanation must be in terms of brain mechanisms. In the previous sub-section, I have explained why this assumption is mistaken. Psychology provides genuine explanations, even in absence of a reduction of its explanations to facts about the brain.

Sometimes, a different contention fuels the objection. Some objectors claim that a behaviorally or functionally characterized central executive system is, or would have to be, an over-endowed homunculus. The central executive system is over-endowed in so far as it is equipped with those of the individual's capacities that the central executive system is supposed to help explain. Such explanation, goes the reasoning, would be worthless. So, no genuine explanation can be given in terms of the central executive system. Dennett, Monsell and Driver, and Allport provided the most influential statements of this second objection.[39]

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[39] See for example Dennett, D. 1978, 124: "If one can get a team or committee of relatively ignorant, narrow-minded, blind homunculi to produce the intelligent behavior of the whole, this is progress. … One discharges fancy homunculi from one's scheme by organizing armies of … idiots to do the work. …We haven't really solved the problem … until [the] Executive is itself broken down into subcomponents that are themselves clearly just unconscious underlaborers who work … without supervision."

Antecedent commitments to implausible requirements for explanation in psychology, and reliance on outdated research nurture the second objection and the support for it. In this sub-section, I illustrate some ways in which research on the central executive system has made progress, yielded testable hypotheses, and new explanations. In the next sub-section I discuss the charge that the central executive system in its current state is an over-endowed homunculus.

Dennett, D. 2005, 137: "As long as your homunculi are more stupid and ignorant than the intelligent agent they compose, the nesting of homunculi within homunculi can be finite, bottoming out, eventually, with agents so unimpressive that they can be replaced by machines."

Dennett merely assumes that the relevant 'breaking down' of the central executive system consists in providing a parallel-distributed processing model of the brain that can carry out the activities that the central executive system serves to explain.

Allport, A. 1993, 200/1: "The concept of a central executive has yet to be elaborated in a way that avoids the homunculus problem, namely, the problem of practically unconstrained explanatory powers. As a consequence, the idea has yet – to my knowledge – to generate specific, hypothesis-generating research."

Stinson, C. 2009, 150: "Causal theories of executive attention [that function to allay homunculus worries about the central executive system] … do not work."

Monsell, S. & Driver, J. 2000, 3/4: "The homunculus has continued to parade about in broad daylight, its powers largely intact and indeed dignified by even grander titles – not merely the "executive" but the "central executive" or the "supervisory attention system"."

It is important to note that the more sweeping claims about the uselessness of the central executive system as a theoretical construct stem from philosophers. The criticisms by Monsell and Driver, and the original worries by Newell served to caution researchers not to be complacent in their reliance on metaphors. Already Monsell and Driver point out that progress had been made in understanding the central executive system.

See also Dennett, D. 1994, chapter 5 and the discussion of that book in Block, N. 1993 and Block, N. 1994.

2.3.1 The Psychology of the Central Executive System

The second objection – that appeals to the central executive system do not yield genuine explanations – derives from outdated research. Many objectors ground their charge in empirical research from the turn of the millennium or earlier. A look at recent research on the psychology of the central executive system shows that the objection is mistaken.

For several decades, the central executive system served exclusively as a placeholder for a number of aspects of the mind that needed explanation.[40] Broadbent's early computational theory of the mind postulated a central processor that selected information through a bottleneck for privileged processing. Others, like Kahneman, thought of the central system as a limited, all-purpose processing resource. Yet others conceived of the central system in terms of the difference between automatic and deliberate action. While postulating a central executive system, these theories did not provide accounts of *how* the system contributed to psychological processing.[41]

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[40] Anderson, V., Jacobs, R. & Anderson, P. (eds.) 2008; Anderson, P. 2008; Miyake, A. & Shah, P. (eds.) 1999; Conway, A., Jarrold, C., Kane, M., Miyake, A., & Towse, J. (eds.) 2007.

[41] Broadbent, D. 1958; Kahneman, D. 1973; Shiffrin, R. & Schneider, W. 1977; Norman, D., & Shallice, T. 1986.

An important step forward was Baddeley's 1986 conceptualization of the central executive system as the principal part of the working memory system.[42] He distinguished the central executive *qua* allocator of resources from working memory as a system of memory stores. The model in its outline is now widely accepted, even though many of its details have been debated.

While Baddeley's work inspired a great number of researchers to investigate his model, they obtained widely diverging results.[43] For decades, research on the central executive system had relied mainly on individual difference studies.[44] By the late 1990s, more sophisticated structural equation modeling methods were widely used in other sciences, for instance, evolutionary biology.

Psychologists first introduced exploratory factor analyses to the study of the executive system. Factor analyses take covariation of observed factors as data. Sophisticated statistical methods extract underlying unobserved, or latent, factors from observed covariations. Covariations between observed data, for example arithmetical and verbal skills, may indicate the influence of an underlying latent factor, for example

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[42] Baddeley, A. 1986; Baddeley, A. 1996; Baddeley, A. 2007; Baddeley, A. 2012. Baddeley’s model shares the basic outline with the central executive system sketched in Section I. Cf. also Anderson, P. 2008, 7; Miyake, A. & Shah, P. (eds.) 1999.

[43] See the criticism especially in Miyake, A. & Shah, P. (eds.) 1999 and Miyake, A., Friedman, N., Emerson, M., Witzki, A., Howerter, A. & Wager, T. 2000, 53 & 78.

[44] Individual difference studies typically picked fairly complex tests for studying executive function. They correlated individuals' performance on different such tests. A consistent result from these studies was that the inter-correlations among different tasks were low and often statistically not significant. These results were used to argue that the central executive system is highly fractionated. Cf. Rabbitt, P. (ed.) 1997; Rabbitt, P. 1997a.

some specific executive function. Exploratory factor analyses register all statistically relevant covariations in a data set. They hence account for an in-principle unlimited number of covariations. These analyses hence yield a potentially unlimited number of supposed latent factors. Often, only few of these latent factors correspond to actual causal factors that underlie the observations. Exploratory factor analyses provided poor guidance for specifying which executive functions influenced individuals' performance on specific tasks.

Miyake et al.[45] addressed this obstacle by introducing confirmatory factor analysis to the study of executive functions. Confirmatory factor analysis starts from an initial hypothesis about the relevant latent factors. Confirmatory factor analysis tests this hypothesis against the covariational data. A measure of fit is used to determine whether a hypothesis is a good one. If the initial hypothesis is a good one, confirmatory factor analysis tries to determine which observed covariations are due to actual causal factors underlying the observations.

Miyake et al. used this new method to identify and characterize the set of basic executive functions introduced earlier – the functions of Switching, Inhibition, and Maintenance. For each of these three target executive functions, Miyake et al. specified three tasks. Performance on these tasks presumably relied on carrying out the respective executive function as exclusively as possible. Take Inhibition, for example. The Antisaccade Task introduced earlier requires the central executive system to suppress

45 Miyake, A., Friedman, N., Emerson, M., Witzki, A., Howerter, A. & Wager, T. 2000.

the influence of a blinking distractor on the individuals' shift of visual attention to the target, which is located in the direction opposite of the distractor. Miyake et al. identified two further tasks as plausibly engaging the central executive system's inhibitory function. In one task, individuals first learned to categorize objects as quickly as possible. On a subsequent trial, individuals had to withhold categorization whenever they heard a tone. In yet a further task – the famous Stroop task – individuals reported the color of a stimulus as quickly as possible. In some of the trials, the stimulus was the name of a color different from the color in which the name was printed. Individuals had to resist reporting the wrong color, the color whose name appeared on the screen.

Miyake et al. measured individuals' performance on each of these tasks. The researchers determined a value for the involvement of the target executive function in those tasks. High correlation of this factor between the three tasks showed that the targeted inhibitory executive function was involved in all three tasks. Miyake et al.'s results showed a strong correlation between the different tasks. In this way Miyake et al. provided evidence that they had correctly identified Switching, Inhibition, and Maintenance as basic executive functions. At the same time, Miyake et al. also showed that the specific tasks they proposed for investigating these executive functions plausibly do engage them fairly exclusively. Miyake et al. had found basic executive functions and paradigms for their study. They had done so in a principled way, by relying on their use of new statistical methods.

Reapplying the same methods to their analyses for the three different executive functions, Miyake et al. showed that the three proposed basic executive functions are clearly distinguishable. Performance on the task sets varies sufficiently to think that the tested executive functions are independent factors.[46]

Miyake et al.'s new approach to the study of the central executive system subsequently yielded further results. Inhibition had long been proposed as one of the core executive functions. Friedman et al.[47] used Miyake et al.'s methods to investigate inhibition. What had been treated as a single competency turned out to be a family of related competencies.[48] *Prepotent Response Inhibition* consists in the exercise of an ability to suppress dominant, automatic, or prepotent responses. We have already encountered this competency in the Antisaccade Task. *Resistance to Distractor Interference* is the exercise of an ability to resist or resolve interference from information concurrently available, but irrelevant to the task at hand. Both types of inhibitory competency must be distinguished from *Resistance to Prior Information* or exercise of the ability to resist intrusions from information that was previously relevant to a task, but has since become irrelevant. Friedman et al. investigated individuals' performance on tasks intended to exclusively engage each of these three types of

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46 Miyake, A., Friedman, N., Emerson, M., Witzki, A., Howerter, A. & Wager, T. 2000, 72. A similar result was obtained for a set of executive functions supposedly controlling visuo-spatial working memory. Cf. Miyake, A., Friedman, N., Rettinger, D., Shah, P. & Hegarty, M. 2001.

47 Friedman, N. & Miyake, A. 2004.; Friedman, N., Miyake, A., Young, S., DeFried., J. Corley., R. & Hewitt, J. 2008; Miyake, A. & Friedman, N. 2012.

48 Harnishfeger 1995; Nigg 2000.

inhibitory competency. The researchers found that individuals' performance on the respective tasks was relatively uncorrelated. More specifically, Friedman et al. showed that individuals' performance on tasks that engaged Resistance to Prior Information was unrelated to their performance on tasks engaging Prepotent Response Inhibition and Resistance to Distractor Interference. These latter two inhibitory competencies, however, turned out to be closely connected. Friedman et al. concluded that these latter two inhibitory competencies, but not Resistance to Prior Information, should be grouped as the inhibitory executive function.[49] This result disconfirmed prior claims to the effect that one and the same inhibitory competency underlies all three types of executive function.[50]

The second line of objection claims that no genuine psychological explanation comes from appealing to the central executive system. The preceding summary of some results of recent research on the central executive system shows this claim to be false.

The Miyake et al. and the Friedman et al. studies provide a basis for, and regiment, research on the central executive system. They investigate new hypotheses about basic executive functions. These new hypotheses derive from the development of new techniques for statistical analysis. The studies devise paradigms for investigating these basic executive functions. The studies generate hypotheses about the interrelation

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49 Friedman, N. & Miyake, A. 2004, 102. See also Friedman, N., Miyake, A., Young, S., DeFried., J. Corley., R. & Hewitt, J. 2008, 23.

50 Hasher, L. & Zacks, R. 1988; Kane, M., Bleckley, M., Conway, A. & Engle, R. 2001.

of the basic executive functions and test them. The studies offer ways of falsifying such hypotheses.

Miyake et al. provide evidence for three independent basic executive functions. Friedman et al. suggest that we should distinguish between two basic types of inhibition. One kind of inhibition consists in resistance to prior information. The other kind consists in prepotent response inhibition and resistance to distractor interference. Both studies provide evidence that a fairly clearly circumscribed set of tasks serves to investigate these different executive functions.

The studies thus contribute to our understanding of a psychological system that helps explain individuals' cognitive activity – the central executive system. As such they provide grounds for predictions and generalizations about individuals' cognitive activity. Aspects of individuals' cognitive activity are explained *in terms of* the executive functions. Characteristic time courses for switching from one mental set to another may, for example, explain individuals' characteristic mistakes in simultaneously performing a multiplication and a random letter generation task. So the studies not only constitute progress in understanding the executive system. They also generate new and better explanations of individuals' performance on specific cognitive tasks.

Explanatory progress, as illustrated by the Miyake et al. and Friedman et al. studies, extends beyond carving out basic executive functions and paradigms for their investigation. A more sharply circumscribed set of executive functions and paradigms for their investigation makes it possible to test hypotheses about the interaction of these executive functions in more complex traditional working-memory tasks. Having such a set of executive functions and paradigms allows neuroscientists to attempt more precise mappings of central executive control to activity in brain areas. Having a set of executive functions drives investigations of the central executive system's relation to intelligence, its role in infant development, ageing, and motivation. A close look at the psychology of the central executive system shows that this science yields a wide variety and increasing number of predictions, explanations, and regimented paradigms for testing them.[51]

Progress in psychology often takes the form of breaking down complex information-processing problems into smaller, more tractable ones. Again, the analogy with vision science helps. Vision science attempts to explain how the visual system

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[51] For more research on the relation between central executive system and the brain, cf. Munakata, Y., Herd, S., Chatham, C., Depue, B., Banich, M. & O'Reilly, R. 2011. 453 ff.; Munakata, Y., Snyder, H. & Chatham, C. 2012.

On the connection between the central executive and more complex tasks, see Miyake, A., Friedman, N., Emerson, M., Witzki, A., Howerter, A. & Wager, T. 2000.

On the connection between the central executive and development, learning, or general intelligence, see Munakata, Y., Snyder, H. & Chatham, C. 2012; Anderson, V., Jacobs, R. & Anderson, P. (eds.) 2008; Anderson, P. 2008; Miyake, A. & Shah, P. (eds.) 1999; Conway, A., Jarrold, C., Kane, M., Miyake, A., & Towse, J. (eds.) 2007; Zaitchik, D., Iqbal, Y. & Carey, S. 2014.

On the central executive and the will or self-control, see Inzlicht, M. & Schmeichel, B. 2012; Kurzban, R., Duckworth, A., Kable, J. & Myers, J. 2013.

For attempts to computationally model executive functions, see O'Reilly, R. 2006; Sprague, N., Ballard, D. & Robinson, A. 2007.

Thanks to Ned Block and Susan Carey for pointing out some of this literature to me.

generates a representation of the distal physical environment from the registration of physical intensities on the retina. Progress, initially, consisted in understanding that this process has several stages. Each stage involves a component process, such as image-based processing, surface-based processing, object-based processing, and so on. Identifying the component processes allowed researchers to propose computational models for the information-transformations achieved by the component processes. Identifying the component processes allowed researchers to integrate data from behavioral studies with knowledge about the neural realization of these more tractable processes. Vision scientists were thus able to model in great detail, for example, how the visual system generates surface-representations from representations of edges. These mathematical models became more sophisticated and more widely integrated with research on other phenomena such as visual attention and motor action. Each step of this development constituted explanatory process.[52]

Research on the central executive system has not yet reached a stage of fully successful mathematical modeling. Findings about correlations of executive functions and the brain are preliminary. It seems, nevertheless, that central executive research has advanced from the initial stage to a stage where more tractable problems are better understood. While research on the central executive may not have the status of a mature science, like vision science, its advances do constitute genuine explanatory progress.

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[52] Marr, D. 1982; Palmer, S. 1999; Frisby, J. & Stone, J. 2010; see also Burge, T. 2003a; Burge, T. 2010; Burge, T. 2010a.

Findings involving the central executive system form part of our best understanding of individuals' cognitive activity. Assuming a cautious scientific realism, we should acknowledge that appeals to the central executive system do genuine explanatory work.

The objection according to which appeals to the central executive system do not yield genuine explanations must be rejected.

2.3.2 Homunculus-Charges[53]

Sometimes, objectors support the claim that the central executive system is explanatorily worthless by pointing out that this system is endowed with abilities making it a homunculus. According to these objectors, the central executive system has those abilities of the individual that the system is supposed to help explain.[54] In this sub-section I suggest that the homunculus-charge, too, rests on a misunderstanding of the science. I then show that even if the homunculus-charge were accurate, it would not discredit the central executive system's explanatory value.

In psychology, a primary explanatory purpose of the central executive system is to help explain individuals' abilities to carry out cognitive processes.[55] Examples of such cognitive processes are instances of deductive or inductive reasoning,

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53 Special thanks to Tyler Burge for help with the argument in this section.

54 I will discuss homunculus-worries about the explanation of *agency* in terms of the central executive system chapter 5.

55 See e.g. Baddeley, A. D. 2007.

mathematical calculations, problem solving, and the like. Carrying out such cognitive processes requires the individual to exercise her abilities to reason, calculate, and solve problems. The central executive system does not have abilities to reason, calculate, or solve problems. Rather, it functions to control these cognitive processes.

Of course, the relevant cognitive processes typically involve the exercise of many different psychological competencies. Remember the example of adding the numbers 123,145 and 224,187. Adding these numbers requires some competency with integers. It requires some competency to add. To add the numbers, the numbers must be maintained in working memory. The central executive system must inhibit irrelevant memories of yesterday's lunch. Only some of the competencies activated in this example are executive functions. Competencies other than the central executive functions are involved in the exercise of these cognitive activities. So the central executive system *could not* exercise the individuals' ability to add.

A stronger version of the homunculus-charge insists that exercises of executive functions themselves are exercises of individuals' competencies. According to this version of the objection, *individuals* switch between task sets, encode information into working memory, maintain information in working memory for concurrent tasks, and inhibit irrelevant information and prepotent responses from interfering with the ongoing cognitive process.

To assess this claim, it will be helpful to reflect on the role of the central executive in psychological explanations. The central executive system is just one of the many sub-systems involved in the individual's execution of cognitive tasks. Psychological sub-systems are components of an individual's psychology. These components must be distinguished from the individual herself.[56]

The digestive system is one of the individual's sub-systems. Her stomach and intestines digest the food she eats. We can say that the individual is having difficulties digesting her food. But on reflection, we firmly distinguish between the digesting of the food by her stomach – a process that occurs *inside* the individual – and processes that we attribute to the individual *herself*. The individual's circulatory system transports blood, and so nutrients, through her body. The pumping of blood is a process occurring inside the individual. We attribute the states and events involved in this process to the individual's circulatory system – say, her heart. The individual does not circulate blood or nutrients.

We equally distinguish individuals' *psychological* sub-systems from individuals themselves. The visual perceptual system is one of human individuals' psychological sub-systems. Transformations in the visual system are events inside the individual in the same sense as the circulation of blood or the digestion of food. The computation of lightness from luminance contours is not an event that we attribute to the individual herself.

The distinction between states and events of individuals' sub-systems and those of the individual is *not* the distinction between individuals' acts and states and events

[56] Burge, T. 2010, 327ff. & 369ff.; Burge, T. 2003; Burge, T. 2010b &c.

the individual undergoes. Visual perceptual events and states, such as my perception of the palm tree, are passive. They are not individuals' acts. Nevertheless we attribute them to the individual herself. She sees the palm tree. Her perceptual system does not see anything.

Processes of individuals' sub-systems have marks that indicate that they are activities *inside*, not *of*, the individual. First, the individual does not make transformations in the early visual system occur. Second, digestive events are not accessible to consciousness. Third, the pumping of blood is not an exercise of the individual's central capabilities.[57] Processes bearing one of these three marks tend to not be events at the level of the whole individual, although the marks are not obviously sufficient for a process to occur at the sub-individual level alone. While our intuitive grip on the distinction is firm, it is difficult to draw it sharply. Understanding the distinction is complicated by the fact that sometimes, states and events are *both* attributable to the individual and her sub-system. The visual perception of the palm tree, for instance, is both a state of the individual and her visual system.

The addition of 123,145 and 224,187 occurs at the level of the whole individual. No sub-system of the individual adds numbers. Activity by the central executive system helps *explain* this individual-level event. Its activity explains the organization of different competencies and memories for achieving the goal of carrying out the calculation. Many of the central executive system's activities do not seem to be the

[57] Cf. Burge, T. 2010, 369ff.

individual's activities. The individual adds the numbers. The individual does not always *also* encode 123,145 and 224,187 into working memory. She does not always update working memory with a 2 when she carries the 1. She does not also maintain the memories of these numbers in working memory. The individual plausibly does not always activate a competency for adding integers from long-term memory. She does not always engage in the activity of suppressing irrelevant memories. Nor does she inhibit orienting attention to the blinking lights of Hollywood Boulevard, in many cases. *Those* activities are exercises of executive functions by the central executive system. It seems plausible that often they are events exclusively at the level of this sub-system, not at the level of the individual.

Empirical research tends to support rejecting the stronger version of the homunculus-charge. In a series of experiments, Lavie and Fockert[58] showed that the influence of irrelevant distractors on individuals' cognitive activities depends on the availability of central executive resources. Fockert and Bremner,[59] for example, asked subjects to adjudicate the relative length of two lines arranged as a cross, while maintaining a set of numbers in working memory. During one trial, a small gray distractor square appeared in one of the square's four quadrants. After completing the line task, individuals were asked whether they saw anything apart from the cross and the masks during the experiment. Whether the subjects had noticed the distractor

58 See Lavie, N. & Dalton, P. 2014; also Block, N. 2010.

59 Fockert, J. & Bremner, A. 2011.

depended on the extent to which central processing resources had been occupied. Holding only few numbers in working memory, most individuals did not notice the gray square. When working memory was filled to capacity, individuals tended to detect the distractor. Fockert and Bremner explain that in the latter case, the line task and maintaining the numbers fully occupy central executive resources. No resources are left for inhibiting the irrelevant square. The distractor obtains access to individuals' consciousness. When resources are allocated exclusively to the line task, the central executive system fully suppresses the irrelevant stimulus.

Neither the suppressed distractor, nor the event of suppressing the distractor is rational-access conscious – activated for report or rational processing such as reasoning.[60] This result is, of course, not surprising. Inhibition functions to keep distractors from gaining access to central resources. It seems highly unlikely that the event of suppressing the distractor has a phenomenal quality to it. The distracting stimulus, after being inhibited, is not phenomenally conscious. So neither the inhibition-event, nor the successfully inhibited stimulus seems accessible to individuals' consciousness. Earlier, I introduced the thought that such accessibility marks states and events' being individual-level states. So the experiments by Fockert and Bremner favor the view according to which not all exercises of the inhibitory executive function are attributable to the individual.

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60 Block, N. 1995a; Burge, T. 1997; Burge, T. 2006.

Research by Soto and others suggests that the same reasoning applies to the central executive system's function to encode information into working memory.[61] Soto, Mäntylä, and Silvanto,[62] for instance, asked individuals to attend to and hold in working memory a brief Gabor cue, shown for 16.67 ms, even if they could not consciously perceive it. After a mask, individuals completed a memory test. They had to determine whether the orientation of a newly presented Gabor patch matched that of the original Gabor cue. Next, individuals were asked to indicate whether they had been conscious of the original Gabor cue. Most individuals had not been even dimly aware of the cue. It is often assumed that for a stimulus to become conscious it would have to be presented for at least 80 ms.[63] These individuals' performance on the memory test was nevertheless above chance. Soto et al. ruled out an explanation of this phenomenon in terms of priming. They explain the result on the basis of an unconsciously encoded, unconsciously maintained working memory of the original Gabor cue. This working memory is not available for report by the individuals. It seems questionable that either the working memory state or the event of encoding the Gabor cue is phenomenally conscious. The memory's influence on individuals' performance on the memory task suggests that the working memory might be rational-access conscious at the time of the memory task. But the event of encoding the stimulus is plausibly not rational-access

[61] Soto, D. & Silvanto, J. 2014.

[62] Soto, D., Mäntylä, T. & Silvanto, J. 2011.

[63] Pockett, S. 2002.

conscious. So, as before, the inaccessibility to consciousness of the executive system's encoding of the stimulus suggests that this event is not attributable to the whole individual.

Of course, states in working memory are often attributable to the individual. Individuals sometimes recall information from memory. Sometimes individuals do suppress a tendency to engage in the wrong kind of activity. Individuals sometimes shift goals and hence switch from one cognitive activity to another. Such states and events are then attributable to the individual herself, not merely her sub-system. Just as in the case of vision, these states and events seem to be attributable to *both* individual and sub-system. It is an important and difficult question when and why states and events of the central executive system are the individual's. I do not have a principled answer to this question.

The important point in the present context is that, again as in the case of vision, many states and events of the central executive system seem not to be the individual's. They are occurrences merely at the level of the sub-system. So they are inaccurately described as activities of a homunculus or a theoretical construct endowed with (at least some of the) capacities of the whole individual.

It is even more important to realize that even if the considerations in the preceding paragraphs turned out to be mistaken and the central executive system were a homunculus, explanations in terms of this system would not be without value. So even if the homunculus-charge turned out to be accurate, the objector would be mistaken in concluding that, therefore, the central executive system is not a valid explanatory construct.

To see the truth of this last claim, suppose that the objector is right when she claims that exercises of executive functions are events at the level of the whole individual. Executive functions are, in this scenario, individuals' competencies to control cognitive activity. The central executive system would consist in a set of individual-competencies. It would have turned out, perhaps surprisingly, that in all relevant cases, individuals not merely add numbers. Individuals also switch from one task to the next, maintain numbers to be added, and activate an adding-competence from long-term memory. The psychologist would now rightly ask the same question she asked before: Which are the executive functions? Which executive functions are the basic ones? How do they impact the exercise of basic cognitive activities such as adding? How do basic executive functions interact to explain individuals' performance on more complex tasks? How can research on individuals' control functions be integrated with other research in psychology and neuroscience? While psychology's answers to these questions purport to concern the activity of one of the individual's systems – not the individuals' own competencies – they would be genuine answers even if they concerned the activity of the individual herself. The entire suite of new hypotheses and explanations sketched in the last sub-section would have to be reformulated in terms of individuals' competencies. But new hypotheses and explanations they would be nevertheless. Generating them would constitute genuine explanatory progress.

The individual's adding could be explained in part on the basis of her exercising cognitive control functions such as maintenance and inhibition. Such explanations would be more detailed, more specific, and differentiated than explanations merely in terms of a generic capacity to add. An explanation of the individual's failure to add correctly while maintaining a sequence of letters in memory and being exposed to loud music would not stop with stating these facts. The explanation would point out how maintaining the letters takes up some of the individuals' resources for controlling cognitive activity. It would point out how under these circumstances, fewer resources are available for suppressing interfering stimuli. It would explain that because of these facts, the noise distracted the individual from her addition. Such an explanation would improve on common-sense psychological explanations not by explaining the individual's activities in terms of one of her systems– the central executive system. Rather, it would constitute explanatory progress by differentiating and providing a more detailed account of the individual's operations. This more detailed, more specific, and differentiated explanation would be superior to the common-sense explanation.

I conclude that not only should we reject the accusation that the central executive system does not figure in genuine psychological explanations. Claims to the effect that the central executive system is an over-endowed homunculus are plausibly spurious. They do not justify the accusation that the central executive system has genuine explanatory value.

2.4

Conclusion

The central executive system has not been discussed much in philosophy. I conjecture that there are two reasons for this fact. One is that the status of psychological research on the central executive system is preliminary. The other reason is that research on the central executive system has been dismissed early on, both in psychology and philosophy, as not genuine. We must appreciate that research on the central executive system is at an early stage. So we should exercise caution with respect to some of the details of this research. But there is no reason to dismiss the notion of a central executive system and explanations in its terms as not genuine. I have shown that attempts at such a dismissal are not well grounded.

Chapter 3

Shifts of Attention Guided by the Individual

One of the deep challenges in action theory is to distinguish activity that an individual guides from activity that occurs without the individual's guidance. Harry Frankfurt probably first poses the challenge in his essay "The Problem of Action." There, he criticizes a Davidsonian causal theory of action. On Frankfurt's reading, this kind of theory entails that what constitutes a bodily action is the intention that causes the agent's body to move. For Frankfurt, the intention's causing the movements could not be what makes them an act. When performing an action, rather, the agent is "necessarily in touch with the movements of his body in a certain way."[64] What decides whether her body's movements constitute an act is "whether or not the movements as they occur are *under the person's guidance*."[65]

We intuitively recognize whether an individual guides her acts or not, in many cases. Frankfurt says that when activity is guided, the activity is purposive. He

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[64] Frankfurt, H. 1988, 71.

[65] *ibid*., 72.

distinguishes between the purposive activity of individuals' sub-systems – the circulation of blood by the circulatory system, the digestion of food in the intestines, the dilation of the pupils when light fades – and purposive activity of the individual herself. The *individual* guides only this latter activity. It constitutes the individual's act only when the individual guides this activity. According to Frankfurt, the analysis of "conditions for attributing the guidance of bodily movements [and other processes] to a whole creature rather than the only some local mechanism within a creature"[66] lies at heart of the analysis of agency – for humans and other animals alike. The *problem* of action, for Frankfurt, has two parts: "One is to explain the notion of guided [purposive] behavior. The other is to specify when the guidance of behavior is attributable to an agent."[67]

One may be doubtful whether individuals' guided activity is always purposive. I may be pacing back and forth while talking. I may guide my walking. But it is at least not obvious in what sense my walking is purposive. One may be doubtful whether the individual guides *all* her acts. Reflex actions such as my moving my head to the right when I see a knife thrower's weapon fly toward me may not be under my guidance.[68] But Frankfurt's basic insight is valid. Understanding individuals' guidance is central to understanding their agency.

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66 *ibid.*, 78.

67 *ibid.*, 74.

68 The example comes from Sean Foran. Cf. Burge, T. 2010, 334/5 Fn. 62.

Little progress has since been made in understanding guidance. Current action theory is not of much help in understanding it. I will discuss some of the extant proposals in chapter 5. In the present chapter, I try to make some progress in understanding guidance by drawing upon psychological research. I focus on shifts of attention. The psychology of attention shifts is highly developed. It constitutes a rich source for better understanding the psychological processes implementing individuals' guidance of such shifts.

In section one, I start from salient examples of attention shifts guided by their agents. I contrast these cases with passive attention shifts occurring without individuals' guidance. I then, in section two, explain and illustrate some of the psychology of these shifts. An initially plausible proposal has it that active and passive shifts are caused by the endogenous and exogenous attentional system, respectively. In section three I explain why this proposal is overly simple – the two systems interact, and not all endogenous factors are plausibly guiders of actions.

In section four I show that at the level of psychological processes, the central executive system's control of attention most closely correlates with individuals' guidance. I propose that central executive control is partly constitutive of individuals' guidance. A better understanding of the psychology of guided shifts provides a deeper understanding of the notion individual's guidance. I continue to support, and elaborate on, this result and its consequences for action theory over the following chapters.

3.1

Active and Passive Shifts: Some Cases

The following cases illustrate active and passive shifts of attention. They illustrate individuals' guidance of their attention shifts.

Suppose that a child intends to look at her own face in a mirror. She shifts her attention to the mirror and focuses on the reflection of her face. The child relies on a memory of her face in the mirror to guide the shift there. Suppose that a macaque is foraging for raspberries. The monkey searches the bushes that usually carry them. He guides his visual attention to a leaf and then fixates a twig. Next he fixates a red bug resembling the berry. The macaque relies on a perception-like memory of the berry in his search. He continues to systematically guide attention in search of berries until he finds them and his hunger is satisfied.

These individuals' shifts of attention are *active* shifts. I will refer to the first kind of attention shift as a 'focusing of attention' – away from current fixation and onto a new object, location, or region in space. When the individual guides visual attention to the new location, she exercises her agency. Shifts of the second kind are shifts during visual search. Individuals shift their visual attention between locations in the visual scene and search these locations for the target of their search. Individuals often guide each individual shift of visual attention in a sequence of shifts constituting a visual search.

In contrast, suppose that the macaque is back with his group. He is being groomed. A fellow macaque works through his coat. Enjoying the procedure, the monkey stares at his surroundings. He is not engaged in any active behavior. What he *sees* is not put to any immediate use. Nevertheless, his eyes and attention are shifting. The macaque is looking around without any immediate specific purpose. His attentional system is in a state of default activity, similar to the respiratory system's activity during breathing.[69] Or suppose a bright, spider-shaped object abruptly appears in the periphery of the child's field of view. The object's appearance disrupts the child's self-scrutiny in the mirror. Her attention rapidly shifts to the object. The object captures the child's attention.

The individuals do not actively shift attention in either case. I will refer to shifts of the first kind as 'default attentional activity.' When individuals' attention moves during the default state, the individuals do not guide these shifts. Shifts of the second kind are shifts due to capture of attention. Again, it is not the individuals that guide those shifts. As will become apparent in the next section, these shifts are entirely caused by individuals' sub-systems.

What distinguishes these cases of active and passive shifts? When do individuals guide their attention shifts? When do their sub-systems cause them? I will develop a

[69] I distinguish this case from active vigilance, which can be overtly similar to mere looking but constitutes an exercise of individuals' agency.

partial answer to these two questions over the course of the next several sections. I derive the proposal from a close reading of the psychology of attention shifts.

3.2
Exogenous and Endogenous Shifts

3.2.1 Exogenous and Endogenous Systems

In his influential cueing-paradigm, Michael Posner provided empirical evidence for the existence of two fundamentally distinct systems for orienting attention: the exogenous and the endogenous system.[70]

Posner et al. instructed individuals to find and identify a target in a display. Posner et al. asked individuals to focus attention at a fixation point on an otherwise empty screen. Next, they showed a display with a cue for target-location. The final display presented the target.

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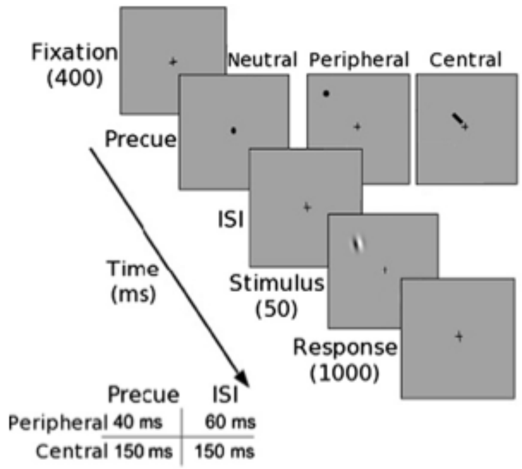
70 Posner, M. 1980; Posner, M., Nissen, M. & Ogden, W. 1978.



[The illustration shows the different displays used in Posner's 1980 study. From Carrasco 2011.]

Posner et al. varied both type of cue and cue-validity. All cues purported to indicate the future location of the target. Invalid cues correctly indicated a location in only 20% of the trials. Valid cues did so in 80% of the trials. Cues were symbolic or direct. Symbolic cues appeared at fixation point. The individuals could interpret valid symbolic cues as indicating the location of the upcoming target. For example, a symbolic cue could be an arrow pointing at the future location of the target. Direct cues – often, small dots or bars – briefly appeared at or close to the purported future location of the target.

Trials in which type of cue and cue-validity varied were compared with neutral trials. In these latter trials, a neutral cue appeared at fixation point. The cue carried no information about the future location of the target. Individuals shifted attention to the target more rapidly on the basis of valid cues. Their performance slowed down when cues were invalid. In these cases, the location indicated by the misleading cues attracted their attention.

Posner et al. found evidence for two distinct, albeit not sharply distinguished, systems for orienting attention. The endogenous system carries out symbolic shifts, direct cues cause shifts through activity of the exogenous system. The two systems carry several signatures, some of which Posner identified.[71] They differ with respect to the stimuli that they respond to. They also differ with respect to how accessible and penetrated they are.[72]

Manipulation of cue validity most strongly affected uses of symbolic cues. It had hardly any effect on trials involving direct cues. When symbolic cues provided individuals with incorrect information, individuals ceased to rely on them for detecting the target. Invalidity of direct cues did not lead to improved performance, even after a series of trials. Individuals could not implement the expectation that the cues would mislead them. They could not ignore the invalid direct cues. Individuals continued to

71 Wright, R. & Ward, L. 2008, 24; Carrasco, M. 2011, 1488.

72 The distinction between these two factors is derived from Fodor's discussion of accessibility and encapsulation. Cf. Fodor, J. 1983. See also Burge, T. 2010. Neither of these notions is very sharp. They can nevertheless serve to highlight features of attention shifts bearing on whether they are active or not.

shift attention to the locations cued by the briefly flashing bars or dots. Individuals could not ignore invalid cues even when explicitly instructed to do so.[73]

The exogenous system responds to stimuli that are physically salient. It responds to some stimuli, detection of which was of special evolutionary importance. The system responds to bright stimuli against a dim background, to horizontal shapes against a background of vertical shapes, to green objects amidst predominantly red objects, to rapidly appearing objects against a stable backdrop. In short, to stimuli that stand out from their environment. Specific visual stimuli may have been of special importance for an animal's survival. Shapes of predators such as spiders or snakes, or the shapes and movements of conspecifics and mates are examples. Evolution has shaped the attentional system so as to respond to these stimuli just as it would respond to physically salient stimuli. The endogenous system's activity, on the other hand, is not restricted to any specific type of stimulus.

The endogenous system's states and events often are, or are *accessed* by, the individual's central states and events. The system's states and events include central states such as intentions, beliefs, expectations, or goals. They are, or could become, rational-access conscious.[74] Its states and events are often available for higher, non-modular and amodal processing such as decision-making and inference. Human individuals can often report being in those states or undergoing such events. Individuals

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73 Jonides, J. 1981.

74 Block, N. 1995a; Burge, T. 1997; Burge, T. 2006.

typically do not access activity, states, or events of the exogenous system in any of these ways. Many of its states and events are not accessible in principle.

States and events of the endogenous system are often *penetrated*. They are, or are under the influence of, the individual's current central states – her current intentions, goals, beliefs, decisions, but also amodal states with non-conceptual structures. In Posner's experiments, for example, individuals developed an expectation that invalid symbolic cues would mislead them. They presumably formed an intention to not rely on these cues. Both their expectations and intentions were central states that subsequently influenced, indeed determined, where the endogenous system shifted attention. Central states and events have little effect on the activity of the exogenous system. In the Posner paradigm, individuals' intention to ignore invalid direct cues had basically no impact on these cue's negative influence on their attention shifts. The states and events of the exogenous system are typically not penetrated. Many of its states and events are in principle beyond central states' influence.

A difference in the evolutionary function of the two systems partly explains these different signatures. The exogenous system is presumably the phylogenetically older system. It is a warning system that disrupts individuals' current behavior in the face of behaviorally highly relevant stimuli. It functions to rapidly detect and orient the individual towards highly salient stimuli, abrupt onsets, danger, mates, and food. Since it functions as a warning system, the operation of this system is very difficult, sometimes impossible to suppress. The phylogenetically more recent endogenous system functions to support planned, goal-directed behavior. This system shifts attention when the individual needs to gather information about her environment, or for the control of individuals' intentional bodily actions.[75]

The core attentional system constituted by its exogenous and endogenous components is grouped around a *priority map*. The priority map is the representational content of a psychological state. I will refer to the state itself as the priority map state. The priority map is a topographical representation of the visual scene. The map assigns priority values to objects and locations in the scene. Locations and objects have priority *for* shifting attention to them. Attention shifts to the location with highest priority. Both the exogenous and endogenous systems generate assignments of priority on this map. When attention shifts exogenously, the exogenous system determines the priority assignment on the map. The endogenous system determines priority values on the priority map for endogenous shifts. Behavioral, brain, and computational studies converge in relying on such a map for understanding the activity of the exogenous and endogenous systems.[76] In what follows, whenever I describe how different systems or

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[75] The endogenous and exogenous systems are not only behaviorally and functionally, but also anatomically distinct. Two different, but overlapping neural networks realize the core attentional system. The endogenous system is instantiated mainly in dorsal, posterior parietal, and frontal cortex. Subcortical networks, on the other hand, mostly realize the exogenous system. There is less agreement about the details for this latter system.

Cf. Corbetta, M. & Shulman, G. 2002; Shipp, S. 2004; Gottlieb, J. 2007; Wright, R. & Ward, L. 2008; Carrasco, M. 2011.

[76] See, for instance, Koch, C. & Ullman, S. 1985; Itti, L. & Koch, C. 2000; Zelinsky, G. 2008; Najemnik, J. & Geisler, W. 2009. I discuss the priority map more fully in Chapter 4.

states help shift attention, it should be understood that they do so by influencing priority assignments on the priority map.

3.2.2 Active and Passive Shifts: A Preliminary Proposal

Psychologists sometimes refer to exogenous (or reflexive, transient, bottom-up) shifts as passive or involuntary shifts. They sometimes identify endogenous (or sustained, top-down) shifts with active or voluntary shifts.[77]

What plausibly motivates psychologists to refer to the first class of shifts as *exo*genous is that these shifts seem to be often entirely driven by physical properties of the sensory stimulus. The source of these shifts hence seems external to the individual. Individuals' goals, intentions, and beliefs influence and effect *endo*genous shifts, on the other hand. These shifts' sources lie within the individual, in some sense.

When individuals guide their activity, it is natural to assume that they access their activity and the states informing the activity. It is natural to think that such states and activities are, or are penetrated by, the individuals' central states and events. Shifts by the endogenous system often have these features. States and events of the exogenous system, however, are often inaccessible and not penetrated.

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[77] James, W. 1890, 416; Carrasco, M. 2011; Wright, R. & Ward, L. 2008.

This difference in the shifts' sources and in their properties plausibly explains why psychologists sometimes refer to endogenous shifts as active and exogenous shifts as passive.

Explanations in psychology typically do not appeal to notions like agency or guidance. Much of psychology does not have agency as its topic. But plausibly, agency is a psychological kind. Psychologists themselves sometimes distinguish exogenous and endogenous shifts as passive and active shifts respectively. The background of assumptions and intuitions against which psychologists introduce the two orienting-systems suggests using this distinction to understand the distinction between active and passive shifts. Together, these considerations suggest a partial solution to Frankfurt's problem of action, at least for attention shifts. They suggests a preliminary proposal as to when individuals guide shifts of attention and when their sub-systems do.

Preliminary Proposal

> Active shifts of attention, guided by the individual, are driven by endogenous factors alone. Passive shifts are driven by exogenous factors alone.

I will explain, elaborate on, and qualify this preliminary proposal throughout the rest of this chapter.

3.2.3 Empirical Support for the Preliminary Proposal

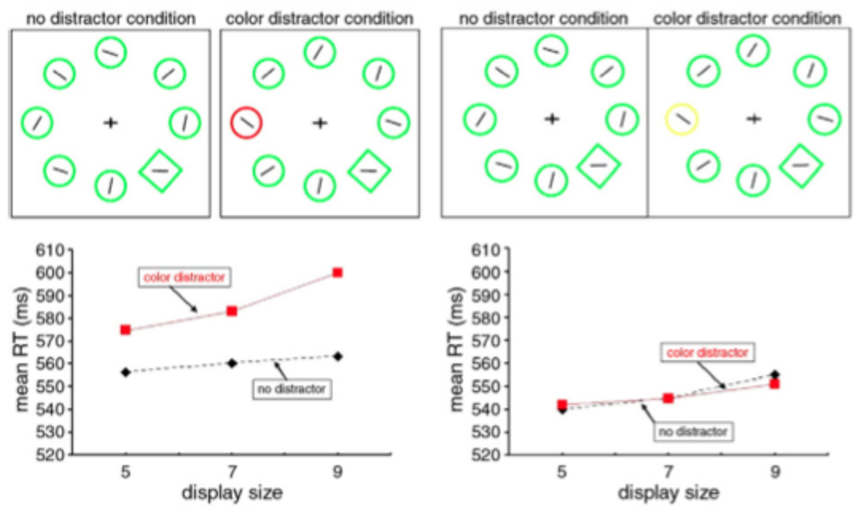
Empirical research on the focusing of attention, capture of attention, and attentional default activity provides initial support for the preliminary proposal. When individuals guide their visual attention to a location to focus it there, endogenous factors alone drive their shifts. During default activity and capture, the exogenous system alone shifts attention.

A stimulus *captures* attention when it is of high physical saliency or behavioral relevance. When a stimulus captures attention, it disrupts or overrides individuals' guidance. Properties of the stimulus and principles governing the individuals' exogenous system control shifts during capture.

Only shortly after Posner's study, Yantis and Jonides[78] provided evidence that attentional capture is due to the exogenous system's operation. Starting from their work, Theeuwes showed that when a stimulus captures attention, it is not under the influence of the endogenous system.[79] In Theeuwes' paradigm, individuals directed attention to a

78 Cf. Jonides, J. 1981; Yantis, S. & Jonides, J. 1984; Yantis, S. & Jonides, J. 1990. Shifts during capture exhibit signature time courses of shifts driven by the exogenous system.

79 Theeuwes, J. 1991a; Theeuwes, J. 1991.



[Displays and search times in Theeuwes' singleton-distractor paradigm. From Theeuwes 2010.]

singleton diamond shape among circles arranged around fixation.

In one set of trials, Theeuwes added a colored distractor to the display. In the neutral condition, all items had the same color – green. When the distractor was added, one of the circles was red. Theeuwes investigated the effect of the distractor circle on how individuals shifted attention.

Individuals knew they had to search for a singleton *shape*. The color of the display-items was irrelevant to their search. Theeuwes reasoned that individuals would suppress shifting attention to irrelevant items. In a subsequent experiment,[80] Theeuwes let individuals explicitly know the particular shape they had to search for – a diamond

[80] Theeuwes, J. 1992.

shape, for example. Individuals thus knew that whatever the distractor item, it did not have the feature defining the target.

Slower reaction times indicated that individuals did not succeed in suppressing disadvantageous shifts to the distractor. Studies of individuals' eye movements confirmed this result.[81] Individuals frequently moved their eyes, and hence shifted attention, to the red distractor. Theeuwes concluded that the individuals' attention shifts to the distractors were insensitive to their intentions and expectations. Just like the appearance of the spider disrupted the child's scrutiny of her in the mirror, Theeuwes' distractors overrode individuals' endogenously driven search for the diamond.

Individuals in these experiments did not guide their attention to the distractors. Attention is captured precisely when the influence of the stimulus and the operation of the exogenous system override the influence of current central states. These central states do not penetrate shifts in attentional capture. The state of the exogenous system that causes attentional capture is inaccessible to the individual. Highly salient stimuli presumably capture attention when they surpass a threshold set by the exogenous system.[82] So shifts during capture are explained on the basis of principles governing the activity of the sub-system alone.[83]

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[81] Godijn, R. & Theeuwes, J. 2003.

[82] Cf. Wright, R. & Ward, L. 2008. The threshold depends on context.

[83] Early psychological research on attentional capture contains two mistakes.

The first mistake was that researchers assumed that whenever individuals' reaction time during search for an item was independent of the number of items in the display, attention was captured. This assumption does violence, however, to the ordinary notion of captured attention. In the intuitive cases of

These features of shifts due to capture support the intuition that the shifts are passive. They underscore that the individual does not guide these shifts.

When the attentional system is in its *default state* the exogenous system shifts attention on the basis of specific saliency-based attentional routines.

Several behavioral studies have shown that in absence of current visual tasks, the attentional system relaxes into a default mode of orienting to whatever is relatively unusual or salient in the present context.[84]

In the default mode, individuals often first perform large, overview saccades when confronted with a new visual scene.[85] Saccades next center on areas in the display that typically are of relevance, such as regions most likely containing animals. After the initial overview saccades, attention shifts between relatively salient locations. Typically, attention in the default mode shifts regularly and continuously. Attention fixates on locations for only short, approximately equal durations.

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attentional capture in section I above, the capturing stimulus interrupted or overrode individuals' ongoing attentional activity.

The second mistake was to think that capture is *strongly* automatic. Researchers assumed that a salient stimulus overrides the individuals' endogenous control under all circumstances. But attentional capture is not strongly automatic. Rather, capture is a function of the relative strength of endogenous factors and the intensity of the salient stimulus.

Cf. Lamy, D. 2008.; Yeh, S. & Liao, H. 2008; Giordano, A., McElree, B. & Carrasco, M. 2009; Carrasco, M. 2011; Folk, C., Ester, E. & Troemel, K. 2009; Lamy, D., Leber, A. & Egeth, H. 2012; Rauschenberger, R. 2003; Ruz, M. & Lupianez, J. 2002.

84 Pashler, H. 2001; Bacon, W. & Egeth, H. 1994.

85 Findlay, J. & Gilchrist, I. 2003.

Saliency-based models predict that attention shifts to locations that are physically salient. The most influential saliency-based model is Itti et al.'s.[86] In this model, locations are physically salient when they contrast along a feature dimension with other close-by locations. The model computes local feature contrast along several feature dimensions such as color, luminance, orientation, or texture. Saliency values for different feature dimensions are then averaged in a central saliency map. The computation of saliency yields a ranking of locations as regards priority for attention shifts on the priority map. This ranking determines the sequence of locations to which attention shifts.

Studies of eye movements confirm that the attentional system often executes saliency-based attentional routines in the default state. Attentional routines are sequences of attention shifts. These sequences are highly patterned and stereotyped. They are highly similar between individuals. Individuals cannot access the states generating these attentional routines. A sequence of shifts in the default state is not directly informed by individuals' beliefs, intentions, and goals. These states do not penetrate default shifts of visual attention. When the macaque shifts attention while being groomed, none of his central states drive these shifts. Relatively salient locations in his environment attract his attention.[87]

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[86] Itti, L. & Koch, C. 2000; Geisler, W. & Cormack, L. 2011.

[87] Ullman, S. 1984; Ullman, S. 1996, Chapter 9; Hayhoe, M. 2000; Cavanagh, P., Labianca, A. & Thornton, I. 2001; Cavanagh, P. 2005.

Individuals do not guide shifts in the default state. Rather, attention shifts in accordance with attentional routines that are plausibly governed by transitions described by saliency-based models. The almost exclusive reliance of these attentional routines on physical saliency and their being largely not accessed or penetrated supports the intuition that these shifts are passive.

Posner's cueing paradigm, of course, describes an instance of the *spatial focusing* of attention. When individuals focus attention at some specific location, an endogenous factor – for example an intention to shift to the location – drives the shift.

In another set of experiments, Theeuwes[88] investigated whether the exogenous system influences such attention shifts. In his experiments, individuals searched for a target-letter amongst three distractor letters. A symbolic cue reliably indicated the location where the target letter would appear. In the following display, an abrupt onset distractor appeared randomly at one of the four possible target-locations. The target display featured all four letters, including the target letter. This last display was shown until individuals found the target. Since the symbolic cue was reliable, Theeuwes expected individuals to focus attention at the indicated location.

Individuals took between 300 ms and 600 ms to focus attention at the symbolically cued location. Theeuwes found that when individuals had time enough to do so, the following peripheral onset cue had no effect whatsoever on reaction times. When the distractor flashed 200 ms after presentation of the cue, individuals did not

[88] Theeuwes, J. 1991; Yantis, S. & Jonides, J. 1990.

have sufficient time to focus attention at the target location. In this condition, the abrupt onset distractor slowed individuals' search and was more likely to attract attention.

When individuals guide their attention to some specific location to focus it there, their endogenous system implements the shift. The exogenous system does not influence the endogenous system's activity. The individual's shift is both accessed and penetrated by the intention. This fact supports the intuition that the individual guides these shifts. It underscores the shift's being active.

In spite of its initial plausibility, the preliminary proposal is overly simple. I briefly elaborate on its shortcomings in the next section. In the following section I propose an amended version of the proposal.

3.3
Interactions: Drawn Attention

3.3.1 Shifts Drawn by Exogenous Factors

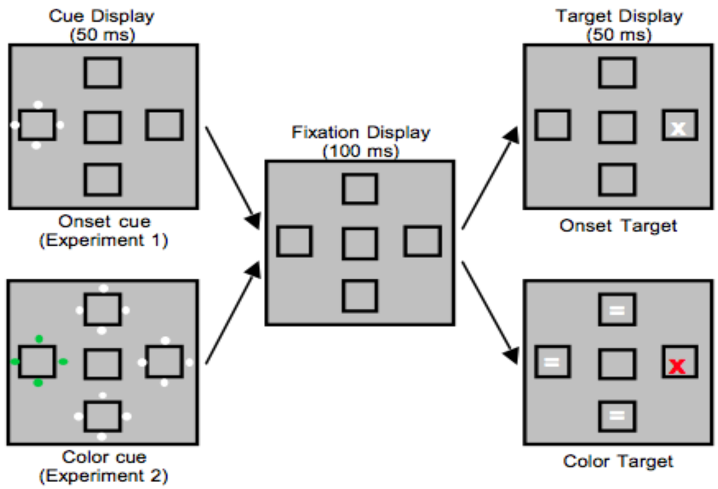
The preliminary proposal has two major shortcomings. One shortcoming is its inability to accommodate interactions between the endogenous and exogenous systems. The other is that the nature of the endogenous factors implementing individuals' guidance is underspecified. I discuss both shortcomings in turn.

According to the preliminary proposal, when an individual guides her attention shift, the endogenous system alone determines priority assignments to locations on the priority map. In passive shifts, the exogenous system determines which locations have priority.

Many shifts that the individual guides, however, result from the interaction of the endogenous and exogenous systems. Attention shifts during visual search are paradigmatically active shifts. The macaque guides his visual attention from one location to the next in his search for berries. Shifts during visual search *typically* involve the interaction of exogenous and endogenous systems. In visual search, priority on the map results from exogenous information about the stimulus and the individual's endogenous goals. This fact raises the question as to when individuals guide such shifts resulting from interaction and when not.

Folk, Remington and Johnston conducted a series of experiments showing that endogenous factors can to some extent shape the activity of the exogenous system.[89] They asked one group of individuals to locate an abruptly appearing letter. Of four possible locations in the search display, three were empty. In the fourth, the letter would appear. Another group of individuals located a color singleton target. In this set of trials, all four locations contained characters. Only the target stood out in color. The cue for *both* types of trial was an abrupt onset configuration, a set of small circles flashing around one of the possible locations.

[89] Folk, C., Remington, R. & Johnston, C. 1992, 1035.



[Cue, fixation, and target displays in the Folk et al. paradigm. From Theeuwes 2010]

Folk et al. found that valid cues shortened reaction times relative to the condition in which no cue was present. Invalid cues, however, increased reaction times *only* when the target was an onset. Search time exhibited no effect if cue and target did not share features.

Folk et al. concluded that abrupt onsets and singletons did not invariably attract attention. Rather, they conjectured that endogenous factors could sometimes configure the exogenous system to respond selectively to specific properties of stimuli that are relevant to the task at hand.[90]

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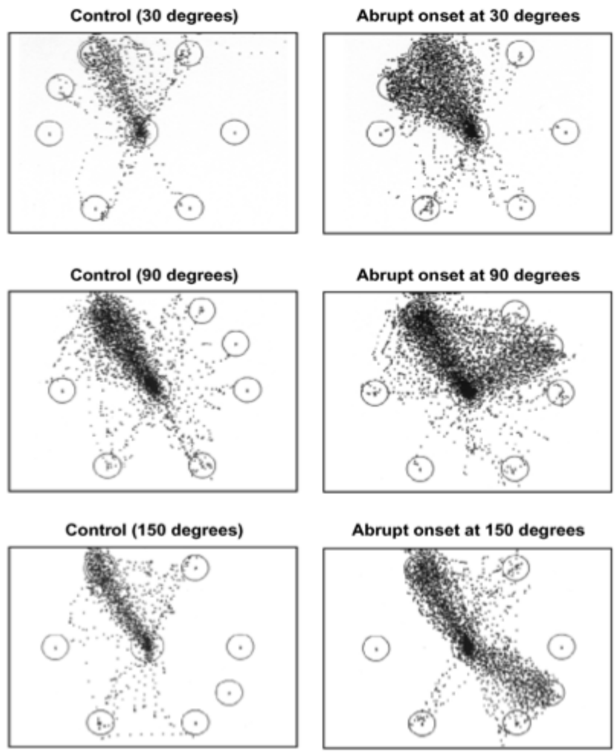
90 Folk, C., Remington, R. & Johnston, C. 1992, 1041ff.

In Folk et al.'s experiments, an endogenous goal drives and constrains the individual's shifts. The exogenous system responds to stimuli of a type determined by the goal. The exogenous system's influence on such endogenously driven shifts does not invariably constitute capture of attention. When the exogenous system does not fully override or interrupt endogenously driven shifts, I will say that attention is *drawn* by a stimulus.

When the onset draws attention to the location of the target, it *enhances* the individual's search. The individual initiates the search. Her search goal configures the exogenous system to be sensitive to onset items. Simultaneously, her attention is attracted by the onset cue. Although the individual relies on the exogenous system to perform the search, she guides the shifts towards the search goal.

When the onset draws attention away from the target's location, it *interferes* with the individual's search. Interference can be of two kinds. One is the kind familiar from Folk et al.'s study. Here, the individual has the goal of finding a stimulus of a certain type. The exogenous system responds to stimuli of that type. The distractor cue, even though a stimulus of the right type is not the target, however. The individual guides her attention shift to the distractor, but her reliance on the exogenous system results in a brute mistake.



[Endpoints of saccades in Theeuwes' paradigms. From Godijn & Theeuwes 2003]

Alternatively, distractors that do *not* match the individual's goal can draw attention. Physically salient distractors detrimentally influence individuals' search. The exogenous system guides attention toward the salient distractor, but is not strong enough to capture individuals' attention. The individual is still guiding her attention shifts.

Research on eye movements illustrates ways in which attention can be drawn away from a target. Theeuwes et al.[91] monitored individuals' eye movements in the singleton and abrupt onset experiments described earlier. The search was initiated by the individual's intention to find the target. When no distractor was present, saccades went directly to the target. In other instances, saccades went to a distractor at a location almost diametrically opposed to the location of the target. It seems likely that the influence of the distractor at almost 150º of the target-location has entirely overridden the influence of the individual's goal, at least for a short time. The distractor captured attention. In 30-40% of the trials when a distractor-singleton was present, however, saccades went in the direction of the distractor, stopped briefly, and then fixated the search target. In these cases the distractor drew attention, but was not strong enough to capture it.

Drawn attention plausibly causes certain characteristic types of eye movements.[92] Individuals who know that a distractor or a cue is invalid and attempt to avoid fixating on them exhibit trajectories curved away from the stimulus. These saccades suggest that the endogenous system counteracts the distractor's influence. They exhibit how the distractor influences the endogenous system, which prevents

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[91] Theeuwes, J., Kramer, A. Hahn, S. Irwin, D. & Zelinsky, G. 1999; Godijn, R. & Theeuwes, J. 2003.

[92] Walker, R. & McSorley, E. 2008.

capture by suppressing the distractor's increased priority. Since the system resists the distractor's influence, the distractor does not capture attention.

Another type of trajectory plausibly showing distractors' influence exhibits curvature towards the stimulus.[93] When monitoring eye movements during tasks like those devised by Theeuwes and Folk et al., researchers found attraction of saccades to the distractor that the system overcame before fixating on the distractor. Thus the saccade first aimed for the distractor, curved away from it before reaching it, and eventually fixated the target. The distractor was salient enough to modulate priority for its location on the priority map and cause an initial shift in its direction, but the influence of the goal was strong enough for the endogenous system to inhibit the erroneous shift and drive it towards the target.

Attention is *drawn* when stimuli attract attention but do not override or disrupt the individual's guidance. The empirical research presented here illustrates the phenomenon of drawn attention.[94] It shows that a fuller characterization of individual's guidance should allow that guided shifts can be drawn. Guided shifts can result from the interaction of endogenous and exogenous systems.

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[93] McPeek, R., Han, J. & Keller, E. 2003; Walker, R., McSorley, E. & Haggard, P. 2006; McSorley, E., Haggard, P. & Walker, R. 2004; Findlay, J. & Walker, R. 1999.

[94] I am not aware of a full scientific account of the psychological processes underlying the distinction between drawn attention and captured attention. I do not know, then, how to sharply draw a line between cases in which a goal still drives a shift and is drawn by a distractor, and cases in which the influence of the goal is overridden and the distractor captures attention.

3.3.2 Shifts Drawn by Non-Guiding Endogenous Factors

The second shortcoming of the preliminary proposal is that the endogenous factor implementing individuals' guidance is underspecified. Psychology considers a wide range of factors to be 'endogenous.' Earlier, I mentioned intentions, beliefs, expectations, and goals, among others. The class of 'endogenous' factors discussed by psychologists is even larger. Active *and* passive shifts exhibit the influence of factors that psychologists consider 'endogenous.' But not all such factors correlate with and plausibly constitute individuals' guidance. These factors, too, draw attention. They do not guide it.

Individuals can be *primed* to be more sensitive and react more readily to certain stimuli.[95] If an individual repeatedly searches for a green diamond, she will get faster at finding green diamonds. Once primed for green diamonds, the individual will find it more difficult to ignore green diamonds during subsequent searches – even if now she is looking for a red circle.

Associations of past *reward* with types of stimuli similarly affect individuals' performance on current search tasks.[96] If green diamonds, in the individual's past, were

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[95] Kristjansson, A. & Campana, G. 2010; Kristjansson, A. & Nakayama, K. 2003; Fecteau, J. & Munoz, D. 2003; Maljkovic, V. & Nakayama, K. 1994; Maljkovic, V. & Nakayama, K. 2000; Chun, M. & Nakayama, K. 2000; Pinto, Y., Olivers, C. & Theeuwes, J. 2005.

[96] Della Libera, C. Chelazzi, L. 2006; Anderson, B. 2013; Anderson, B. & Yantis, S. 2013; Anderson, B., Laurent, P. & Yantis, S. 2011a; Anderson, B., Laurent, P. & Yantis, S. 2012.

associated with some kind of reward – indicating a food source – the individual's attention shifts will be more likely attracted by them, even if she is engaged in a search for a red circle.

Individuals store statistical information about *configurations* in visual scenes.[97] When a search target consistently appears at a certain distance and angle from, say, a heptagon of vertical bars, individuals more readily shift attention to a location at the same distance and angle from such a configuration. The memory for the configuration draws attention to the location.

Individuals store large amounts of information about *objects and scenes* in long-term memory.[98] These memories, too, influence how individuals shift attention. Suppose the individual is searching for a certain type of food. The individual finds herself in an environment where predators are likely to stalk her in lower branches of certain types of trees. The individual will be more likely to shift attention to the lower branches of those trees even if such shifts of attention interfere with her search for the food.

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[97] Chun, M. & Jiang, Y. 1998; Cf. also Chun, M. & Jiang, Y. 1999; Chun, M. & Jiang, Y. 2003; Chun, M. 2003; Chun, M. & Nakayama, K. 2000; Chun, M. & Turk-Browne, N. 2008.

[98] Bar, M. 2004; Brady, T., Konkle, T., Alvarez, G. & Oliva, A. 2008; Konkle, T., Brady, T., Alvarez, G. & Oliva, A. 2010; Brady, T., Konkle, T. & Alvarez, G. 2011; Hollingworth 2005; Hollingworth, A. 2008; Wu, C., Wick, F. & Pomplun, M. 2014; Hollingworth, A. 2014; Oliva, A. 2005; Torralba, A. 2003.; Torralba, A. 2005; Torralba, A., Oliva, A., Castelhano, M. & Henderson, J. 2006; Brockmole, J., Castelhano, M. & Henderson, J. 2006; Brockmole, J. & Henderson, J. 2006a; Brockmole, J. & Henderson, J. 2006b; Eckstein, M., Drescher, B. & Shimozaki, S. 2006.

All these endogenous factors draw attention. The influence of these endogenous factors is largely not accessed and not penetrated. Shifts due to these influences can be largely explained in terms of the activity of the underlying memory systems alone. As in the case of the exogenous system's influence on shifts, these points support the intuition that none of these factors constitute the guidance by the individual of the associated shifts.

But these properties of factors modulating attention shifts can at best serve as a heuristic for factors that constitute individuals' guidance. Even working memory can *draw* attention. And working memory representations are accessed; working memory representations are not only penetrated by individuals' current activated central states – they are *among* these states.

When individuals hold the color of a circle in working memory, for example, subsequent search for a diamond will be influenced by this memory.[99] Suppose an individual searches a display that contains the target, but also distractors, one of which has the memorized color. Individuals are then more likely to guide attention to that distractor. Their search times increase and attention shifts decrease in accuracy.

The representation stored in working memory influences the individual's shifts of attention during her visual search for the diamond. The influence from working memory interferes with the individual's search. But since even the shift to the distractor

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99 Soto, D., Humphreys, G. & Heinke, D. 2006; Soto, D., Hodsoll, J. Rotshtein, P. & Humphreys, G. 2008; Soto, D., Humphreys, G., Heinke, D. & Blanco, M. 2005; Downing, P. 2000; Downing, P. & Dodds, C. 2004; Olivers, C., Meijer, F. & Theeuwes, J. 2006.

that has the circle's color is driven by the individual's goal, the individual guides this shift. Things go wrong – the individual makes a mistake in shifting attention to the distractor; her attention is *drawn* to the distractor. She nonetheless guides her shift.

Exogenous and endogenous factors alike draw attention. None of the factors discussed decide whether the individual guides her attention shift.

3.4

Shifts Guided By the Individual

I will now present, explain, and provide empirical support for, a partial solution to Frankfurt's problem of action, as applied to attention shifts. I make a proposal as to what endogenous factor partly constitutes[100] the individual's guidance of her active shifts.

Active Shifts of Attention

> The central executive system's control over an individual's active shifts of attention partly constitutes the individual's guidance of these shifts. Shifts controlled by the central executive system are active shifts, guided by the

[100] I here establish only the *correlation* between individuals' guidance and central executive control. I argue for a slightly modified proposal about the *constitution* of guidance in chapter 5.

individual, even when they are drawn (but not captured) by exogenous or other, non-guiding endogenous factors.

As I detailed in the last chapter, the central executive system functions to control individuals' cognitive processes. These processes may, or may not, be exercises of agency. The central executive system controls processes like problem solving, remembering, deductive inference, calculations, and so on.[101]

The central executive system organizes and coordinates central processing and storage resources for the implementation of individuals' goals and the execution of cognitive processes more generally. Central resources are resources for executing central processes – processes that involve the transformation of central, non-modular and amodal, states.

The central executive system controls such processes, at the most basic level, by flexibly allocating processing and storage resources to the respective processes.

Three executive functions are signature competencies associated with the central executive system. They constitute ways in which the central executive system allocates its resources. The executive functions are the abilities to *switch* mental set, *maintain* relevant memories, and *inhibit* prepotent responses and distractor stimuli. Switching

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[101] The system presumably plays an important role in the control of bodily action, too. This role is not as well understood as the system's role in controlling mental processes. Hence I focus on instances of purely mental operations. For a more extensive discussion of the central executive system, see Chapter 2.

consists in the process of abandoning one cognitive process or task and initiating another. It is an exercise of a competence to organize different, competing activities at a time, and over time. Maintenance is the activation and holding active of relevant long-term memories and of encoding incoming task-relevant information in working memory, in the service of ongoing cognitive processes. Inhibition of prepotent responses and distractors is the process of suppressing irrelevant cognitive processes and stimuli. It consists not merely in withdrawing central resources from cognitive processes and stimuli, but in suppressing their influence on the execution of ongoing tasks.

The central executive system is one of the many psychological systems that enter psychological explanations. We must distinguish it from the individual herself.[102] Individuals act. Individuals guide their acts. Psychological *systems* do not act. But individuals' exercises of agency rely on the activity of these individuals' sub-systems. The psychological systems implement individuals' acts. My main point in this chapter is that all exercises of individuals' agency in shifting attention correlate with the central executive's control over the attentional system in psychological explanation. Central executive control is absent from cases of passive shifts. I propose that the central executive system implements the individual's guidance of these acts.

The proposal, if true, contributes to a solution of Frankfurt's problem of action at least for attention shifts. Frankfurt tried to understand what it is for a process to be

102 See again Chapter 2.

purposive or guided. He tried to understand when this guidance is the individuals', as opposed to that merely of one of her sub-systems. Individuals guide their attention shifts when the central executive system controls them. Attentional activity is purposive when the central executive system directs it towards some goal. They are attributable to the individual partly because the central executive system controls them.

The central executive system forms part of the endogenous system for shifting attention. The central executive system controls attention shifts, even in cases where exogenous factors, or specific endogenous factors draw attention and interfere with search. In making room for these factors, the present proposal improves on the preliminary proposal.

3.4.1 Central Executive Control of Active Attention Shifts in Visual Search

Remember the macaque's visually searching for a raspberry. The monkey guides his attention from a leaf, to a twig, to a bug. He continues to shift his visual attention across the brushes until he has found the raspberry.

The central executive system implements the individuals' guidance of their attention shifts. It is the factor, at the level of explanation in terms of psychological systems, whose activity corresponds to and realizes part of the agency that the individual herself exercises over her attention.

When the monkey sets a raspberry as the goal of his search, the central executive system activates an iconic memory of the raspberry. But it does not merely activate the memory. The activated memory implements the monkey's setting the berry *as* the goal of the cognitive process – the visual search – that ensues. The central executive system activates the visual attentional system *for search* by providing the iconic memory of the raspberry as the target template input for this system's computations. The target template input by the central executive system governs, determines, and shapes the activity of the visual attentional system.

When the monkey begins to search for the raspberry, the central executive system initiates computations in the visual attentional system that yield a priority assignment for possible target locations on the priority map. The computational mechanisms underlying the priority map generate a ranking of locations as more or less likely to contain the target of the search. This computational mechanism determines the priority ranking on the basis of visual similarity between items at locations and the representation of the target representation activated in working memory by the central executive system.[103]

When the monkey shifts visual attention to the first location – the leaf – the priority map represents *that* location as to be searched for an object resembling the target template. Its representation of that location as the most likely location of the

[103] This presentation of the priority map's activity is strongly simplified. For a more realistic presentation, see Chapter 4.

search target causes the allocation of visual attentional resources for search of that location.

Suppose that the monkey briefly fixates attention on the leaf and sees that there are no berries there. The attentional system then deploys visual attentional resources to determine that the item at the fixated location does not match the template. The central executive system registers the absence of the target from that location in a visuo-spatial working memory.

When the monkey shifts attention to the next location – the twig – the priority map represents this new location as the next-most likely location for the target. For the computation of this subsequent location, the central executive system provides both the template of the target and the memory of the already visited location for determining priority on the map. From this information, the mechanism underlying the priority map computes a new ranking for likely locations of the target. It causes visual attentional resources to shift there. This process repeats until the search terminates.

When the monkey finds the berry, the visual attentional system computes a sufficient match between the item at a searched location and the iconic memory of the berry activated by the central executive system. The central executive system may now switch mental set from the goal of finding the berry to that of reaching for it.

The priority map, controlled by the central executive system, indicates where to shift attention, for each shift during visual search. The central executive controls the computation of the location to which attention shifts next. Its control implements the monkey's guidance of his shifts.

Even in this simple instance of visual search, the central executive system may exercise all three signature executive functions. First, in activating the target template and holding it in working memory as a goal, the central executive system *switches* from whatever task the monkey was carrying out before to that of finding the raspberry.

Second, the central executive system *maintains* representations activated from long-term memory and stored in working memory, and their influence on the computations of the priority map.

Third, the central executive system *inhibits* the influence of physically salient distractors or non-guiding endogenous on the priority map. It suppresses alternative cognitive processes. Maybe the monkey should next plan a route into the crowns of surrounding trees. Or maybe he has an instinct to continuously check the brush for possible predators. The central executive system suppresses these alternative cognitive processes in favor of completing the search.

In principle, none of these specific executive functions need be exercised for the central executive system to control some cognitive process. The basic way in which the central executive system controls is by allocating central resources to the process. In visual search, plausibly, a search template must always be held in memory. Efficient search requires tracking and memorizing already visited locations. Usually, there will be many salient distractors in a visual display, many other memory influences, and alternative processes to be carried out that need to be suppressed. But at the most basic level, the central executive system controls a shift of attention even if it does not exercise these specific executive functions. The executive system might control a particular shift of attention, even if no memory and inhibition are required for its execution.

When the individual guides his attention shift to some particular location, during visual search, the central executive system implements his guidance at the level of psychological processes explained in terms of psychological systems. Central executive control is the correlate of the individuals' guidance of attention shifts at the level of psychological systems.

3.4.2 Absence of Central Executive Control from Passive Shifts

Attention might be captured during visual search – maybe a snake approaches while the monkey is scanning the brush. The exogenous attentional system assigns priority for a shift to the location of the snake. The shift is not driven by the individual's goal of finding the berry. The exogenous system overrides the central executive system's control over computations determining priority on the map that causes attention shifts.

The monkey does not guide her shift in this case. When the individual's attention is captured, the central executive is not, or no longer, in control of the attentional system.

The same is true for attention shifts during default activity. When the monkey stares at his surroundings while being groomed, saliency-based computations determine rankings of locations on the priority map. The priority map causes attention to shift across the visual scene according to these rankings.

The monkey does not guide his shifts during default activity. The central executive system does not influence these computations of priority on the map.

3.4.3 Drawn Attention and the Central Executive System

Earlier I explained that physically salient stimuli and a range of non-guiding endogenous factors could draw attention even during active shifts.

Suppose, again, that the monkey searches for his raspberry. His first fixation lands on the leaf. His goal of finding a raspberry drives this shift of attention to the leaf. Now suppose, further, that the leaf is physically salient. The exogenous system's modulation of priority assignments on the map interferes with the central executive's control of priority computations, without interrupting the search. The leaf attracts attention not because it resembles the template, but because it is physically salient. Or suppose that the leaf attracts attention because the monkey has implicitly memorized its location as statistically likely to contain a berry. This memory increases priority for the leaf's location.

When physical saliency or some endogenous factor interferes in these ways with central executive control of attention shifts, attention is drawn to a stimulus. The monkey still guides attention, but his guidance is limited.

3.4.4 Empirical Support for the Proposal

Psychology distinguishes drawn attention from individual's guidance on the basis of whether the central executive system allocates sufficient resources to the search.

Olivers and Eimer[104] performed experiments similar to those sketched in section three. In their studies, too, individuals had to memorize a color, perform a visual search, and a memory test. The memorized color influenced attention shifts during a subsequent search. When their subjects could not predict whether they would first complete the search or the memory test, individuals set *both* goals to guide subsequent cognitive processing. Olivers and Eimer found that the effect of the memorized color on the subsequent search doubled, relative to the condition where individuals could predict which task they would have to complete next. Olivers and Eimer explained this result as

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[104] Olivers, C. & Eimer, M. 2011; Olivers, C., Meijer, F. & Theeuwes, J. 2006; Olivers, C., Peters, J., Houtkamp, R. & Roelfsma, P. 2011; Stokes, M. & Duncan, J. 2014.

due to the allocation of central resources to *both* representations governing the cognitive processes.

Experiments of this type[105] support the idea that the central executive system's control – its allocation of resources for the control – of a cognitive process is the psychological systems counterpart of individual's guidance of attention shifts to locations.[106]

There is ample evidence for all three signature executive functions in visual search. *Maintenance* of relevant representations in memory is required for the execution of visual search. For example, Oh and Kim[107] showed that when individuals had to memorize locations of four squares on a screen, a subsequent visual search slowed down. The individuals were less effective at finding the search target. Oh and Kim explained their result by pointing out that these individuals' visuo-spatial working memory was filled to capacity. If the memory storage for locations is filled, the central executive cannot effectively control assignments of priority on the priority map.

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105 Soto, D., Humphreys, G. & Heinke, D. 2006; Soto, D., Hodsoll, J. Rotshtein, P. & Humphreys, G. 2008; Soto, D., Humphreys, G., Heinke, D. & Blanco, M. 2005; Downing, P. 2000; Downing, P. & Dodds, C. 2004; Peters, J., Goebel, R. & Roelfsma, P. 2009; Kiyonaga, A., Egner, T. & Soto, D. 2012; Woodman, G. & Chun, M. 2006; Woodman, G. & Luck, S. 2007; Anderson, D., Vogel, E. & Awh, E. 2013; Anderson, E., Mannan, S., Rees, G., Sumner, P. & Kennard, C. 2008; Poole, B. & Kane, M. 2009; Peterson, M., Beck, M. & Wong, J. 2008; Bays, P. & Husain, M. 2012.

106 Other behavioral studies corroborate this result. Leonard and Egeth showed, for example, that allocating additional resources to finding some specific target speeds up individuals' search. Cf. Leonard, C. & Egeth, H. 2008; Lamy, D. & Kristjansson, A. 2013; Lamy, D., Leber, A. & Egeth, H. 201; Lamy, D. 2005. Han & Kim showed that concurrent central executive processing – for example due to completion of a subtraction task – interferes with individuals' performance on search tasks. Cf. Han, S. & Kim, M. 2004.

107 Oh, S. & Kim, M. 2004; Woodman, G. & Luck, S. 2004.

Switching of mental set is required to abandon a task and initiate a visual search. Walther and Fei-Fei[108] showed that visual search exhibits typical effects of switching. They asked subjects to switch back and forth between the task of searching for a target in a display, and that of reporting the color of the display's frame. The central executive system takes between 200 ms and 800 ms to switch tasks. Individuals' performance on the second task was only impaired when they had less than 200 ms to switch sets. These experiments support the claim that switching into the set for visual search, and establishing this set, requires the central executive to exercise the relevant executive function.

Inhibition of irrelevant distractors is required to search a cluttered display. Lavie et al.[109] found that individuals shift attention to distractors more often, when the individuals had to concurrently generate random numbers or perform calculations on numbers. The number of individuals' attention shifts to a distractor, and the amount of time they needed to find the target, increased in proportion with the amount of unrelated central processing individuals had to carry out. Lavie et al. thus showed that the central executive is needed, in visual search, to inhibit the detrimental effect of distractors.

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108 Walther, D. & Fei-Fei, Li 2007; cf. also Lavie, N., Hirst, A., De Fockert, J. & Viding, E. 2004.

109 Lavie, N. & De Fockert, J. 2005; Lavie, N., Hirst, A., De Fockert, J. & Viding, E. 2004; De Fockert, J. Rees, G., Frith, C. & Lavie, N. 2001; Lavie, N. 2000; Fukuda, K. & Vogel, E. 2009; Lavie, N. & Dalton, P. 2014; Peterson, M., Beck, M. & Wong, J. 2008; Awh, E., Matsukura, M. & Serences, J. 2003.

3.4.5 Central Executive Control of Other Active Attention Shifts

Many active shifts of attention occur during visual search. But individuals also guide attention shifts outside of visual search.

We have already encountered one further instance of active attention shifts. Individuals can intentionally guide their attention to some specific object, location, or region. The central executive initiates the shift by activating the intention in working memory. It activates competencies for 'translating' the propositional demonstrative – shift attention *there* – into an assignment of priority for just one location on the priority map.[110]

Shifts subserving more complex, goal-driven intentional actions form another large class of active attention shifts.[111] One sub-class of these shifts consists in shifts subserving motor behavior. Individuals often guide visual attention to objects they do or will manipulate, to locations they walk towards, or to their limbs when moving them. When performing motor actions, individuals often shift attention in highly patterned, stereotyped ways. Such shifts are elements in attentional routines that serve to control bodily behavior. Many of these shifts are on some level driven by the individual's intention to perform the motor action. The central executive system holds these

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[110] Unsworth, N., Schrock, J. & Engle, R. 2004.

[111] Pelz, J. 1995; Pelz, J. & Canosa, R. 2001; Pelz, J., Hayhoe, M. & Loeber, R. 2001; Fairchild, M., Johnson, G., Babcock, J. & Pelz, J. 2001; Hayhoe, M. & Ballard, D. 2005; Land, M. 2006; Sprague, N., Ballard, D. & Robinson, A. 2007; Land, M. 2009.

intentions in memory and activates relevant attentional routines for their implementation. Through its activation of a routine, the central executive system controls the assignment of priority to specific locations or regions on the priority map, and thereby the subsequent shifts of attention.

Another sub-class of shifts subserving intentional actions contains active shifts directed toward the goal of acquiring information, as opposed to carrying out bodily action.[112] Suppose that an individual sets out to count the number of males in the image. Completing these tasks requires her to shift attention across the image. The relevant shifts are again elements of attentional routines, tailored to the effective completion of the cognitive task. The central executive holds the intention to count the males in the image in working memory. On its basis, the central executive activates whichever attentional routine serves the counting. The resulting priority map state controlled by the influence of the central executive causes the shift of attention to its destination.

3.5

Conclusion: Central Executive Control and Guidance by the Individual

I have shown that in salient cases in which individuals guide their attention shifts, the central executive system controls the attentional system and hence the shifts.

[112] Ballard, D. & Hayhoe, M. 2009; Babcock, J., Lipps, M. & Pelz, J. 2002; Canosa, R., Pelz, J., Mennie, N. & Peak, J. 2003.

In salient instances of passive attention shifts, not guided by the individual, the central executive system does not control the systems that determine destinations for the shifts.

Control by the central executive system is the correlate of individuals' guidance over attention shifts at the level of psychological systems. I have explained and illustrated how the central executive implements individuals' guidance. I have described how empirical research on attention shifts and the central executive system supports this claim. I have thus provided *prima facie* support for the proposal that central executive control partly constitutes individuals' guidance over attention shifts – and thereby contributed to an answer to Frankfurt's problem of action, as applied to such shifts. I continue to develop the proposal over the following chapters.

Chapter 4

The Priority Map

In the present chapter I introduce the priority map and discuss its role in actively guided shifts of visual attention. The priority map helps direct all shifts of visual attention. I argue that the priority map is a representational state with geometric, non-conceptual, rather than propositional structure.

An influential tradition in action theory, stemming from G.E.M. Anscombe and Donald Davidson, holds that actions are constitutively guided to their completion by conceptual intentions. This tradition emphasizes the role of practical reasoning for the constitution of action. Propositional thoughts that can enter into propositional practical reasoning constitutively guide actions, according to this tradition. These thoughts are conceptual intentions. The tradition ignores the importance of other, non-conceptual capacities for guiding action. The tradition ignores actions of animals that do not have conceptual capacities.

I show that non-conceptual priority maps ultimately help guide even attention shifts caused by a conceptual intention. I suggest that, indeed, *no* conceptual intention is needed even for humans to actively shift visual attention. My discussion illustrates a concrete instance of psychological agency explained in terms of individuals' non-conceptual competencies. Active shifts of attention provide a model for thinking about non-propositional psychological agency in humans and other animals.

In section one I introduce the distinction between propositional, conceptual and geometric, non-conceptual psychological states.

In section two I illustrate how all major models of visual attention shifts commit to these shifts' being guided by a priority map. I show that these models assume that the mental state instantiating the priority map has geometric structure.

Section three addresses objections to non-conceptual representational states stemming from Zenon Pylyshyn. I provide further considerations in favor of thinking that the priority map has non-conceptual structure. I show that the priority map's geometric structure essentially shapes explanations in terms of relevant computational models of attention shifts. And I discuss additional results from behavioral studies and neuroscience that support the claim that the priority map has non-conceptual, and indeed geometric structure. Priority maps are non-conceptual representational states. Their use in psychological explanations weighs against philosophical positions according to which all representational states have propositional structure.

In section four I address a position according to which it is granted that the priority map itself has non-conceptual structure. Active shifts, however, involve activity of the central executive system. The position holds that the central executive imports conceptual structure into the state. I argue that there is no support for this position, and hence, that active shifts of attention are often partly guided by non-conceptual states.

In section five I reflect on the role of conceptual intentions in attention shifts. I critically discuss the traditional view, stemming from Anscombe and Davidson, according to which, constitutively, all actions are guided by a conceptual intention. Many active shifts of attention are caused by a conceptual intention. In all these cases, the conceptual intention relies on the non-conceptual priority map for its guidance. I discuss different ways in which conceptual intentions and the priority map interact. I point out that the priority map can guide active shifts of visual attention in absence of conceptual intentions. Active shifts of visual attention provide a model for non-conceptual psychological agency more generally.

4.1

The Geometric Structure of Priority Map States

Psychological states have structured representational contents. The contents of thoughts, in particular, are often assumed to have propositional structure. The contention that thinking constitutively involves a capacity for propositional inference often motivates this assumption. Propositional inference requires its premises and conclusion to have logical form. Thoughts' contents are possible premises and conclusions of propositional inference. So thoughts' contents have logical form.

Thoughts' contents' logical form partly constitutes their propositional structure.[113]

On this view, the logical form of thought contents is marked, in these contents, by structural features such as predicates, logical connectives, existential, and universal quantifiers. Such basic compositional devices explain how complete thoughts' truth-values depend on the semantic values of their components. These devices form the basis of explanations of propositional inferences that thoughts enter into. The devices help explain thoughts' characteristic systematicity – components of thoughts can be recombined in systematic ways. And they help explain thoughts' productivity, or the infinite number of possible thoughts. Sometimes, thought is characterized as roughly sentence-like, sharing the structure of language. The logical form thoughts and sentences share motivates this analogy. Judgments, beliefs, and intentions are thoughts in just this sense. They can enter propositional inference and hence share the basic logical form and propositional structure of all thought. Concepts are components of propositional representational contents. I will call (components of) thoughts' representational contents *conceptual* contents. *Non-conceptual* contents are (components of) contents of non-propositional psychological states.

The priority map state that helps guide a shift of attention is *not* an intention with conceptual content. It does not have the form

[113] In what follows, I adopt the terminology from Burge, T. 2010. Cf. also Burge, T. 2005. Some have argued that thought need not be propositional. Cf. Rescorla, M. 2009a/b and Camp, E. 2007. These matters may be terminological to some extent. My main aim in this section is to contrast propositionally structured contents with geometrically structured contents.

I intend to shift attention there.[114]

The priority map's content does not contain markers of propositional structure such as the concepts and, or, all, or some. The priority map's structure is not like that of a sentence. Rather, the priority map has *geometric* structure. The priority map functions to represent geometric features of the field of view. The priority map represents objects and properties as at certain locations, at specific distances and directions from each other and from the observer. The priority map plausibly does so using the basic semantic apparatus of physical maps.[115] Minimally, this last fact requires that the representational state itself have geometric structure that represents the geometric structure of the field of view. More specifically, points on the priority map – components of the representational state – are geometrically related to each other. Their geometric relation functions to represent geometric relations in the environment.

A set of objects between all of which a *distance* is defined is a geometric structure.[116] A familiar geometric structure is Euclidean space. In Euclidean space, the

[114] I indicate representational contents of psychological states by underlining them.

[115] I take this formulation from Rescorla, M. 2009a. I am heavily indebted to his work on cognitive maps.

[116] I will not discuss topological spaces. Computational models of attention shifts are committed to the priority map's having Euclidean structure. It therefore has topological structure. My argument would not be deeply affected if the priority map had *only* topological, but not Euclidean structure. The priority map would, in this case, have spatial, but not geometric structure.

distance between two points is defined as the length of the straight line connecting them. The priority map is a geometric structure because points on the map are at specific distances from each other.

Skeptics about non-conceptual content have pointed out that it is difficult to understand what it might mean for a representational state to have geometric structure. Zenon Pylyshyn, for example, maintains that the only clear sense in which a representational state might have geometric structure would be for the state to be laid out in physical space.[117] Several philosophers have replied that one might alternatively understand the representational states' having geometric structure *functionally*.[118] Just as we attribute propositional structure to representational states because these states enter into deductive inferential transitions, states with geometric structure enter into geometric transitions. I will elaborate on this strategy below.

Philosophers of psychology debate whether there could be non-conceptual content on other grounds as well. If there could be such a thing, what might non-conceptual content be? What might a semantics for non-conceptual contents look like? And even if we had an agreed-upon conception of non-conceptual content – are there any non-conceptual psychological states in actual psychologies? In this chapter, I will *not* address the skeptic about non-conceptual content. That is, I will *not* attempt to argue against the position according to which non-conceptual content is impossible. I will *not*

117 Pylyshyn, Z. 2002; Pylyshyn, Z. 2003.

118 Block, N. 1983; Block, N. 1995c; Rescorla, M. 2009; Rescorla, M. 2009a; Rescorla, M. 2009b.

try to show that there is a workable conception of non-conceptual content. Instead, I will assume that recent developments both in the philosophy of psychology and in psychology itself show that the skeptic is likely mistaken. I contribute to the debate by providing a case study of psychological explanation that plausibly appeals to non-conceptual states.[119]

4.2

Priority Maps in Computational Models

All major theories of attention shifts assume that a priority map guides shifts of visual attention. The priority map is a psychological state that assigns priority values for attention shifts to locations in the field of vision. Computational models of attention shifts describe the computations of the psychological mechanism that achieves these assignments of priority. All models assume that priority is assigned to locations on a topographic map of (parts of) the field of view. The priority map indicates the goals for

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119 For early contributions to this debate, see Block, N. (ed.) 1981. For a recent overview, cf. Speaks, J. 2005.

Arguments to the effect that non-conceptual content is impossible, or that no workable conception exists, have been given, for example, by McDowell, J. 1994 and Pylyshyn, Z. 2003. Early arguments for the existence of non-conceptual content can be found in Evans, G. 1982; Block, N. 1983; Peacocke, C. 1992; Peacocke, C. 1998; Peacocke, C. 2001; Peacocke, C. 2001a.

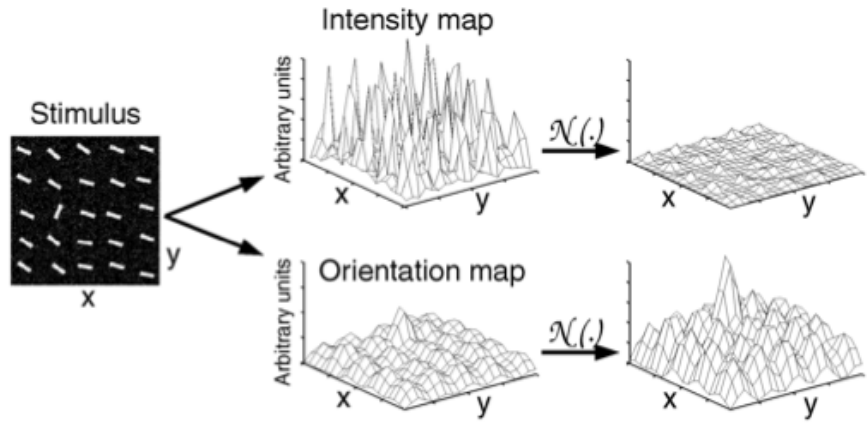
Recent contributions have been made by Rescorla, M. 2009; Rescorla, M. 2009a; Rescorla, M. 2009b; Burge, T. 2003; Burge, T. 2009; Burge, T. 2010; Burge, T. 2010a; Burge, T. 2010b; Burge, T. 2011; Fodor, J. 2007; Heck, R. 2007; Camp, E. 2007. Psychologists mostly assume the existence of non-conceptual, in particular, picture-like contents. See, for instance, Carey, S. 2009; Carey, S. 2011 (also personal communication).

attention's next shift *by* indicating the location with highest priority.

Computational models of attention shifts assume that the priority map has Euclidean structure. They share this commitment, whether they model active or passive shifts. Saliency-based models such as those stemming from Koch and Ullman[120] explain passive shifts of attention. They best predict shifts of attention during default activity. In saliency-based models, the priority of a location is a function of physical saliency. A location is physically salient if it is significantly different from its surroundings as regards certain physical properties. The intuitive idea is that, if one item in a display is green and all other items are red, the green item will attract attention. If one item is particularly bright, while all other items are dim, the bright item will attract attention. Saliency-based models compute the saliency of a location from several distinct feature maps. Feature maps register values for one stimulus dimension at each location in the field of vision. They indicate relative saliency along that dimension for each location. Feature dimensions include luminance, contrast, color, orientation edges, and others. Next, a mechanism combines saliency-information from feature maps for different dimensions, weighs this information, and generates a final assignment of priority across feature dimensions in a central saliency map. All models deriving from Koch and Ullman's saliency-based model explicitly assume that both the feature maps and the central saliency map are topographic, Euclidean maps. They represent locations within

[120] Koch, C. & Ullman, S. 1985; Cf. also Itti, L. & Baldi, P. 2005; Itti, L. & Baldi, P. 2009; Itti, L. & Koch, C. 2000; Itti, L. & Koch, C. 2001; Itti, L., Koch, C. & Niebur E. 1998; Borji, A. & Itti, L. 2012; Bruce, N. & Tsotsos, J. 2005; Bruce, N. & Tsotsos, J. 2009; Itti, L. & Borij, A. 2014.

the field of vision as more or less salient.

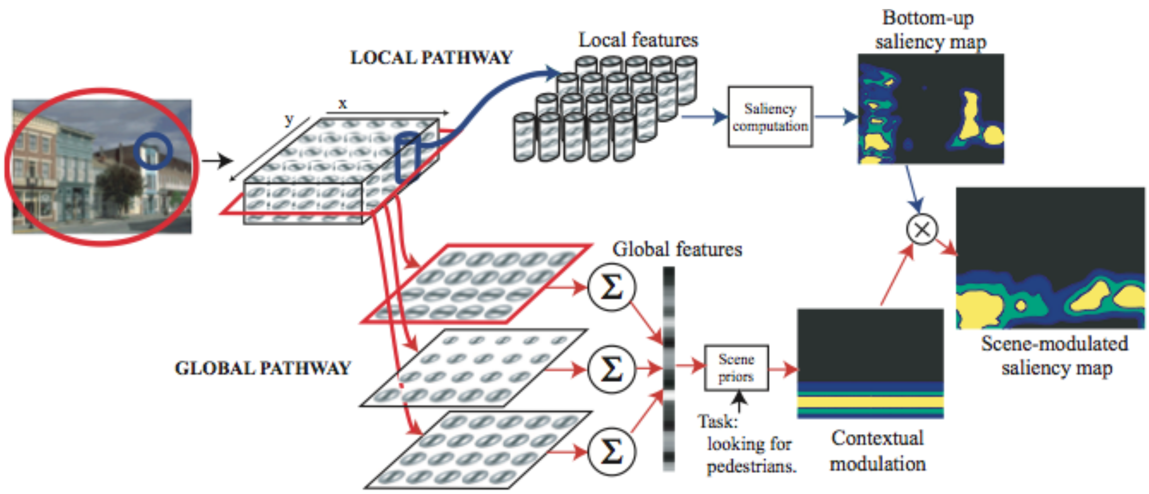


[Saliency maps. From Itti, L., Koch, C. & Niebur E. 1998, 1255]

Models integrating endogenous influences such as scene-information or face-recognition derive from the same modeling-approach. They, too, assume that priority is assigned on a Euclidean topographic map. Torralba et al. proposed probably the most influential model of this kind.[121] The model features two pathways, one local and one global. The local pathway computes saliency for positions in the scene, as in the saliency-based models. The global pathway computes saliency of scene-locations on the basis of stored knowledge about scene gist and types of scenes. These computations rely

[121] Torralba, A., Oliva, A., Castelhano, M. & Henderson, J. 2006; Cf. also Torralba 2005 & 2003; Oliva, A. & Torralba, A. 2001; Ehinger, K., Hidalgo-Sotelo, B., Torralba, A. & Oliva, A. 2009; Einhaeuser, W., Rutishauser, U. & Koch, C. 2008; Oliva, A. 2005; Oliva, A., Castelhano, M & Henderson, J. 2003.

on filters that extract global scene properties from local scene properties. For example, a street scene may contain predominantly horizontal features in the bottom half and vertical features in the top half. The global pathway identifies a type of scene on the basis of such global geometric features of the scene. Information about scene gist or type of scene then directly influences computations of priority. This information increases priority for regions of a scene that are more likely to contain items of interest or relevance to the individual. In a street scene, for example, humans are more likely to be found on the sidewalk than in the sky. Recognition of a scene as a street scene during search for humans directly increases priority of the relevant regions in the priority map. Similarly, models can be enriched by face- or person-detectors to increase saliency for regions containing face- or person-shaped objects. Again, all these models explicitly assume that information about saliency of locations and regions is registered on a topographic, Euclidean map.

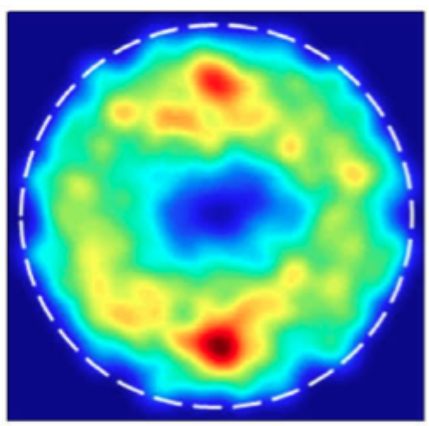


[Saliency and scene recognition pathways. From Torralba, A., Oliva, A., Castelhano, M. & Henderson, J. 2006, 4]

Models for visual search, too, explicitly assign priority for shifts during search to locations on a topographic, Euclidean map. Najemnik and Geisler's[122] search model, for instance, computes the location with highest priority as the location, shifting attention to which minimizes loss of information about the location of the target. It computes which shift would make finding the target with the next, i.e. the following shift, most likely. In carrying out this computation the model relies on template matching. Template matching is the process of comparing the defining parameters of the search target with responses along those parameters from items at locations in the visual

[122] Najemnik, J. & Geisler, W. 2009; Najemnik, J. & Geisler, W. 2008; Najemnik, J. & Geisler, W. 2005; Cf. also Zelinsky, G. 2008; Pomplun, M., Reingold, E., Shen, J. & Williams, D. 2000; Pomplun, M., Reingold, E. & Shen, J. 2003; Wolfe, J. 1994; Wolfe, J. 2014; Treisman, A. & Gelade, G. 1980; Eckstein, M. 2011; Geisler, W. & Cormack, L. 2011.

scene. Information about similarity between template and responses deteriorates when the Euclidean distance between potential target locations and possible fixation location increases. Greater distance from fixation signifies poorer discrimination of the target by the visual system. The model thus computes loss of information as a function of template matching responses, and discriminability at a location. The model computes discriminability at a location from that location's eccentricity relative to a possible fixation point. Priority of locations derived from these computations is indicated in a Euclidean, topographic map of the field of vision.



[Priority map for the entropy searcher. From Najemnik, J. & Geisler, W. 2009, 1291]

Computational models of attention shifts thus assume that a priority map with Euclidean structure, hence geometric structure, helps effect shifts of attention. These models constitute our best scientific explanations of shifts of attention. We should accept that the entities presupposed by our best scientific explanations exist. So we should accept that psychological states instantiating priority maps with geometric structure exist.

4.3

Explanation By Geometric States

Adapting Zenon Pylyshyn's objection against non-conceptual content, one might reply that while computational models of attention shifts *assume* that the priority map has geometric structure, this structure is inessential to explanations in terms of these models.[123] Computations yielding a priority assignment might be performed on sets of points, or on vectors. Priority maps themselves might be understood as sets of points, or vectors, that do not have any inherent geometric structure. According to this reply, our best scientific theories of attention shifts do *not* require that priority maps be geometrically structured psychological states. Since we hence lack good reason to think that the priority map has geometric structure, according to this reply, the most plausible alternative is that priority maps have conceptual content.

I will provide three considerations to counter this reply. First, and most importantly, I will suggest that the priority map's geometric structure *is* central to

123 Pylyshyn, Z. 2002, 167f.; Pylyzhyn, Z. 2003, 359ff.

explanations in terms of computational models. Logical structure plays no role in these explanations. Computational models do not merely assume that the priority map has geometric structure. Their explanations are shaped by the priority map's geometric structure. Next, I will discuss additional evidence from behavioral studies and neuroscience that supports the claim that the priority map has geometric structure. I argue, second, that the retinotopic structure of brain areas realizing the priority map supports the claim that the psychological state has geometric structure. Third, visuo-spatial memory systems retaining information in geometric format support at least visual search. I suggest that their geometric format, too, supports the claim that the states guiding attention-shifts have geometric format.

4.3.1 Characteristic Transitions[124]

Psychological states have structured contents. Psychological states enter characteristic transitions. The specific structures of psychological states' contents partly explain characteristic transitions that the states enter into. Psychological states enter into characteristic transitions partly in virtue of the structure that their contents have.[125]

Consider propositionally structured states. These states have logical structure. Individuals characteristically infer <u>Socrates is mortal</u> from <u>All men are mortal</u> and

124 Thanks to Gabriel Greenberg for help with this section.

125 Block, N. 1983; Block, N. 1995; Rescorla, M. 2009a.

Socrates is a man. They characteristically infer This is a ball from This is either a ball or a cylinder and This is not a cylinder. Such characteristic transitions are the subject of important psychological generalizations about those states and the psychological competencies underlying them. The transitions are best explained by the states' having a universal quantifier and a disjunction as part of their structure. The transitions are best explained on the basis of some competence to infer in accordance with the inference rules governing universal quantifiers and disjunction.[126]

To argue that a kind of psychological state's content has some specific structure, one should therefore show that the kind of psychological state enters into characteristic transitions that are best explained by the state's having that specific structure.

Computational models of visual search explain shifts of attention on the basis of transitions from one state of the priority map to another such state. One state of the priority map indicates some specific location as the target of the next shift. The updated priority map indicates the location for the following fixation. Transitions between priority map-states are the characteristic transitions explaining shifts of attention. Computational models do not merely posit that the priority map has geometric structure. Rather, the geometric structure of priority map-states itself shapes the characteristic transitions between priority-map states. It determines the computations involved in the updating of the priority map.

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126 See for example Johnson-Laird, P. 1983, Johnson-Laird, P. & Byrne, R. 1991, and Rips, L. 1994.

While it is possible to translate the computational models into models relying exclusively on propositionally structured representations, such a translation brings no explanatory advantage. Plausibly, such a translation brings an explanatory disadvantage. The salient alternative to attributing logical structure to the map is to take computational models at face value and accept that the priority map has geometric structure. I will return to this point at the end of this sub-section.

Computational models of attention shifts must predict and explain signature ways in which individuals shift visual attention. One such signature way of shifting visual attention are *center-of-gravity* shifts.[127] When confronted with displays containing several items that resemble the search target, or are relatively salient, humans and monkeys alike tend not to fixate each of these items. They do not even always fixate the item that most resembles the search target, or is most salient. Rather, they tend to shift attention to a location at the geometric center of these items. If two locations are equally salient, for example, individuals tend to fixate the halfway point on the straight line connecting the two items. If three locations grouped approximately as corners of a triangle are equally similar to the search target, individuals tend to fixate the location at the center of the triangle.

Center-of-gravity shifts suggest that the geometric relations between locations with relatively high priority influence how individuals shift attention. They suggest that

[127] Cf. Findlay, J. & Gilchrist, I. 2003, 72 & 97.

the computations determining shifts of attention are sensitive to the geometric relations between priority locations.

A closer look at the best computational models of attention-shifts supports this impression. To explain center-of-gravity shifts, but also quite generally, the computations involved in the process of updating the priority map rely on its geometric structure. I will illustrate how they do so. Since the actual mathematical models are very complex, I will present them in a strongly simplified fashion.

The characteristic transitions that priority maps enter into are transitions involved in the updating of these maps. The updating process consists in the transition from the priority map's specifying one location for fixation f_1 to its specifying the next fixation-location f_2 after having shifted attention to f_1. This updating process can be usefully broken down into three component computations.

For the first component, suppose that the individual fixates attention at f_1. A process of *template matching* assigns a similarity-value to each location in the field of vision. The details of this process are not of concern for present purposes. The template is a representation of the search target. The template is held in memory throughout the search. A process of template matching compares the template with items at each location in the field of vision. The process determines how similar items at each location are to the search template. Suppose that the process yields a similarity-value between *0* and *1*, such that values closer to *1* represent higher similarity to the target. Template matching thus assigns a similarity-value between *0* and *1* to each location in the field of vision. Many of these similarity-values may have been carried over from prior template matching. Details depend on specific models.

The most successful models of visual search assume that shifts of attention during visual search depend on the role of a *fixation area*.[128] The fixation area is the segment of the field of vision that receives sufficient processing resources to establish whether the target is present or not at locations within the segment. One might think of the fixation area as the infamous 'spotlight' of attention.[129] Suppose that the fixation area is the circle around fixation with radius *R*. This distance is measured in Euclidean coordinates. All locations within this circle receive sufficient processing resources to determine whether the search target is present at those locations. Assume further that the target is *not* present at locations within *R* from f_1 upon the first shift of attention. The mechanism now sets similarity-values for all locations within *R* to zero.[130] For all locations at distance *R* or less from f_1, the system has now determined whether or not the target is present.

The first component process thus updates similarity-values for locations by setting similarity-values to zero for locations at *R* or less from f_1.

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128 I am here most closely following Pomplun, M., Reingold, E., Shen, J. & Williams, D. 2000. An analogue of the fixation area is called 'visibility area', cf. Najemnik, J. & Geisler, W. 2009.

129 While sometimes a helpful metaphor, there are many reasons to think that emphasis on a spotlight of attention is in the end misleading. See Brefczynski-Lewis, J., Datta, R., Lewis, J. & DeYoe, E. 2009; Datta, R. & DeYoe, E. 2009; Block, N. 2010.

130 This component of the updating process correlates with what is sometimes called 'inhibition of return.'

The second component process takes the first step toward determining a priority value for the next fixation. This component computes the *weighted average of similarity-values* within fixation areas for each possible next fixation f_n at all locations. The computation is straightforward. For each possible fixation f_n, the system has available all similarity-values within the fixation area R around f_n. The system determines which locations are at distance R or less from f_n. The system weighs similarity-values at all locations according to how distant the locations are from f_n. Locations farther removed from f_n receive lesser weight than those closer to fixation. Then the system adds similarity-values for all locations within the fixation area and computes the average for all locations. To illustrate, suppose that the system obtains the following grid of similarity-values for what turns out to be its next fixation f_2:

.1	.1	.7
.8	.1	.1
.1	.7	.1

Assume that the center of the grid of values corresponds to the point of fixation. Assume further that similarity-values are boosted by adding *.1* at the center of fixation (yielding *.2* in this particular case). The system thus obtains the weighted average of *.32* for fixating f_2. Suppose that for the alternative next fixation f_m, the system obtained the following grid of weighed values:

.1	.1	.1
.1	.8	.1
.1	.1	.7

Again, weighting boosts the value at fixation by adding *.1* to it (yielding *.9* in this particular case). The system obtains the weighted average of *.24* for fixating f_m. The system always picks the fixation with highest weighted average similarity-value. Accordingly, in this particular case it picked fixating f_2 over f_m.

Note that we can understand f_m as the result of moving fixation one location to the left relative to fixation f_2. Fixation f_m is a fixation on the highest similarity value in the grid of values underlying fixation f_2. The present example thus is a case in which the system determines a fixation *between* peaks of similarity-values, rather than fixating one of the peaks. The example illustrates how a fixation between peaks of similarity-values – and hence not on the *highest* similarity peak – generates a higher value for weighted average similarity. We can thus see how a model implementing the component processes illustrated so far will generate center-of-gravity fixations. Because fixating attention between similarity peaks increases the weighted average similarity-value for a fixation, the system shifts attention to the center-of-gravity of highly similar locations.

It will be helpful to motivate this last step. Why do models assume that priority of locations is computed from weighted averages of similarity-values? Different models motivate this step differently.[131] One basic motivation that they all share is the brute fact that this assumption leads to correct predictions of shifts of attention during visual search. Different families of models explain this brute fact in different ways, however. An important family of models motivates this type of computation on the basis of facts about the *neural implementation* of the priority map.[132] Similarity-values correspond to amounts of neural activation. As a matter of brute fact, retinotopically structured areas of the brain such as superior colliculus and frontal eye fields that are responsible for allocating attention seem to compute the weighted average of activation to determine the next fixation.[133] Another important family of models arrives at similar computations on the basis of *Bayesian and Information-Theoretic considerations*.[134] Models in this family derive from the assumption that attention shifts so as to obtain maximum information about the location of the target. The fixation-location providing maximum information about target-location need not coincide with the single most likely target-location. Intuitively, the system gathers more information about the location of the

131 Typically, differently models also implement it somewhat differently. The actual algorithms that different models provide take very different forms.

132 See section 3.2.

133 Zelinsky, G. 2008; Findlay, J. & Walker, R. 1999; Pomplun, M., Reingold, E., Shen, J. & Williams, D. 2000.

134 Bruce, N. & Tsotsos, J. 2005; Eckstein, M. 2011; Itti, L. & Baldi, P. 2009; Najemnik, J. & Geisler, W. 2009.

target by ruling out three very likely locations and fixating f_2, than by fixating the most likely location f_m, but ruling out only two possible locations. Both fixations cover the highest similarity location. But only f_2 covers the third likely location. Fixating f_2 hence provides information for the next shift, should the target not be found at the highest priority location. Weighted averages and hence center-of-gravity shifts are beneficial because they make search more efficient.

The following figure shows the fixations computed by Pomplun et al.'s[135] search model. Suppose that the search started at f_1 in the lower diagram. The next fixation f_2 is a center-of-gravity fixation, as illustrated in the discussion of the second component of the updating process. Fixations f_3 and f_4 indicate single, isolated horizontal bars in the topographic map above. The bars in both locations match the target template equally well. The model computed fixation f_3 over f_4, even though there is no obvious way in which one fixation might be more beneficial than the other, from the principles introduced so far.

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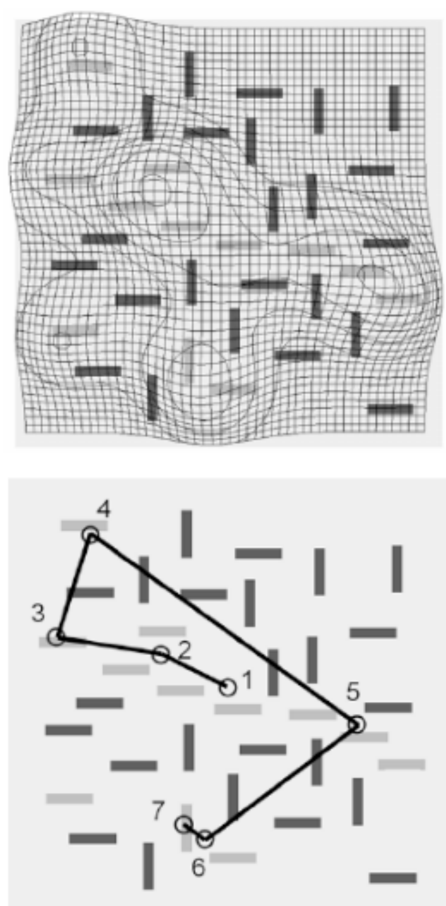
[135] Pomplun, M., Reingold, E., Shen, J. & Williams, D. 2000; Pomplun, M., Reingold, E. & Shen, J. 2003.

The third component process explains why the system determines f_3 as the next fixation. Between possible fixations yielding equal values for weighted averaging of similarity-values, the system determines the fixation closest to current fixation as the highest priority location. Even though f_3 and f_4 are, by assumption, equal as regards the value resulting from weighted



[The upper map indicates similarity assignments as peaks in a topographic map. Search target was a horizontal, lightly colored bar. The lower diagram shows the sequence of fixations that the model made. From Pomplun, M., Reingold, E., Shen, J. & Williams, D. 2000.]

averaging, the system determines f_3 for its next fixation, simply because f_3 is less distant from current fixation f_2. Shifts to closer locations are faster and hence more effective for the system.

By completing the three component processes, the system has updated the priority map. A new location has been determined as the highest-priority location. This new location is the goal for the next attention shift.

All three component processes are computations on the same geometrically structured set of locations. The first component partially updates similarity-values by measuring which locations are at Euclidean distance R from the peak indicated on the priority map for fixation f_1. The second component determines, for all possible next fixations f_n, which locations are at Euclidean distance R or less from f_n and then computes the weighted average similarity value for these locations. The third component computes which of two weighted average similarity value peaks f_n and f_m, and hence possible next fixations, is at closer Euclidean distance from current fixation f_2.

Components one and two presuppose that the locations indicated as having priority on the priority map are at Euclidean distances from locations to which similarity-values have been assigned. These components presuppose that those different assignments are made to the same locations, and hence on the same map. From the fact that locations with priority are at Euclidean distances from locations with similarity-assignments, and the fact that these locations are the same locations under both assignments, it follows that locations with priority at different times are themselves at Euclidean distances from each other.

Component three makes this derived fact explicit: to determine which of two equally high peaks for weighted average similarity f_n and f_m to go to, the system determines the Euclidean distance between f_n and f_2, and f_m and f_2. The peak closest to f_2 receives highest priority. So, locations with priority on the priority map are at Euclidean distances from each other. They hence are embedded within a geometric structure.

Updating of priority maps is the characteristic kind of transition the priority map enters into. All three component computational processes governing the updating transition are geometric computations on a geometric structure. These models are our best scientific explanations of the updating of the priority map. So, our best scientific explanation describes updating of the priority map as a process governed by computations on a geometric structure. Computational models do not merely assume that the priority map has geometric structure. They rely on the priority map's having geometric structure in their explanations.

Locations on the priority map represent locations in the field of vision. Geometric relations between locations on the priority map represent geometric features of the field of vision. In having geometric structure that represents geometric features of the field of vision, the priority map plausibly shares the basic semantic apparatus of physical maps.

The objector might insist, with Pylyshyn,[136] that even these computations might be implemented on the basis of propositionally structured representations. The models might be understood as involving large memories for similarity-values and priority-values predicated of locations, and all the spatial relations – in particular, the Euclidean distances – between all locations, not on a map, but in the visual scene.

For such a priority 'map' to have logical structure, the map should enter into logical inferences. As a matter of fact, updating the priority map does not involve transitions governed by familiar inference rules such as *reductio ad absurdum*, *modus tollens*, universal instantiation, and so on. So the objector would have to redescribe the transitions leading to the updating of the map as logical inferences. [137] When computing the location for the next fixation of attention the model might infer – applying *modus ponens*, for example – that if fixation goes to some specific location, then, some specific set of other locations is at most at distance *R* from fixation. In this way, the model might obtain all locations within the fixation area for some hypothetical fixation. Next, the model might infer that, if a location is within distance *R* from fixation, then its similarity-value is added to the values for a computation of the weighted average similarity value.

It *is* possible to model the updating processes as logical inferences. But it is unclear what the explanatory advantage of such modeling would be. Already at this

136 Pylyshyn, Z. 2002, 165ff.; Pylyzhyn, Z. 2003, 359ff.

137 Cf. Rescorla 2009a, 392ff.; Camp, E. 2007, 170ff.

point, it becomes apparent that the real explanatory work is done by weighted averaging over locations in the fixation area and the trigonometric computation of the distance of a location from fixation. Embedding these computations in logical inferences does not contribute to explanations in terms of the model. The expressive power of representational elements characteristic of propositional contents is not needed for the updating of priority maps. Importing such expressive power into the model must be motivated by actual uses of the priority map. Psychology does not seem to provide support for reformulation.

On the other hand, while it is possible to represent the information contained in the priority map propositionally, such representation would likely add complexity to the transitions performed in updating the map. A geometric priority map contains information about priority assignments for a large number of locations. It contains information about all the relevant geometric relations between different locations. A propositional reformulation of the map would likely store this information in form of atomic sentences. Updating the geometric representation requires performing a few mathematical operations on the priority map as a whole. In the propositional reformulation, for each new piece of information about some location, all its implications for all other locations, and their relations to each other, would have to be inferred. Propositional format would seem to import non-negligible computational complexities into the operations of the algorithm. Geometric format allows more rapid, effective computation of spatial information. Propositional representations allow representing more abstract, non-local information. This in-principle difference between the representational formats would likely appear in empirical data on the system's behavior. The fact that psychologists and computer scientists unanimously chose ways of modeling attention shifts without logical inference suggests that these ways better account for the empirical data about the system's behavior.

So while the argument above does not prove that the priority map *must* have geometric structure, it puts the burden of proof on the opponent of ascribing such structure to actual priority maps. *Prima facie*, the characteristic transitions that these representations enter into are not logical inferences. So, *prima facie*, there is no reason to think that these representations have logical structure. The salient alternative to the map's having logical structure is to take the models at face value and ascribe geometric structure to the map. Its having such structure would provide a natural explanation as to why it enters into the kinds of transitions characteristic of it.

The characteristic transitions that priority maps enter into support the claim that the priority map has non-conceptual, and in particular geometric, structure. The state that guides attention shifts to their goal-location is a state with non-conceptual content.

4.3.2 Retinotopy

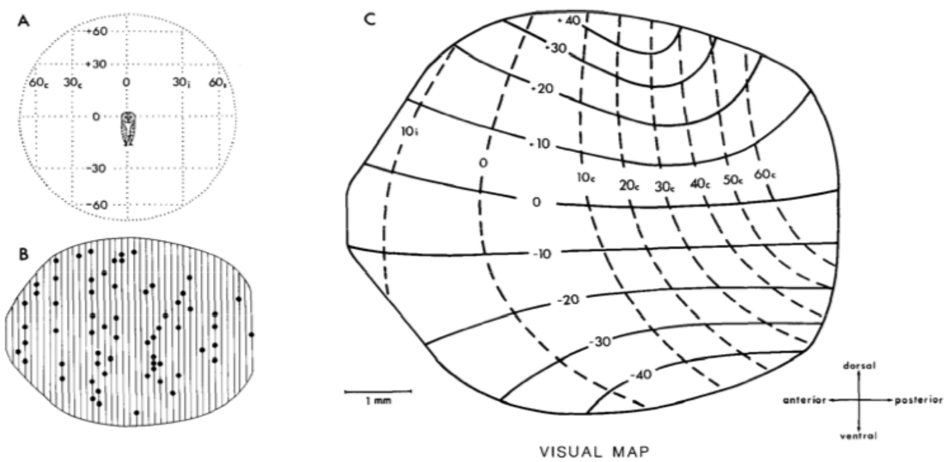
What is known about brain structures that realize the priority map supports the claim that the psychological state has geometric structure.

Visual cortices together with the superior colliculus and the ventral pulvinar are the neural networks that realize the exogenous attentional system. The prefrontal cortex, the posterior parietal cortex (especially lateral intraparietal sulcus), and the frontal eye field realize the endogenous attentional system. Superior colliculus and frontal eye fields, possibly also the pulvinar and lateral intraparietal cortex – most likely a combination of these areas, possibly only one of them – instantiate the priority map.[138]

The brain regions realizing the priority map have retinotopic structure. Different neurons map onto different, overlapping portions of the visual field. Locations in the visual field map onto parts of the brain region in retinotopic coordinates. There is hence a one-one correspondence between locations on the retina and locations in the relevant brain structures. The retinotopic brain structure preserves topographic, spatial relations between receptive field locations. It preserves distance relations. Together, the neurons in a retinotopic brain structure form a mapping of much of the visual field onto neurons. Simply put, stimulation at a location on the retina causes neural activity at the corresponding location in the retinotopic brain structure. If one location is to the left of

[138] Knudsen, E. 2007; Bisley, J. & Goldberg, M. 2003; Colby, C. & Goldberg, M. 1999; Bisley, J. & Goldberg, M. 2010; Schall, J. 2013; Goldberg, M. E., Bisley, J., Powell, K. & Gottlieb, J. 2006; Shipp, S. 2004; Treue, S. 2003.

another location on the retina, the corresponding location in the retinotopic brain structure will be to the left of that corresponding to the neighbor location on the retina.



[Retinotopic map in the barn owl's optic tectum, the homolog of humans' superior colliculus. From Knudsen, E. 1982, 1186]

The priority map's shifting visual attention to a location corresponds to neural activity in the brain areas realizing the priority map causing neural activity in visual areas. Neural activity at locations in the superior colliculus, pulvinar, the frontal eye fields, and the lateral intraparietal cortex causes enhanced neural activity at corresponding locations in the visual cortex. Often, this neural activity will cause a saccade to the relevant location. The evidence for this connection is abundant. For example, Moore and Armstrong[139] showed that stimulating locations in the retinotopic

[139] Moore, T. & Armstrong, K. 2003; Armstrong, K., Fitzgerald, J. & Moore, T. 2006; Awh, E., Armstrong, K. & Moore, T. 2006.

map in the frontal eye field – presumably responsible for voluntary shifts of attention – caused enhanced activity of spatially corresponding neurons in V4. If stimulation of the frontal eye field locations exceeded a certain threshold, the individual performed a saccade to the stimulated location. Bisley and Goldberg[140] showed increased activation at salient locations in the lateral intraparietal sulcus' retinotopic map preceding shifts of attention or gaze to those locations. Plausibly, increased neural activity in these brain areas helps cause an attention shift on the basis of a priority assignment on the priority map.

The brain structures realizing the priority map are retinotopically structured. Since they have retinotopic structure, they have geometric structure. Allocation of priority to locations in the priority map corresponds with changes in neural activity at locations in the retinotopic brain structure corresponding to the locations represented by the map. These changes in neural activity are involved in the causation of shifts of attention to the relevant locations. A simple explanation of this correspondence between neural activity and allocation of priority in the representation is that the brain structures isomorphically realize the allocation of priority in the priority map. This explanation strongly suggests that, similarly, the retinotopic, geometric structure of the brain areas realizing the priority map preserve the geometric structure of the priority map. This is the explanation provided by neuroscience: the retinotopic structure of the brain areas

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140 Bisley, J. & Goldberg, M. 2010.

realizing the priority map confirms the commitments models of attention shifts in terms of this map.

The fact that brain structures realizing the priority map have retinotopic structure is best explained by their having the same structure as the representational states they help realize. So the brain states' having geometric structure provides further support for the claim that the representational state has geometric structure.

4.3.3 Visuo-spatial Memory Systems

Behavioral studies corroborate the claim that the priority map has geometric structure. Evidence from behavioral experiments suggests that visual search relies on visuo-spatial memory systems, in particular working memory. These memories store representational contents with geometric structure. The memory stores provide a constituent of the state guiding active attention shifts – the target template. They inform computations yielding assignments of priority on the priority map. Their providing constituents of the guiding state, and their influence on priority assignments suggests that they share their geometric format with the priority map.

When maintaining several visually represented objects in visual working memory, individuals often search less effectively. In Woodman et al.'s[141] experiments, individuals searched for a square with a gap on one side while simultaneously

[141] Woodman, G., Luck, S. & Schall, J. 2007.

completing a memory task. For the memory task, they remembered four colored squares. After completing the search, the individuals were again confronted with the memory display and determined whether anything about the colored squares had changed. Woodman et al. compared a condition in which the target was variable between trials – *where* the square had its gap changed from trial to trial – to a condition in which the target remained fixed. They found heavy interference between memory and search tasks in the variable condition. Woodman et al. explain the interference in the variable condition by the individuals' maintaining the template for their search in visual working memory. Because visual working memory is limited and likely filled to capacity by the memory task alone, maintaining the further item – the search template – negatively affects search.[142]

When asked to maintain spatial information in visual working memory, individuals revisited already searched locations more frequently.[143] As in experiments involving visual working memory, interference indicates that visual search relies on spatial working memory for its efficiency.

Representations in visual or spatial working memory are assumed to have geometric structure.[144] Visuo-spatial working memories are distinguished from

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142 Cf. also Woodman, G. & Luck, S. 2007; Woodman, G., Carlisle, N. & Reinhart, R. 2013; Woodman, G. & Chun, M. 2006; Woodman, G., Vogel, E. & Luck, S. 2001; Miller, E., Erickson, C. & Desimone, R. 1996; Luck, S. & Vogel, E. 1997; Eng, H., Chen, D. & Jiang, Y. 2005.

143 Cf. Woodman, G. & Luck, S. 2004; Oh, S. & Kim, M. 2004; Jonides, J., Smith, E., Koeppe, R. Awh, E., Minoshima, S. & Mintun, M. 1993. See also the discussion in Chapter 3 above.

144 Luck, S. & Hollingworth, A. (ed.) 2008, 3ff.

propositional memories on the basis of non-interference between tasks tapping into both memory stores. The different formats of the representations in the different working memory systems partly explain non-interference between tasks.[145]

Both memories of target templates and already visited locations directly influence priority assignments on the priority map. Spatial memories inhibit attention from returning to locations that have been searched. Memories of target templates enter the computation of priority in visual search. Most computational models of visual search assign priority to locations on the basis of matching, or similarity between target template and items at locations. Representations of items at locations have a format similar to that of representations in the visual system. Models of target matching often assume that representations of items at locations and target templates basically have the same geometric format. Indeed, in many cases, computational accounts of target matching assume that it consists in a series of geometric transformations on items at locations and target template.[146]

The involvement in visual search of memory systems assumed to store representations with geometric format suggests that the priority map shares this format. The simplest explanation of the influence of visuo-spatial memories on computations of

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145 Baddeley, A. D. 1986; Baddeley, A. D. 1996; Baddeley, A. D. 2003; Baddeley, A. D. 2007; Baddeley, A. D.. 2012; Brady, T., Konkle, T. & Alvarez, G. 2011; Knudsen, E. 2007; Luck, S. & Hollingworth, A. (ed.) 2008; Luck, S. & Vogel, E. 1997.

146 Ullman, S. 1996.

priority assignments on the priority map assumes that memories and map share a common geometric format.

The retention of the search template in visuo-spatial memory stores suggests that the memory of the template has geometric, hence non-conceptual structure. It supports the view that the part of the act-guiding state corresponding to the search template is not a concept. Because part of the state has geometric structure, it seems plausible that the entire state has geometric structure.

Objections launched against the claim that the priority map has geometric format could be repeated against assumptions that certain memory systems store information in geometric format. Doing so would have to be empirically motivated. It would require motivating a better alternative to the explanation of interference patterns on the basis of working memory systems' formats. It would require reinterpretation of a wide range of current psychological research. Until a better proposal is made, we may take psychology's explanations at face value. Until such an alternative proposal is made, the behavioral studies mentioned above support the position according to which the priority map has geometric structure.

4.4

Central Executive Control as Yielding Conceptual Intentional Guidance

Another objector might concede that the representational content of the priority map has non-conceptual, even geometric structure. In active shifts, however, the central executive system controls shifts of attention. The objector might claim that central executive control consists in, or requires, guidance by conceptual states. So, she might conclude, conceptual states guide active attentional shifts.

The objector would claim that central executive control is, or is sufficient for, guidance by the individual's conceptual intention. According to this objection, the intention guiding active shifts during search has a content of the type: <u>to search for the red square</u>. On this proposal, central executive control gives rise to, or partly constitutes, guidance by a conceptual intention. Central executive control, according to this proposal, generates guidance by a conceptual intention due to aspects of the central executive system's nature. Through the central executive system, the intention controls activity of the attentional system. States of the priority map are merely sub-individual states. They contribute to shifts of attention. But the *individual's* guidance consists in the intention's guidance.

The objection's second premise might be taken to apply to all animals. The objector would then be arguing from the claim that, in all animals, central executive control is, or requires, guidance by conceptual states. But this premise is too strong.

Central executive systems control activity in many animals. There is evidence for executive control in primates,[147] other mammals such as rodents,[148] and birds.[149] Non-modular, possibly amodal central executive processes have been hypothesized even in insects as relatively simple as ants.[150] Some of these animals plausibly do not have conceptual competencies. So, central executive control *could not* be, or require, guidance by conceptual states.

A stronger premise restricts the claim to specific groups of animals, for instance certain primates, maybe humans. At least in those animals – animals that *have* conceptual competencies – central executive control is, or requires, guidance by a conceptual intention. The objector might support this premise by pointing out that research on the central executive system describes its states as more abstract, relatively independent of any specific sense modality.

But psychology only supports the requirement that psychological states partly constituted by the central executive system's activity be *non-modular* and *intermodal*. The central system functions as an interface for different perceptual and other

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147 Caselli, L. & Chelazzi, L. 2011; Rossi, A., Pessoa, L., Desimone, R. & Ungerleider, L. 2009; Chudasama, Y. 2011; Stoet, G. & Snyder, L. 2003; Stoet, G. & Snyder, L. 2009; Stuphorn, V. & Schall, J. 2006; Moore, T., Schafer, R. & Noudoost, B. 2010; Wallis, J. 2010.

148 Dalley, J., Cardinal, R. & Robbins, T. 2004; Chudasama, Y. 2011.

149 Milmine, M., Rose, J. & Colombo, M. 2008; Butler, A. & Cotterill, R. 2006; Jarvis, E., Güntürkün, O., Bruce, L., Csillag, A., Karten, H., Kuenzel, W., Medina, L., Paxinos, G., Perkel, D., Shimizu, T., Striedter, G., Wild, J., Ball, G., Dugas-Ford, J., Durand, S., Hough, G., Husband, S., Kubikova, L., Lee, D.., Mello, C.., Powers, A., Siang, C., Smulders, T., Wada, K,. White, S., Yamamoto, K., Reiner, A. & Butler, A. 2005; Güntürkün, O. 2005; Güntürkün, O. 2005a.

150 Gronenberg, W. 2008.

psychological systems such as the motor system. States and events in the individual's sub-systems influence central states and events. Central executive processes access, and to some extent penetrate, processes in subsystems. The events and states involved in its processes influence, and are influenced by, processing from different perceptual systems. Its function suggests that its states have a format that favors integration of information from different subsystems. Central states thus likely have a format distinct from that characteristic of specific perceptual systems.

These requirements do not entail that the central executive's states and events must have *conceptual* format. Psychology explicitly assumes that central (executive) processes involve non-modular, intermodal states of *different* formats. Logical form is one format. But psychology explicitly assumes that visuo-spatial contents with perception-like formats are maintained in visuo-spatial working memory.[151] These contents participate in central processing. They help guide attentional and other activity. Contents stored in the range of different memory systems constituting working memory have different formats. Differences in format stem from certain memory stores' closer relation to specific perceptual systems. Visuo-spatial working memory, for example, plausibly closely relates to systems for sense perception. This relation to sense perception plausibly explains the memories' perception-like format. The central executive's allocating resources to processes does not, in and of itself, change the format

[151] Baddeley, A. D. 1986; Baddeley, A. D. 1996; Baddeley, A. D. 2003; Baddeley, A. D. 2007; Baddeley, A. D.. 2012; Brady, T., Konkle, T. & Alvarez, G. 2011; Knudsen, E. 2007; Luck, S. & Hollingworth, A. (ed.) 2008; Luck, S. & Vogel, E. 1997.

of the states and events involved in these processes. Appeal to the nature of the central executive system alone – even in humans – does not establish that conceptual states must be involved in its activity.

4.5

The Role of Conceptual Intentions

An influential tradition in action theory holds that, constitutively, all actions are guided to their completion by a conceptual intention. G.E.M. Anscombe started this tradition in analytic philosophy. Donald Davidson was probably first to state the view explicitly. It has dominated action theory ever since. An emphasis on the role of practical reasoning in human action presumably motivates this tradition. At least in humans, reason and thought guide central cases of action. Intentions just are thoughts that can result from practical reasoning and guide action. Since these intentions are thoughts and can result from practical reasoning, they have conceptual contents.[152]

I think that this tradition is guilty of two mistakes. First, it overlooks the crucial role of non-conceptual capacities in guiding action. Second, the tradition ignores actions by other animals, but plausibly also by humans, that are not guided by a conceptual intention. Reflection on the role of conceptual intentions and the priority map in active,

[152] The *loci classici* are Anscombe, G.E.M. 1953 and Davidson, D. 1980. Cf. also, for example, Goldman, A. 1970; Searle, J. 1983; Brand, M. 1984; Bratman, M. 1987; Mele, A. 1992; McDowell, J. 1994; Velleman, D. J. 2000; McDowell, J. 2007; McDowell, J. 2010.

guided shifts of visual attention throws these two mistakes into relief.

A priority map state directs attention shifts during visual search to their destination. I have argued that this priority map state has geometric, not propositional format. The emphasis on the priority map is not meant to suggest that conceptual intentions play no role in shifting attention. No doubt, conceptual intentions' role in causing active attention shifts is important.

Empirical research on visual search shows that the priority map guides all attention shifts during visual search. Psychology explains shifts during capture of attention and in the default state in terms of the priority map. Investigations of shifts during interactive behavior – behavior in which bodily and attentional activities interact – and cognitive tasks, too, appeal to the priority map as directing visual attention.[153] Computational studies on attentional routines model shifts during routines as based on the priority map.

It seems plausible that *all* salient kinds of attention shifts, at least in vision, must go through the priority map.[154] We have no taxonomy for all attention shifts. Nor do we have equally advanced scientific studies for all the different kinds of attention shifts that have been identified. But all shifts of visual attention are to locations, regions, or entities in space. Whichever representation guides those shifts must function to direct visual attention to locations, regions, or entities in the visual scene. The visual

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[153] Hamid, S., Stankiewicz, B. & Hayhoe, M. 2010; Hayhoe, M. 2000; Hayhoe, M., Shrivastava, A., Mruczek, R. & Pelz, J. 2003; Sprague, N., Ballard, D. & Robinson, A. 2007; Land, M. & Tatler, B. 2009.

[154] I exclude attention shifts due to oculomotor reflexes or tremor, for example.

attentional system already has a way of representing locations, regions, and objects in the visual scene – the priority map. The priority map provides an especially effective way of representing space and shifting attention to locations in space. It seems likely that the attentional system would rely on this existing representational structure for directing all shifts of visual attention to locations, regions, or entities in the visual scene. Psychology assumes that this conjecture is true.

Even when a conceptual intention helps guide attention shifts, the intention does not guide the shifts alone. Non-conceptual representational resources are required for guiding an attention shift to its completion. I again focus my discussion on visual search. Psychology shows that even when a conceptual intention initiates a visual search, eventually, the priority map and its associated mechanisms determine the precise location for individual attention shifts. Suppose that an individual has the intention to find a raspberry in the display. This generic, high-level intention does not, by itself, determine any specific location as the destination for an attention shift. According to the science, the following happens. The concept raspberry helps activate iconic memories of raspberries. A representation of an object of a certain shape and color serves as a template of the search target, the berry. The central executive maintains this representation in working memory and on its basis controls assignments of priority on the priority map. The priority map draws on geometric information contained in the map for its priority assignments. The computations of these assignments result in transitions from one priority map state to the next. The computations of these assignments govern transitions between geometric, not propositional states. Each specific priority map state contains the instructions specifying the destination for visual attention's next shift.

Conceptual intentions might play a causal role at different junctions. The individual's intention to find a raspberry might initiate the entire visual search. Additional, lower-level intentions might cause attention shifts to specific locations during the search. Suppose that the individual's search consists of three attention shifts, to three different locations. The priority map and its mechanisms determine each location. But a conceptual intention to shift there$_i$ might be required for attention to actually shift. The demonstrative in the intention's content refers to the respective location specified as the destination for the *i*-th shift. The complex state that guides each individual shift hence consists of at least the high level intention to find a raspberry, the low level intention to shift there$_i$, and the priority map state fixing the reference of the demonstrative there$_i$ to the specific destination of the attention shift. The priority map, on this picture, 'takes over' below the level of the low-level intention. The priority map fixes the referent of the demonstrative in the intention's content – the location for attention's next shift – by representing that location has having highest priority.

Alternatively, the conceptual intention to find a raspberry might initiate the visual search.[155] The priority map and its computational mechanisms might 'take over'

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[155] Michael Bratman has argued against what he calls the 'Simple View' of intentional action. According to this view, *each* action must be caused by a conceptual intention whose content refers to the action. So, on the simple view, each active shift of attention is caused by a conceptual intention whose

there. No further conceptual intentions might play a role in bringing about specific shifts of attention to specific destinations during the search. Suppose that on the alternative in the preceding paragraph the low-level intention functioned to initiate a shift to attention's next destination. Allocation of central executive resources might fulfill this function on the present alternative. The complex state guiding each specific attention shift would consist of the generic conceptual intention and the geometric state of the priority map specifying the destination of each specific shift. The complex state would not contain a low-level intention to shift there$_i$.

Empirical research does not directly address the question, which of these alternative pictures correctly describes shifts during visual search. Both are possible. Individuals are not conscious of having specific intentions to shift there$_i$ during all visual searches. But much of our psychology is unconscious. These intentions' being unconscious does not rule out the existence of such intentions. Maybe both variants occur in actual psychologies. Maybe additional factors decide whether an individual guides specific shifts during visual search on the basis of complex states containing low level intentions or not. In the present context, it suffices to note that all shifts during visual search do rely on the priority map at some level. On either variant, conceptual

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content denotes the event of shifting attention. Bratman proposes a more complex view according to which the intention causing an action need not be an intention to perform the act in question. Rather, it suffices for the intention to be a background intention, which confers act-status upon the activities flowing from it. A problem for this view is that much activity might flow from such an intention that is not active. How to distinguish between the acts and the non-acts that flow from the conceptual intention? As in my second alternative discussed in this paragraph, that the acts flowing from such an intention might be understood as controlled by the central executive. Cf. Bratman, M. 1987, especially Chapters 8 & 9.

competencies without the priority map do not specify the destination for shifts of visual attention. The conceptual intention alone does not guide the attention shift to its completion.

The second variant seems in some contexts more likely, however. Pending additional factors that call for the additional causal work of low-level conceptual intentions, these intentions seem redundant. The computational models do not require additional intentions for shifting attention. Once the search target is set, the priority map and the associated mechanisms *alone* can carry out the search, including the entire sequence of attention shifts until the target has been found. The postulation of additional low-level intentions would have to be motivated. What might motivate postulating such states? Additional conceptual intentions might account for additional causal force behind the guiding state driving some specific shift of attention. Forming the lower-level intention presumably would require additional activity in a conceptual system, requiring additional time. So, in specific circumstances, additional conceptual intentions might account for the longer duration of the computation and hence the shift. Empirical research does not provide clear criteria for deciding the matter. Absent such additional motivation, however, the computational models support suspending attribution of additional conceptual intentions.

This last consideration strongly suggests that, in principle, *no* conceptual intention is needed to guide attention during visual search.[156] Models for shifts during visual search make no essential appeal to conceptual states. The central executive system and the priority map alone suffice to guide active shifts during visual search. Additional considerations are needed to support postulating conceptual intentions as causal factors in visual search. Nothing about the search process in and of itself requires such conceptual states. Humans perform myriads of attention shifts every day. Many of them constitute spontaneous visual searches.[157] Shifts during such spontaneous searches seem to be plausible candidates for attention shifts guided by priority map and central executive system alone.

Reflection on other animals suggests that the central executive system and the priority map alone may implement individuals' guidance of attention shifts in these animals. Primates, rodents, and birds actively direct attention.[158] Often they exhibit patterns of attention shifts similar to those we find in humans. It is unclear whether all these animals have conceptual competencies. Many arthropods actively guide their attention shifts. The jumping spider, for example, guides attention in search for its prey,

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[156] See the arguments for a similar conclusion in Ruben, D. 2003 and Nanay, B. 2014.

[157] The non-conceptual guiding states can be understood in analogy to Searle's intentions in action. See his discussion of spontaneous action in Searle, J. 1983, Chapter 3.

[158] Dutta, A. & Gutfreund, Y. 2014; Knudsen, E. 1982; Kayser, C., Petkov, C., Lippert, M. & Logothetis, N. 2005; Nothdurft, H.-C., Pigarev, I. & Kastner, S. 2009; Einhaeuser, W., Kruse, W., Hoffmann, K.-P. & Koenig, P. 2006; Berger, D., Pazienti, A., Flores, F., Nawrot, M., Maldonado, P. & Gruen, S. 2012.

and for plotting a route along the floor of the jungle.[159] When the spider shifts visual attention, it does so actively. But spiders plausibly do not have conceptual competencies. Spiders do not have conceptual thought. So their active shifts *could not* be explained on the basis of conceptual attentions.

Whether or not these animals have conceptual competencies is an empirical matter. Whether or not these animals' agency must be explained in terms of conceptual or non-conceptual competencies must be decided by animal psychology and ethology. But suppose that we acknowledge that the geometric states of the priority map can help guide active attention shifts in absence of conceptual intentions. We then have a model for these animals' agency. When we have such a model, we can acknowledge that these animals act. We may at the same time eschew premature commitments on the empirical issue.

The emphasis of traditional action theory on conceptual intentions' constitutive role for action is at odds with these considerations. The traditional view would have to either deny that humans and other animals act when they shift attention on the basis of non-conceptual states alone. Or it would have to decree, from the armchair, that these animals' acts are always caused by conceptual intentions. The first position would simply be false, the second empirically tenuous.

The traditional view ignores the priority map's crucial role in directing individual attention shifts to their destination. Conceptual intentions alone do *not* guide

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[159] Cross, F. & Jackson, R. 2010; Jackson, R. & Cross, F. 2011.

individual attention shifts to their destination. The central executive and the priority map jointly guide each individual shift to its destination. The non-conceptual competency is part of the individual's capacity to guide her attention shift. While a conceptual intention is part of the causal chain leading to each individual shift, an account of individuals' guidance of these shifts in terms of conceptual competencies alone would be incomplete. I will discuss this last point more fully in the next chapter.

Reflection on the priority map's role in actively guided shifts of visual attention suggests abandoning the traditional view. Action theory should begin to investigate the role of different representational competencies in action.

4.6

Conclusion

In this chapter, I have argued that priority maps that guide many shifts of attention have representational contents with geometric structure. I have argued, in particular, that often, such psychological states with geometrically structured contents guide active shifts of attention. They may do so, even when no conceptual intention guides the relevant shifts. We should abandon the traditional view according to which all actions are constitutively guided by a conceptual intention.

Chapter 5

The Constitution of Guidance

In this last chapter I want to tie together the threads from the preceding three chapters. In section one I restate the proposal that this dissertation argues for. When individuals guide their attention shifts, then, actually constitutively, in psychologies sufficiently like those of actual primates, the central executive system controls these shifts. I sketch how my proposal helps solve Frankfurt's problem of action.

In section two I explain what it means that executive control is *actually* constitutive. The proposal is extensionally adequate for certain psychologies in the actual world. It is plausibly true for such psychologies in relatively close-by worlds. It may be not metaphysically necessary, even for the relevant kinds of psychologies.

In section three I elaborate on how the proposal helps explain, illuminate, and understand individuals' guidance. I reflect on the notion guidance by the individual and explain why central executive control plausibly realizes individuals' guidance.

In section four I discuss and reject several objections to my proposal.

I close, in section five with some speculative remarks on the scope of my proposal. I indicate several dimensions along which it contributes to current theorizing of action.

5.1

Individuals' Guidance of Visual Attention

The central executive system's control over an individual's active shifts of attention, I proposed earlier, partly constitutes the individual's guidance of these shifts. The proposal was based on findings about the correlation of guidance and central executive control in active attention shifts. In this chapter I establish the slightly qualified claim:

> Constitution of Guidance
>
> When individuals guide their visual attention shifts, then, if these individuals have psychologies sufficiently similar to those of actual primates, it is actually constitutive of their guidance that the central executive system controls these shifts.

The central executive system controls such shifts by controlling assignments of priority to locations on the priority map that determines the shifts' destinations. The central executive system controls assignments on the priority map by allocating central resources to the computation of these assignments.

In visual search, for example, the central executive system sets a search template that shapes computations of destinations for attention shifts. The central executive system maintains already visited locations in working memory. The central executive system suppresses factors that might interfere with the search. The central executive system allocates central resources to the exercise of competencies that sustain the search.

The proposal contributes to solving Frankfurt's problem(s) of action. Frankfurt writes: “[A]n explication of the nature of action must deal with two distinct problems. One is to explain the notion of guided behavior. The other is to specify when the guidance of behavior is attributable to an agent and not simply … to some local process going on within the agent’s body. The first problem concerns the conditions under which behavior is purposive, while the second concerns the conditions under which purposive behavior is intentional.”[160]

Frankfurt goes on to elaborate on the form that a solution to his problems might take. He writes that “behavior is purposive when its course is subject to adjustments which compensate for the effects of forces which would otherwise interfere with the course of the behavior ... . The behavior is in that case under the guidance of an

[160] Frankfurt, H. 1988, 74; I leave it open whether guided behavior is merely purposive behavior. I leave it open whether purposive behavior attributable to the individual is sufficient for intentional behavior. No matter whether either claim is true, Frankfurt identifies, I think, two questions that are central to understanding individuals’ guidance.

independent causal mechanism, whose readiness to bring about compensatory adjustments tends to ensure that the behavior is accomplished. The activity of such a mechanism is normally not, of course guided by us. Rather it *is*, when we are performing and action, our guidance of our behavior."[161]

In trying to solve the problem of action, Frankfurt cautions us, we should not "exaggerate the peculiarity of what human beings do."[162] Instead, we should acknowledge that "[t]he conditions for attributing guidance of bodily movements to a whole creature, rather than only to some local mechanism within a creature, evidently obtain outside of human life. Hence they cannot be satisfactorily understood by relying upon concepts which are inapplicable to spiders and their ilk."[163]

Frankfurt here asks for constitutive conditions on individuals' guidance. I next want to sketch in what ways my proposal addresses Frankfurt's points. In the following two sections I will explain what constitutive conditions are and why my proposal provides *actually constitutive* conditions on individuals' guidance. The discussion in these sections also provides a fuller explanation as to how my proposal contributes to solving Frankfurt's problem of action.

Frankfurt states that the problem of action has two components. The first component consists in explaining the notion of guided behavior. Guided behavior just is

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[161] *ibid*., 75.

[162] *ibid*., 78.

[163] *ibid*.

a purposive process. Frankfurt suggests that the answer to this question will specify a causal mechanism. This mechanism will tend to assure the successful completion of the purposive process by adjusting for interfering forces.

My proposal specifies a causal mechanism of this kind. The attentional system, with its exogenous and endogenous components, has a function to shift visual attention. The system functions to allocate visual attention in ways beneficial to the organism. The system was shaped by the evolutionary need of balancing the cost of distributing visual resources against the benefits of doing so. The attentional system partly functions to eliminate irrelevant stimuli from further processing. The system is, in Frankfurt's terms, a causal mechanism that undergoes purposive processes. Appeal to the attentional system thus helps solve the first part of Frankfurt's problem of action.

My proposal heeds Frankfurt's warning to acknowledge and consider the guidance of animals other than humans. I have argued that the geometric priority map eventually helps guide all shifts of visual attention, even those driven in part by a conceptual intention. But sometimes, *no* conceptual intentions enter the causal processes that result in the act. The priority map, controlled by the central executive system, can be the sole guider of a shift of visual attention. As I explained earlier, the central executive system together with the non-conceptual priority map provides a plausible model for the guidance of animals other than humans – animals that do not have conceptual competencies.[164]

The proposal suggests that guidance is a matter of the architecture of individuals' psychologies. Psychology tends to see higher animals' minds as hierarchically structured. At the bottom of the hierarchy, perceptual systems compute a confined range of inputs in basically modular, automatic fashion. Psychological systems higher in this hierarchy take wider ranges of inputs. These systems are integrated to a greater degree with other psychological systems. Processing at higher levels abstracts from sensory input to an increasing degree. The processing becomes more flexible. My proposal identifies a type of psychological processing that implements individuals' guidance. This type of processing may implement individuals' guidance in any relevantly similar psychology. The proposal makes no essential reference to specific representational competencies such as conceptual competencies. These competencies occur in only a relatively narrow range of animals. When non-conceptual states and central executive system together control an act, they constitute a type of guidance that is continuous between humans and a wider range of other animals.

The second component of Frankfurt's problem of action consists in specifying when purposive processes are attributable to the *individual*. This problem arises not merely in the context of explaining agency. An individual's stomach digests food and extracts nutrients from it. Digestion is a purposive process. The process occurs inside the individual. We can, colloquially, say that the individual digests the food. But we

164 See Chapter 4.

would deny that the individual makes the extraction of nutrients occur. In this sense, the digestive process cannot be attributed to the individual. We make the same distinction for psychological processes. The visual system computes lightness properties from luminance contours. We attribute these computations to the visual system, one of the individual's sub-systems. The individual does not compute lightness from luminance contours. We distinguish whether a psychological process is attributable to the whole individual or *merely* one of her sub-systems.

Frankfurt asks when purposive processes are properly speaking the individual's. Again, he suggests that specifying the right kind of causal mechanism solves the problem. We must specify the mechanism that is or constitutes an individual's guidance. My proposal specifies a causal mechanism of this kind. When individuals guide their shifts of visual attention, the central executive system controls the attentional system in such a way as to realize individuals' goals. The causal mechanism consists in the central executive system and parts of the attentional system. When purposive attentional processes can be attributed to the individual, not merely to the attentional system, then the central executive system controls them. This type of psychological processing promises to illuminate purposive processes' attributability to individuals more generally.

5.2

Central Executive Control as Actually Constitutive

What is a constitutive condition? I adopt the notion from Tyler Burge.[165] Constitutive conditions are "conditions that are necessary, sufficient, or necessary and sufficient to be something of [a] kind or with [a] nature, and [they] are in principle potentially relevant to explaining, understanding, illuminating the kind or nature."[166] Constitutive conditions on individuals' guidance specify what it *is* for an individual to guide an act.

An answer to a constitutive question, however, does not merely provide some necessary, sufficient, or necessary and sufficient condition on being a certain kind or nature. Rather, constitutive questions concern necessary or sufficient conditions that "help *explain* something's having the nature that it has."[167] Say that nothing exists in a world in which 2+2=5. This necessary condition on being a nature does nothing to explain or illuminate that nature.

Being H_2O plausibly constitutes, and grounds an explanation of the nature of, water. Constitutive conditions need not be parts of natures. Constitutive conditions need not yield reductive accounts of natures. Maybe explanations involving water can be

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165 Burge, T. 2010, 57.

166 *ibid.,* 58.

167 *ibid*.

reduced to explanations in terms of H_2O. Constitutive conditions that do not validate such reduction can nevertheless ground explanations and understanding of a nature. They can ground scientific explanations that help illuminate the nature.

Central executive control is, I think, neither metaphysically necessary nor sufficient for individuals' guidance of visual attention. Central executive control is rather, I maintain, *actually constitutive* for guidance by individuals with psychologies sufficiently similar to those of actual primates. Central executive control is a condition on guidance of attention shifts by such individuals in the *actual* world. This condition plays the explanatory role that constitutive conditions perform more generally. At least in relatively close-by worlds, I maintain, central executive control implements the guidance of individuals with psychologies sufficiently similar to those of actual primates. I want to first rehearse, and elaborate on, the correlation of central executive control and individuals' guidance of their shifts of visual attention.[168]

On the one hand, consider the range of attention shifts that are passive, and without guidance by the individual. Fixational eye movements and concomitant attention shifts (if any), for example, never constitute individuals' acts.[169] If the same stimulus activates retinal neurons for an extended time, neural responses and the quality of visual processing degrade. Fixational eye movements occur during a fixation to

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[168] See Chapter 3.

[169] Martinez-Conde, S., Macknik, S. & Hubel, D. 2004; Martinez-Conde, S., Macknik, S., Troncoso, X. & Hubel, D. 2009.

counteract such neural adaptation. These movements, when noticed, seem to the human observer to be no more than a trembling of the eye.[170]

Another example of automatic eye movements are vestibulo-ocular and optokinetic reflexes.[171] They function to stabilize fixation of gaze. These reflexes counteract movements of the body to maintain fixation on an object. For instance, the eyes of an individual seated on a turning chair will exhibit a characteristic saw tooth pattern that corrects for displacement of gaze.

More central types of passive attention shifts are, of course, attentional capture and shifts during default activity. A stimulus *captures* attention when it is of high physical saliency or behavioral relevance. When a stimulus captures attention, it disrupts or overrides individuals' guidance. Properties of the stimulus and principles governing individuals' exogenous attentional system control shifts during capture. When the attentional system is in its *default state* the exogenous system shifts attention on the basis of specific saliency-based attentional routines. The exogenous attentional system generates both types of passive shift on the basis of physical properties of the stimulus and saliency-based algorithms for computing sequences of attention shifts.

None of these passive shifts of visual attention feature control by the central executive system.

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170 Thre types of fixational eye movements are tremor, drift, and microsaccades. Tremor consists of wave-like, fast movements with extremely small amplitude. Drift has similarly small amplitude but occurs much more slowly. Microsaccades are small, fast, jerk-like eye movements that occur during fixation. They often correct movements of the eyes due to drift.

171 Findlay, J. & Gilchrist, I. 2003, 22ff.

On the other hand, recall the range of active shifts of visual attention, guided by the individual. I emphasized shifts during visual search. The series of shifts during visual search constitutes an attentional routine, driven by the individual's goal of finding some specific item in the visual scene. The individual sets a goal for her search. She then systematically moves attention across the scene until she finds her target or aborts the search.

Individuals completing some cognitive task shift attention actively. Suppose that an individual is asked to determine the material circumstances of a family depicted in a painting, as in Yarbus' famous study.[172] The individual actively acquires the information that allows her to answer the question. She shifts attention in systematic ways. Different cognitive goals generate different patterns of attention shifts. Patterns for any given cognitive goal are similar for the same individual at different times and between different individuals. These shifts are elements of attentional routines driven by a cognitive goal.

Many motor tasks depend on the acquisition of specific visual information by the individual. Individuals actively shift visual attention for this purpose during everyday activities such as sandwich making or when placing a return shot in tennis. All these different activities' successful performance is supported by specific, skilled patterns of eye movements. The experienced tennis player fixates the top of the net to anticipate the location where the ball will bounce. This fixation-pattern allows her to

[172] Yarbus, A. 1967.

ideally return the shot.[173] Again, such patterns of fixation constitute highly stereotyped attentional routines.

When individuals focus attention on some specific item in the visual scene, say as a consequence of a conscious decision or a conceptual intention, they do so actively. The decision or intention determines a location or an object in the visual scene upon which to fixate attention.

The central executive system controls all these shifts.

We do not have a full taxonomy of attention shifts. Nor do we have a full understanding of the psychological processes underlying each type of attention shift. But current psychological research exhibits a strong correlation between individuals' guidance of their shifts of visual attention and control by the central executive system. So in the actual world, central executive control appears to be a condition on individuals' guidance of visual attention shifts.

The proposal must be qualified further. Many animals in the actual world, such as snails, seem to guide their acts, but probably do not have a central executive system. Psychological animals guide their visual attention, but we do not know whether they all have a central executive system. The psychological research I relied on in developing my proposal focused on humans and other primates.

Consider the jumping spider. When the jumping spider plots her route through the jungle toward her prey, she first fixates attention on her prey among the branches of

[173] Land, M. & Furneaux, S. 1997; Land, M. & Tatler, B. 2009.

a tree. She then guides attention from her prey to obstacles on the jungle floor. The spider scans nearby trees and branches for whether they provide an opportunity to jump on her prey.[174]

We do not know enough about spiders to say with certainty whether the spider has a central executive system. We should be open as regards the precise nature of the central executive system. I claim that the activity of some system for controlling cognitive processes actually constitutes individuals' guidance of these processes. I do not commit to some specific set of executive functions. The precise nature of the central executive system might vary among different kinds of animals. Determining its nature is an empirical matter. Our knowledge of the psychology especially of fairly simple animals is rather poor. There is some research suggesting that ants have a central system of sorts. Much of that research is speculative. We simply do not know whether ants, if they have a central system, have a central *executive* system that controls central processing. And even if we knew all these things, we would still not know whether the same is true for the jumping spider.[175]

My proposal is open to integrating other animals, should empirical research warrant doing so. This feature constitutes a strength of the proposal.

It seems plausible that all sufficiently complex psychological animals should have a central system. Such a central system – an intermodal, non-modular system –

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[174] Cross, F. & Jackson, R. 2010; Jackson, R. & Cross, F. 2011.

[175] Gronenberg, W. 2008; See also Chapter 4.

would serve as an interface for different perceptual, cognitive, and motor systems. A functional level for the integration and coordination of information from different modalities and psychological sub-systems would plausibly benefit such animals, from an evolutionary point of view. And even greater benefit would probably stem from integration and coordination *for* the animals' goals. Yet greater benefit would likely accrue if the system had the capacity to regulate the integration and coordination of resources for pursuing individuals' goals. Simple animals will not need such a level of processing. But we can plausibly expect that more complex animals will tend to exhibit a level of processing that fulfills this integrative and coordinative function. So we should expect that sufficiently complex psychological animals will often have a controller for the central system – a central executive system. These considerations suggest that for animals with fairly complex psychologies, in environments sufficiently like the actual world, guidance will be implemented by the control of a central executive system.

As plausible as these speculations seem, they are merely speculations. We do not know enough about actual psychologies of most animals less complex than primates. Much less are we in a position to know what psychologies of possible animals in merely possible worlds might look like. Ethology and comparative psychology support the verdict that primates in the actual world exhibit central executive systems of the type discussed. I restrict my proposal to individuals with psychologies similar to those of actual primates.

5.3

Central Executive Control as Explanatory

The most important feature of constitutive conditions is that they help ground explanations and understanding of natures. Central executive control is actually constitutive of individuals' guidance of their attention shifts because it helps illuminate its nature. By seeing why central executive control is a plausible candidate for realizing individuals' guidance, we can understand how central executive control helps understand the nature of guidance.

Reflection on the notion guidance by the individual helps us see how appeal to central executive control can help illuminate it. I first consider why central executive control plausibly implements guidance by the individual. Next I reflect on how central executive control furthers the understanding of the notion.

What is a good guide? Consider the example of a mountain guide. First, the good guide *sets the goal* for the expedition's ascent. She picks a peak as her expedition's destination and orients her expedition toward the peak, using a map, a view of the peak, or her memory of the trail. Second, the good mountain guide *has relevant organizational competencies*. She brings the map, rope, pickax, and crampons. She knows how to use them. The good mountain guide is able to negotiate the terrain that the expedition crosses. She knows the route to that peak (and how to plot alternate routes in case something goes wrong). She knows how to get members of the expedition in line and instruct them. Third, a good mountain guide uses these competencies, as needed, to *stably steer toward* the goal of the expedition. She gets the crampons out when the expedition crosses ice. She trudges ahead, showing the way. The good mountain guide exerts her and the expedition's energy only to the degree required. If necessary, she will give members of the expedition the occasional push to get them over a hump. If necessary, she will quell their resistance on a stretch that strikes them as unduly strenuous.[176]

Appeals to the central executive system help us understand individual's guidance by connecting it with a kind – central executive control – that appears in psychological explanations. Reflection on this kind reveals how central executive control implements aspects of the notion guidance laid out in the foregoing paragraph. It illuminates empirical conditions that realize aspects of guidance, and hence guidance itself, in actual psychologies.

Reflection on the notion of a good guide suggested that guidance requires exercising a competency for setting goals, organizational competencies that hold available relevant resources for attaining the goal, and the exercise of these competencies, as needed, to stably steer toward that goal.

For cognitive processes, central executive control implements these three aspects of the notion guidance. First, the central executive system implements individuals' goal

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[176] Cf. the *Oxford English Dictionary*: "One who guides; one who leads or shows the way, esp. to a traveller in a strange country; *spec.* one who is hired to conduct a traveller or tourist (e.g. over a mountain, through a forest, or over a city or building) and to point out objects of interest."

setting. When the individual sets a goal for visual search, the central executive system holds a representation of the goal in working memory by allocating processing resources to that representation. Second, the central executive system realizes organizational competencies for attaining the individual's goal. These competencies allocate resources for the search. The central executive system has the power to activate competencies and states from memory. The system can allocate central processing resources to whatever processes serve the set goal. Its three executive functions serve to initiate, coordinate, and organize competencies, states, and processing resources. Third, the central executive system, when functioning well, exercises its organizational competencies – allocates resources – in ways that further the individual's goal. In visual search the system inhibits interfering, salient stimuli from locations that likely do not contain the search target. The system allocates central processing resources to the attentional mechanisms that compute the next shift's destination. The system stores already visited locations in working memory.

By seeing how central executive control implements different aspects of guidance we acquire a deeper, fuller understanding of its nature.

Central executive control furthers our understanding of guidance *by the individual* in similar fashion. We should first note that the central executive system is a *prima facie* plausible candidate for implementing guidance by the individual because the central executive system helps realize central instances of processes that are attributable to the whole individual. The system helps realize central instances of individuals' acts. The central executive system is crucial to carrying out visual search, mental arithmetic, problem solving, deductive inference, and many other cognitive processes. In psychology, one of the main explanatory roles of postulating the central executive system is to help explain individuals' goal-represented processes. Central instances of all these processes occur at the level of the whole individual.

What about postulating the central executive system allows to explain, illuminate, and further our understanding of guidance by the individual? Illuminating our notion of a psychological individual is a deep, difficult task. I do not pretend to contribute much to it. But it seems uncontroversial that when an individual guides an action, the process constituting the action cannot be external to the individual. Nor can the process *only* occur as a process of one of her sub-systems.

When the central executive system controls a psychological process, that process is part of the individual's psychology. So the process, including its control by the central executive system, does not occur outside the individual. When the central executive system controls a psychological process, that process is not merely a modular process. Rather, such processes are central processes. They typically occur at the level of the whole individual. The processes often have the features that mark the level of the individual: they are often conscious, individuals often make them occur, and they are exercises of individuals' central capabilities.[177]

More importantly, the central executive system *functions to integrate and unify*

[177] Burge, T. 2010, 369.

the individuals' states and competencies for the successful execution of individual-level cognitive processes. The system organizes and activates resources for a cognitive process. The system coordinates cognitive processes both simultaneously and through time. By integrating capacities for a cognitive process, the central executive system unifies the activities and products of individuals' different psychological sub-systems and enables a process at the level of the whole individual.

Most importantly, the central executive system performs such integration *for attaining individuals' goals*. The central executive system functions to implement individuals' goal-represented activities – activities directed at a goal that the individual represents. The integration and unification achieved by the central executive system serves, in central cases, the attainment of individuals' goals. In explanations of many other processes psychology does not appeal to goals of the individual. Computations of edge-representations from representations of illumination gradients are explained in terms of transformations by the visual system, without influence from individuals' goals.

Central executive control thus marks a level of integration that unifies psychological processes in individual's sub-systems so as to generate the individual's activities, directed at the individual's goals. This system contributes to unifying psychological processing in different psychological sub-systems so as to make them an individual's goal-represented activities. (Goal-represented activities are directed at a goal that the individual represents.) Because central executive control marks such a level of integration and unification for sufficiently complex psychologies, the central executive system is a plausible realizer of individuals' guidance.

Several qualifications need to be stated. We must note that the central executive system need not always implement goal-represented activity. An individual may engage in deductive inference without pursuing some specific goal. The individual may infer on a whim.[178] The central executive system may provide working memory storage for intermediate steps and central processing power performing the inference.

The central executive system controls cognitive processes that do not require integration of different competencies and resources. Simple, spontaneous, active shifts of attention from one location to the next may not require such integration. All these shifts require may be that the central executive system allocate resources to the priority map.

The central executive system may, of course, malfunction in its control over a cognitive process. The system may activate the wrong competencies for achieving a given goal.

In all these instances, the individual nevertheless guides the process. A guide can exercise her abilities as a guide without setting a goal and without an expedition. She may go on a very short solo hike. She can pick the wrong way or direct without knowing where she goes. Doing so makes her a bad guide. She is a guide nevertheless.

For my purposes it suffices to see that the central executive system constitutes a

178 I owe this example to Tyler Burge.

level of psychological functioning that plausibly implements, and constitutes a basis for understanding, the individual's guidance. I have explained why central executive control plausibly implements individuals' guidance. How does seeing this connection help us *understand* individuals' guidance?

The proposal helps understand individuals' guidance by connecting it with law-like explanations in empirical psychology. It makes the detail of such explanations bear on the notion of individuals' guidance. I cannot offer a full theory of what explanation, illumination, understanding, and progress along these dimensions consist in. I trust that we recognize explanatory progress when we see it.

I nevertheless want to point out three ways in which such a connection plausibly furthers our understanding of guidance by the individual. First, scientific explanation provides detail about how guidance actually works, how it is realized in actual psychologies. The wealth of empirical knowledge about the central executive system and details of its functioning *de facto* stretches beyond what philosophers have discovered about guidance in an a priori manner. Many of the details of the central executive system's functioning may be empirical facts, *in principle* inaccessible to a priori discovery. These details nevertheless help understand guidance's nature.

Second, scientific explanation connects guidance, through its implementation by the central executive system, to empirical research on many other phenomena. The investigation of these phenomena appeals to the central executive system. These phenomena may include, for instance, research on general intelligence, the character and quality of memory systems, and models of reasoning. The correlation between central executive control and individuals' guidance places the latter notion in a network of other explanatory notions and scientific findings. The correlation furthers our understanding of guidance by the individual by widening the conceptual and explanatory network in which the notion is embedded. Again, the network of explanations and explanatory notions in which guidance is embedded, and its role in this network, may in principle not be accessible on the basis of a priori reflection alone.

Third, connecting individuals' guidance with law-like explanation in psychology places a constraint on, and corrects, alleged results of a priori reasoning about the notion. For example, central executive control is a condition on individuals' guidance over their visual attention shifts. Empirical psychology acknowledges instances of central executive control that are not accompanied by individuals' higher-order thought. Some philosophers have proclaimed higher-order thought a necessary condition on individuals' guidance.[179] Empirical psychology shows these philosophers to be mistaken.

Acknowledging these points about actual constitution allows us to see more clearly how my proposal contributes to a solution to Frankfurt's problem of action. Central executive control implements and realizes individuals' purposive – indeed, goal-represented – processes. In Frankfurt's terms, it thus implements and realizes a form of guidance. Central executive control implements and realizes processes that are

179 Cf. Velleman, D. 2000 and Korsgaard, C. 2009.

guided by the individual. The system thus helps implement and realize processes that are attributable to the whole individual. Central executive control furthers our understanding of individuals' guidance by connecting that notion with scientific psychological research. My proposal helps solve Frankfurt's problems by specifying conditions that implement individuals' guidance and help explain its nature.

5.4

Some Objections

In this section I discuss four lines of objection against my proposal. The first revolves around circularity worries. The second formulates doubts about my proposal's scope. The third rejects the claim that my proposal specifies an actually constitutive condition on individuals' guidance. The fourth maintains that reflection on empirical psychology could not possibly contribute to our understanding of natures.

5.4.1 Circularity

The first line of objection resembles homunculus-worries about the central executive system that I discussed earlier.[180] Objectors may worry that the appeal to the central executive system as actually constitutive of individuals' guidance tacitly imports

[180] See Chapter 2.

agential events into my account of guidance, and hence of agency. The explanation of guidance and agency in terms of the central executive system would threaten to be circular. This line of objection might take several forms. I discuss two.

The objector might think that *all* exercises of central executive functions are themselves individuals' acts. I would then be explaining individuals' guidance of their acts in terms of other guided psychological acts – exercises of executive functions. Thus circularly explaining guidance and agency in terms of guidance and agency would not be of much value, the objector might charge.

This version of the circularity objection rests on a misunderstanding, however. Not all exercises of executive functions are acts. Earlier I explained that, plausibly, not all exercises of executive functions are attributable to the individual. Remember the individual who is adding 123,145 and 224,287. While she is adding these numbers, her central executive system may be inhibiting salient visual distractors from entering central processing. The system may encode 2 into working memory for carrying, without that memory's being accessible to consciousness. These considerations suggest that such exercises of the executive functions *inhibition* and *maintenance* do not occur at the level of the whole individual. All *acts*, however, do occur at the level of the whole individual. All acts can be attributed to the individual herself, as opposed to one of her sub-systems. So these exercises of executive functions could not be individuals' acts.

This result seems independently plausible. The central executive system stores and maintains the carried numbers. Merely storing and maintaining numbers in working memory does plausibly not always constitute an exercise of agency. It does not seem that I am always actively suppressing the distracting stimulus that I am not aware of.

The objector might concede that not all instances of inhibition and maintenance are individuals' agency. She might reply that at least *some* exercises of executive functions are individuals' acts. In certain circumstances, the central executive system's inhibition or maintenance of a stimulus is the individual's act. Or alternatively, the objector might claim that while inhibition and maintenance are usually not individuals' acts, exercises of the switching-function usually are. This objector might now charge that appeals to central executive control can help explain individuals' guidance *only* when the exercise of central executive control is an act by the individual. In this case, again, I would be explaining guidance, and hence agency, in terms of agency.

I want to concede that some instances of maintenance, inhibition, and switching plausibly are individuals' acts. It seems much less likely that in *all* instances of psychological agency, the central executive system's contribution itself is an act by the individual. Suppose, for example, that an individual is mentally passive at one moment, but actively focuses visual attention on the wall, in the next moment. Suppose that the central executive system does not need to inhibit or maintain any stimuli. It merely allocates central resources to the visual attentional system. This allocation plausibly is a constituent of the active focusing. But it is not clear at all that it is a further act, in addition to the focusing of visual attention.

More importantly, suppose that the objector is right. Suppose that it turned out that in all active processes, the central executive system's activity was found to be itself an act by the individual. This discovery would be an *empirical* discovery about our agency. We would have discovered empirically that all psychological acts are partly constituted by an exercise of an executive function that itself is an act by the individual. Such a discovery *would* further our understanding of the nature of agency.

An alternative version of the circularity-objection maintains that my proposal tacitly assumes that the central executive system is whichever system constitutes the agency of individuals' psychological acts.

The proposal does not make such an assumption. Psychology does not at the outset assume that the central executive system is the agency-constituting system. Rather, the system functions to enable certain types of cognitive processes. These processes include reasoning, problem-solving, attending, working memory-processes, mental calculations, and many others. Among these processes are goal-represented cognitive activities. *They* are, of course, salient exercises of individuals' agency. But, first, not all cognitive processes that appeals to the central executive system explain are goal-represented processes. Individuals might actively solve a chess problem without pursuing any represented goal in doing so. And, second, not all cognitive processes that appeals to the central executive system serve to explain are obviously the individual's acts. Individuals might solve chess problems without actively doing anything. The solutions may 'pop into their minds' or occur to them passively. Reference to the central executive system may help explain instances of passive mind-wandering that require working memory resources. Empirical research will have to decide whether these episodes actually involve central executive control. Psychology, and hence my proposal, does not merely assume that the central executive system is whichever system constitutes active processes.

The first line of objection, in its different versions, should be rejected.

5.4.2 Scope

Another objector doubts that central executive control actually correlates with shifts guided by the individual. Central executive control does not, even in the actual world, and even in actual primates, implement individuals' guidance of attention shifts. Rather, the objector claims, there are cases in which other psychological episodes implement individuals' guidance of attention shifts.

Such an objector will likely adhere some specific theory of guidance. The objector will make a claim as to what, other than central executive control, constitutes individuals' guidance of crucial shifts of attention. For present purposes, suppose that the objector thinks that causation by a conceptual intention constitutes individuals' guidance. But such causation does not require, the objector says, central executive control. So, my proposal is false.

The plausibility of such a proposal depends on its details. How might the intention cause the attention shift such that the intention's causal influence would constitute the individual's guidance?

The objector might accept that individuals' guided shifts rely on the priority map. She might claim that sometimes, conceptual intentions cause attention shifts by *directly* affecting assignments on the priority map. Such assignments might be claimed to occur without the central executive system's controlling the intention's influence on the map. But how exactly does the intention influence the state of the map, if not through the central executive system's control? Empirical psychology does not acknowledge cases in which intentions influence the priority map in such alternative ways. There are no known cases of such an influence on the priority map. Rather, central cases of intentions' influence on the attentional system require central executive control. The central executive system controls the transformation of the intention's conceptual instructions into information that determines the state of the priority map. The central executive system controls the attentional system's activity so as to ensure the execution of the conceptual intention.[181]

Earlier I briefly discussed a mechanism that might serve as an alternative example. I mentioned ways in which long-term memories can modulate the attentional system's default settings. An individual may have a memory that forest scenes likely contain interesting objects at mid-range, in trees' branches. This memory may directly modulate the attentional system's activity. Suppose that the visual system identifies a visual scene as that of a forest. This classification activates the memory of correlations

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[181] See also the discussions in section 2 and Chapter 3.

between forest scenes and interesting locations. The long-term memory increases the base-line salience or priority assignments for locations in the visual scene that coincide with trees' branches. This modulation of the priority map's default state may influence attention shifts in two ways. First, it may shape attentional routines in the default state, leading to more frequent attention shifts to tree branches, as opposed to shifts only to physically salient locations. Second, even when individuals guide their shifts, such increased default priority may draw, possibly even capture, attention. As I argued earlier, such modulation of the priority map does not constitute guidance, whether it occurs alone or in the context of guided shifts.[182]

Intentions might similarly modulate the priority map's default state. Suppose that the long-term memory is not a belief, but an intention <u>to generally scan tree branches in forest scenes</u>. Suppose that the intention's influence on the priority map and individual shifts of attention is the same as in the case of the belief. I believe that such shifts would constitute instances of default activity or drawn attention, just as in the case of the belief stored in long-term memory. More importantly, there is no empirical reason to think that intentions actually have this influence on attention shift.[183]

Might there not be other ways in which intentions could directly influence

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[182] See Chapter 3.

[183] I am not aware of a plausible argument for the claim that such shifts would constitute individuals' acts. But suppose we conceded this claim to the objector. Even so, we would plausibly not consider the shifts to be guided by the individual. They would be better classified as reflex actions. The intention, once it is formed, would set up the attentional system so as to automatically shift attention in specific ways. The intention's execution would largely bypass individuals' other currently active central states. Shifts to locations primed by the intention would seem to resemble prepared reflexes.

individuals' shifts without being controlled by the central executive system? Intentions might affect attention shifts through a direct causal channel, without passing through representational transformations such as those required by the priority map. The considerations from the last paragraph seem to reapply. It seems unlikely to me that such an influence would constitute individuals' guidance. Again, the more important point is that there is no empirical support for the claim that such shifts of attention actually occur.

We do not have direct evidence for such alternative influences of intention on the attentional system. I am not aware of a detailed alternative model for such influences that does not appeal to the priority map. Such influences would plausibly not constitute agency. The second line of objection, too, can be rejected.

5.4.3 Constitution

A third objector might deny that my account helps understand individuals' guidance of visual attention shifts. This objection, too, comes in two versions.

According to the first version of this objection, shifts of visual attention, for example during visual search, are not individuals' acts. They are not passive occurrences that merely happen to the individual either. Rather, they constitute "mere activity." So, these shifts will not exhibit conditions on genuine agency or guidance.

According to the second version of this objection, shifts of visual attention are individuals' acts. These shifts are exercises of individuals' agency. But, says the objector, my proposal misidentifies the true constitutor of their agency.

Many action theories posit a constitutor of agency. Support for the theories stems from their power to account for instances of action. Arguments in favor of some specific account of agency often rely on correlative evidence: whenever an individual intuitively acts, the theory's constitutor of action is involved in the act. A priori reflection on agency may provide an alternative source of support for some specific action theory.

I first briefly comment on the claim that relevant shifts of attention are not genuine acts. Next, I discuss the charge that some psychological item other than central executive control constitutes these episodes' agency. Finally I consider what strikes me as the most influential a priori argument for an alternative constitutor of action.

I take our intuitive judgment about attention shifts as a *datum*. Shifts during visual search, the focusing of attention, and many other attentional episodes, are active shifts. The individual guides those shifts. The burden of proof is on the objector to show that these intuitions are mistaken. I am not aware of a good reason to deny that shifts of attention are genuine acts.

David Velleman, Harry Frankfurt, Christine Korsgaard, and Michael Bratman distinguish between mere activities and human persons' full-blown actions.[184] I reject the notion that individuals can be agents of an act to a greater or lesser extent.

184 Velleman, D. J. 2000; Frankfurt, H. 1988; Bratman, M. 2007; Korsgaard, C. 2009.

Individuals may be more or less in control of their actions.[185] They cannot be more or less their actions' agents. So I reject the objector's first claim.

What evidence is there to think that some other psychological item constitutes the agency in attention shifts? The most salient alternative proposes that a conceptual intention constitutes individuals' guidance. I will confine my discussion to this rival account.[186] The objector would claim that relevant shifts of attention are acts, not because the central executive system controls them. Rather, they are acts because a conceptual intention causes them.

What positive reasons can such an opponent provide for the claim that a conceptual intention constitutes individuals' guidance of relevant intention shifts? *Prima facie*, psychology supports a correlation between shifts guided by the individual and central executive control. In human agents, many shifts of visual attention plausibly rely on the non-conceptual state of the priority map alone, without help from a conceptual intention. Pending additional support, postulating causation by an additional conceptual intention would be postulating a redundant further state. Psychology does not support postulating such further states.

The objector might deny that humans guide their attention shifts in these cases. Or she might insist that a conceptual intention is present in all such cases. Both

[185] Elsewhere I explain that we should understand these philosophers as identifying cases in which individuals lack certain types of control over their actions. Cf. my "Core Agential Control."

[186] This type of account stems from Anscombe, G.E.M. 1953, Davidson, D. 1980, and Searle, J. 1983. See also the discussion in Chapter 4.5 and section 4 below.

positions strike me as *ad hoc*. They override present and future empirical research in an unwarranted a priori fashion. The more modest position acknowledges the empirical knowledge that we have. Thus I think it reasonable to reject this position.

What support might a priori reflection on the notion of <u>agency</u> lend to either version of the objection? Perhaps David Velleman has formulated the most influential a priori consideration that might seem to favor discarding my proposal. He assumes that "each person is his [U]nderstanding," or Reason.[187] So, at least *persons* guide their actions only when their Reason or Understanding guides the actions. Now the objector might reason as follows. Understanding and Reason are conceptual capacities. So, conceptual states must guide persons' acts.

I am not convinced by the claim that persons are to be identified with their Reason. Actual agents act on a physical world with their physical bodies. These agents have memory, perception, emotions, and systems for motor control (including their muscles). Some of these faculties are plausibly non-conceptual faculties. All these different faculties contribute to the agents' actions. If any of the non-conceptual faculties helped constitute these agents, then the objector's argument might be used to establish that non-conceptual states can guide individuals' actions. It seems likely that different faculties contribute in different ways to the individual's constitution. It would require detailed argument to establish that faculties other than Reason do not contribute to the agents' constitution. I am not aware that such argument has been given. Without

[187] Velleman, D. J. 2000, 6. I capitalize 'Reason' and 'Understanding' when I intend to refer to the capacities.

providing such argument, the objector has not established his conclusion, that only conceptual states can be guiders of action.[188]

I think it safe to reject the third line of objection, too.

5.4.4 Methodology

The fourth objection maintains that central executive control could not possibly help explain the nature of individuals' guidance. A thing's nature fixes what that thing is across possible worlds. So explanations of natures must be explanations that are true across possible worlds. But the methodology of reflecting on empirical science at best offers information about the implementation of guidance in *this* world, the actual world. Such reflection tells us what contingently happens whenever actual individuals guide their acts. How, challenges the objector, could this information possibly help explain the *nature* of guidance across possible worlds?

Earlier I sketched three ways in which reflection on central executive control furthers our understanding of guidance's nature. First, such reflection provides detail about the implementation of individuals' guidance that bears on guidance's nature. Second, such reflection uncovers interconnections between individuals' guidance and other features of their psychology. The interconnections bear on guidance's nature. Third, reflection on empirical psychology provides limiting conditions on plausible a

[188] I am here indebted to Hieronymi, P. 2009.

priori claim about individuals' guidance. Some of the empirical detail about guidance may be in principle inaccessible to a priori reflection alone.

The deeper philosophical rationale for reflecting on the empirical sciences in order to uncover the nature of guidance lies in the truth of anti-individualism about representational content. A specific philosophical method typically motivates the objector's charge. No empirical knowledge could serve philosophical investigations of natures across possible worlds. What other faculties might we rely on? The objector typically proposes the purely a priori investigation of our concepts as the only alternative. Anti-individualism has shown this methodological position to be mistaken. Anti-individualism is the view that the nature of individuals' mental states, and in particular, the representational contents of these states, constitutively depends on relations between the individuals in those states and a subject matter beyond those individuals.[189] The definitions and explications that individuals provide through a priori reflection on their concepts are often incomplete and fallacious. Entire communities, including a community's specialists, can err in explicating the meaning of a concept. Kinds in the actual world fix the meanings of many thoughts. Progress in understanding concepts such as <u>life</u>, <u>water</u>, and <u>species</u> required empirical investigation of these concepts' referents. Recent advances in the philosophy of psychology exemplify how empirical science can promote philosophical understanding of concepts such as

[189] Burge, T. 2010, 61; for anti-individualism about meaning more generally, see Kripke, S. 1980; Putnam, H. 1962; Putnam, H. 1970; Putnam, H. 1973; Putnam, H. 1975; but especially the essays in Burge, T. 2007.

consciousness and vision.[190]

The notions agency, and guidance by the individual, invite the same method for their investigation. Mere a priori reflection on the notion guidance by the individual has not produced much insight, in recent action theory. Reflection on different kinds of actual individuals, and different ways in which they act, reveals a baffling variety. Paramecia, cnidarians, insects, birds, fishes, mammals, and primates are all individuals. They all act. How could a priori reflection on the notion individual have revealed such a variety? And if an individuals' guidance depends on what kind of individual she is, how could mere a priori reflection on the notion guidance by the individual reveal how a cnidarian guides her acts? A fuller understanding of different individuals' guidance, it seems to me, is bound to require help from empirical science.

5.5

Contribution to the Study of Agency

My proposal is narrowly constrained to the case of guided shifts of visual attention. I fully expect that further investigation will reveal that it also applies to shifts of other forms of attention, such as attention in other perceptual modalities and central attention.[191]

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190 Cf. Burge, T. 2010; Block, N. 2008.

191 Wright, R. & Ward, L. 2008; Spence, C. 2014.

I think it very likely that the same account can be given for other types of psychological agency. I conjecture that my proposal will help explain the guidance that individuals exercise in active thinking. Psychological episodes such as judgments, inferences, and decisions are often acts. Individual guide these episodes. Traditional action theory has had difficulties accounting for the episodes' agency.[192] My proposal promises such an account in terms of control by the central executive system. This speculation is plausible because the central executive system was originally introduced partly in order to explain episodes of thinking. Classical tasks for testing executive control require individuals to solve chess problems, perform mental arithmetic, sort cards according to abstract rules, and generate random series of letters or numbers.[193]

The relation between central executive control and bodily action is probably more complicated. It is less well understood. The motor system seems to be more autonomous from central executive control. Many motor behaviors seem to occur in a fairly automatic or reflexive fashion. Even a quick survey of motor disorders, for example, suggests that much motor activity occurs that does not seem to be under the executive system's control. In the anarchic hand syndrome, for instance, the motor system carries out fairly complex behaviors such as the unbuttoning of a shirt.

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[192] See the brief discussion of problems for action theories endemic to psychological acts in Chapter 1.

[193] Baddeley, A. D. 2007, 124ff. Uncovering the precise nature of the relation between central executive control and *active* thinking requires more detailed research into the psychology of these episodes.

Utilization behaviors occur as against individuals' explicitly set goals, stimulated by a perceived affordance. A patient visiting his doctor's apartment, for example, when he saw that the sheets in the bedroom were turned back, took off his clothes and his wig, and went to bed. Psychologists speculate that in such cases, the motor system carries out more or less automatic, overlearned behaviors, in absence of, or overriding, central executive control. Plausibly, these individuals do not act, when they carry out these behaviors.[194] So again, it would seem that central executive control might illuminate individuals' guidance, even for motor actions.[195]

In this section I reflect on the contribution my proposal makes to the study of agency, *assuming that the following conjecture is true*:

> When an individual, with a psychology sufficiently like that of actual primates, guides her psychological or bodily act, then, actually constitutively, her central executive system controls the processes constituting the act.

In what follows, I want to throw into relief the potential explanatory power of this proposal. I sketch how, beyond illuminating the nature of guidance, the proposal may contribute to addressing two challenges that current action theories face. I conclude

[194] My intuitions about these cases are not straightforward. If we want to insist that these are examples of reflex actions, we might have to allow that the individual does not guide all actions.

[195] Baddeley, A. D. 2007, 317ff.; Shadmehr, R. & Wise, S. 2005; Wolpert, D., Ghahramani, Z. & Jordan, M. 1995; Wolpert, D. & Kawato, M. 1998.

by briefly commenting on how it relates to the five major families of action-theories.

I refer to members of the first, and most influential, family of action theories as *intention-based*. This label is a simplification. I intend the label to denote action theories that proclaim that agency consist in an event's causation, in the right way, by a specific type of mental state. The relevant mental state is not itself an action. The state might be the individual's conceptual intention, a belief/desire-pair constituting the individual's reason for acting, or a desire. Donald Davidson, for example, proclaims that someone "is the agent of an act if what he does can be described under an aspect that makes it intentional."[196] For Davidson, an event is intentional just in case a belief and a pro-attitude of the agent caused the event.[197] John Searle contends that "[a]n action is a composite entity of which one component is an intention in action. …There can't be any actions, not even unintentional actions, without intentions in action."[198]

The second family has *trying-based* theories as its members. According to these theories, an event is an action just in case the individual's trying caused the event in the right way. Tryings are agential events that cause, and are parts of, the action itself. Thus writes Brian O'Shaughnessy: "All physical action involves a willing or bringing about of act-neutral bodily events."[199] And Christoper Peacocke claims that "[f]or a mental

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[196] Davidson, D. 1980, 46.

[197] *ibid*., Essays 1 and 5.

[198] Searle, J. 1983, 107; Cf. also Goldman, A. 1970; McDowell, J. 1994; McDowell, J. 2007; Mele, A. 1992; Bratman, M. 1987; Brand, M. 1984; Bishop, J. 1989; Pears, D. 1975.

[199] O'Shaughnessy, B. 1973, 369; Cf. Also O'Shaughnessy, B. 1980.

event to be a mental action, it must consist of an event which either is, or constitutively involves, a trying."[200]

The third family consists of *higher-order* theories of action. These theories contend that an event is an action just in case it is caused in the right way by an intention (or a desire, or a reason) and a higher-order state endorsing that intention (or desire, or reason). David Velleman and Christine Korsgaard are proponents of such theories, at least for human actions. Thus says Velleman: "[Human] action is activity regulated by … reflective understanding."[201] And Korsgaard describes her topic as "*human* agency – that is to say, self-conscious agency."[202]

Members of the fourth family are *agent-causation* theories of action. These theories state that an event is an action just in case the individual herself causes the event to occur. Roderick Chisholm is the most famous recent proponent of an agent-causation theory of action. In his words, "when a person acts freely, then he causes his own undertaking and … there is no event or set of events constituting a sufficient causal condition for that undertaking."[203]

Finally, there is the family of *responsibility-based* theories. According to these

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200 Peacocke, C. 2007, 6, Cf. also Hornsby, J. 1980.

201 Velleman, D. 2000, 30.

202 Korsgaard, C. 2009, 26; Sometimes, Frankfurt seems to lean in this direction. Cf. his Frankfurt, H. 1988, 19.

203 Chisholm, R. 1978, 627; also his Chisholm, R. 1976.

theories, an event is an action just in case the individual is answerable for the event. Anscombe, for example, suggests that intentional actions are "actions to which a certain sense of the question 'Why?' is given application [namely the sense] in which the answer, if positive, gives a reason for acting."[204] For Pamela Hieronymi, to act is to be "vulnerable to certain sorts of criticism and open to certain kinds of questions – in particular, one is open to questions and criticisms that would be satisfied by reasons that (one takes to) bear positively on whether to φ."[205]

We should first note that my proposal constitutes a methodological advance over most recent action theory. Much philosophical reflection on action disregards relevant empirical knowledge, despite the progress that reflection on such knowledge has yielded in the philosophy of mind. I develop my proposal from reflection on pertinent empirical research.[206]

My proposal can, I think, advance the discussion of two challenges that members of the first four families of action theories face. I cannot do full justice to either debate, in the present context. So I will content myself with a rough, preliminary sketch of the different positions in the debates, and of the way in which my proposal might advance the debates.

Reflection on empirical science may help address the first challenge: the

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204 Anscombe, G.E.M. 1953, 9.

205 Hieronymi, P. 2009a, 138.

206 Cf. the last section. Two exceptions are Brand, M. 1984 and Nanay, B. 2014.

problem of deviant causal chains. The first four families of action theories propose that some specific cause constitutes an event's being an action. Whether the favored, action-constituting cause is a pair of beliefs and desires, an intention, a higher-order state, a trying, or the agent herself – some wayward element might interfere between the action-constituting cause and the event that is the action. In this case, the action-constituting cause effects the action but the individual may still not guide the action. For convenience, I focus my discussion on intentions as action-constituting causes.

Consider Frankfurt's example of a robber at a cocktail party. The robber intends to spill his drink in order to signal his conspirators to launch the robbery. His intention causes him to be nervous. Due to his nervousness, he spills his drink. The robber's intention to spill the drink caused him to spill his drink. But the robber did not guide the spilling of his drink. Causation by the intention did not constitute guidance *because* the intention caused the spilling in the wrong way.

We lack a satisfying account of non-deviant, action-constituting causation. I cannot do justice to all attempts to provide such an account. A full discussion of the problem of causal deviance is beyond the scope of this section. Instead, I provide a cursory sketch to illustrate how my proposal contributes to a better understanding of the issue of deviance.[207]

Some philosophers pointed out that there is a potential causal gap between

[207] Goldman, A., 1970; Bishop, J. 1989; Brand, M. 1984; Ginet, C. 1990; Enç, B. 2003; Mele, A. 1992; Stout, R. 2005.

intentions and action-events. The causal chain between the action-constituting cause and its effect might be wayward or deviant. The causal gap opens such theories of action to counterexamples like Frankfurt's. An early, alleged solution to the problem of deviance comes from Myles Brand. He postulates that the intention be the *proximal* cause of the action-event.[208] If the intention proximally causes the action, on his account, there is no event such that the intention causes that event, and the event causes the action. In this case, the intention allegedly causes the behavior non-deviantly. The analysis struck critics as empty. Proximal causation, for many critics, seemed just to *be* non-deviant causation. Brand seemed close to stipulating that an intention causes an action non-deviantly just in case it causes the action non-deviantly. Critics accused Brand for not contributing much to analyzing non-deviant causation.

Other analyses postulated that the causing intentions be concurrent with the action. John Searle proposes that such concurrent intentions-in-action are constitutive of action.[209] But of course, the temporal relation alone does not affect whether the intention causes the behavior in the right way or not. An alien factor might interfere with the causal chain connecting behavior and intention. The agent's intention to perform the action might be simultaneous with the movement of her body. But the intention might cause the movement only by activating some evil scientist's contraption. The contraption might then, simultaneously, make the individual's body

[208] Brand, M. 1984, 19ff.

[209] Searle, J. 1983, 83ff.

move. So it seems that Searle's proposal does not solve the problem of non-deviant causation either.

Yet other analyses proposed to explain non-deviant causation counterfactually. John Bishop suggests that behavior is caused in the right way just in case the behavior exhibits "a certain responsiveness or sensitivity to the content of the intention that causes it."[210] In the case of the nervous robber, a slightly different intention would not have caused a different behavior. Suppose that the robber intended to spill the drink five seconds later than in the initial example. This intention might plausibly have had the same effect on his psychology. It would have rendered him nervous. His nervousness would have undermined his guidance of the action. He might have spilled his drink accidentally, just as in the original case. In instances of guided action, Bishop suggests, the act is sensitive to such slight differences in the intention's content. The robber would have spilled his drink five seconds later, had he thus intended. [211]

Counterfactual accounts tend to dissatisfy because they do not explain in virtue of *what* there should be a counterfactual dependence between some cause and some effect. Such accounts do not specify why the robber's psychology and motor system should generate some counterfactual dependence. We expect an account of the

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210 Bishop, J. 1989, 148ff.; Peacocke, C. 1979.

211 It has been pointed out that such counterfactual dependence of the effect on the cause is too strong a requirement on non-deviant causation. Consider a scenario in which a neuroscientist interferes with the robber's action whenever (and only when) he intends to engage in a slightly different action. The neuroscientist then causes, by assumption, the robber to perform the original action. Nevertheless, the robber performs the action intentionally, guides his action, and the action's causation is not wayward, in the original case. Cf. Frankfurt, H. 1988, 1; Lewis, D. 1980; Enç, B. 2003, 104.

functioning of these systems in response to the challenge of causal deviance. Counterfactual proposals do not provide such an account. Berent Enç offers an account in terms of a system's well functioning. He proposes that non-deviant action is caused by an intention when the underlying system functions in the way it is supposed to: "[T]he fact that the intention causes [an intermediate event] X is explained by the fact that X results in [the action]."[212] Such explanation is functional explanation. The intermediary events functionally contribute to the non-deviant causation of the action because, for example, the system has been selected by evolution.

But we can imagine circumstances in which the robber's nervousness may have consistently triggered beneficial behavior in evolutionary past. So we can imagine that there is, in the robber's psychology, a mechanism that functions to trigger action in cases of nervousness. Nevertheless we would, I think, distinguish between such events and proper instances of acts guided by the individual. Intuitively, the mechanism is not of the right kind to implement individuals' guidance.

Donald Davidson and Alvin Goldman, suggested that specifying non-deviant causation might be an empirical matter.[213] Neither ever tried to give an empirical account of non-deviant causation. Such a stance is problematic insofar as the existence of such an account is merely assumed. Furthermore, this stance has been accused of at best yielding an account of how we, contingently, act, and guide our actions. Empirical

212 Enç, B. 2003, 112.

213 Davidson, D. 1980; Goldman, A., 1970, 62.

science, it is said, does not provide an account of necessary and sufficient conditions on non-deviant causation.

My proposal is, of course, based on empirical research. So it might be seen as developing the strategy expressed by Davidson and Goldman. The proposal illuminates non-deviant causation by relying on psychological research. Psychology discovers causal laws. In particular, the law-like regularities involving the assignment of priority by the central executive system to the priority map are causal laws. Appeal to these psychological laws provides a fuller, more detailed specification of actual, non-deviant causal chains.

Such appeal provides a fuller understanding of the psychological systems that non-deviant causation must pass through when individuals guide their acts. These systems are well functioning and their presence in individuals presumably is often due to evolutionary selection. Appeal to psychological explanations goes beyond the functional characterization of non-deviant causation by providing empirical detail about the systems that must function well in order for individuals to guide their acts.

My proposal's contribution to a fuller understanding might be criticized for not providing necessary and sufficient conditions for non-deviantly caused action. I accept this criticism. But I do not think that it makes my contribution pointless. My proposal contributes to understanding non-deviant causation across at least a range of relatively close-by possible worlds. Wherever individuals with psychologies fairly similar to those of actual primates guide their acts, we should expect that a central executive system figure in the psychological laws correlated with such guidance.

My main aim is not to provide necessary or sufficient conditions. I aim for deeper understanding. Understanding the conditions that implement individuals' guidance, even exclusively in the actual world, furthers such understanding. At least in this sense, the proposal contributes to theorizing about non-deviant causation.

Agent-causal accounts have been accused of postulating an unscientific form of causation. They postulate causation not by events, but by agents. The accounts have been widely dismissed on this basis. But agent-causal accounts have a *prima facie* strength as regards the second challenge recent action theories face. One of the deepest intuitions about agency is that acts must have the agent as their source. We find it expressed by Aristotle, when he writes that "the soul is the cause of animate bodies as being in itself the origin of motion."[214] Or in Kant: "This active subject [would begin] its effects in the sensible world from itself."[215] As Chisholm put it, "the philosophical question is not – or at least it shouldn't be – the question whether or not there is 'agent causation.'"[216] Agents *are* the causal sources of their actions. The philosophical challenge, for Chisholm, is whether such causation can be explained in terms of processes and events that do not involve the agent.

Intention and trying-based theories do not address this question. Their action-

214 DA II.4, 415b10/2; DA I.3, 406a2; NE 1111a24; MA 9, 703a1/3.

215 B567/9; see also Kant's *Lectures on Metaphysics*, Kant, I. 1997, 29:822 & 29:903.

216 Chisholm, R. 1978, 622.

constituting states and events are the individual's. But neither type of theory explains in virtue of what these states constitute the individual's contribution to the act.

Higher-order theories reject the claim that such states and events constitute the individual's contribution. As Frankfurt put it, beliefs, desires, and intentions may move an individual to act while the individual herself is "a helpless bystander to the forces that move him."[217] Such accounts of action, according to Velleman, fall "victim to a fundamental problem in the philosophy of action – that of finding a place for agents in the explanatory order in the world."[218] The task is to "look for events and states to play the role of the agent."[219] Specific higher-order states, according to Velleman, play this role. For example, higher-order theorists have claimed that an addict who does not reflect on her desire to take a drug does not really act, when she takes the drug. In such a case, the individual is said to not really be the source of the action.

I disagree with the higher-order theorist's description of the addict-case. The addict's intention must be attributed to the whole individual. She acts, and guides her actions. I do think, however, that two alternative considerations highlight the need to *explain* what constitutes the individual's contribution to an act. They put pressure on any account of agency that does not provide such an explanation. The first consideration charges current action theories with hyper-intellectualizing agency. According to these

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217 Frankfurt, H. 1988, 21.

218 Velleman, D. 2000, 127.

219 *ibid.*, 137.

theories, only individuals with fairly sophisticated psychologies can be the sources of their actions. The second consideration departs from the observation that the psychology of action is extremely complex. Performing any motor action involves computations over a vast number of representational states. Plausibly, not all of them are attributable to the individual. They plausibly are not all constitutive of the agent's contribution to the action.

First, any action theory postulating that the agent's contribution to her action consists in conceptual beliefs, desires, or intentions, or even in higher-order reflective conceptual states, hyper-intellectualizes action.[220] Non-psychological animals such as ciliates plausibly act. Relatively simple animals such as ants act. These animals plausibly do not have conceptual competencies. They do not have reflective competencies and higher-order states. According to the theories under discussion, the individuals' being a source of their action requires conceptual or even reflective competencies. Such requirements are clearly wrong and inconsistent with current empirical knowledge. Ants and spiders act and guide their actions. *They* are the sources of their actions. We should try to understand in what sense such simpler individuals are the sources of their actions.

Second, many conceptual and non-conceptual states contribute to each of an

[220] Trying-based accounts are a special case. These accounts may well be compatible with the agency of primitive animals. (They typically are not. O'Shaughnessy, B. 1973, for example, thinks of tryings as realizing belief-desire pairs.) The accounts need not take a stand on whether tryings involve specific representational competencies, such as conceptual abilities. So it may well be possible that ants' actions are caused by tryings.

individual's psychological and bodily acts. The computations that the perceptual and motor systems perform even during simple motor actions are extremely complex. Suppose that an individual guides her hand to pick up a cup. Visual information about the cup must be integrated with visual and proprioceptive information about position and orientation of the eyes, the head, the different joints of the arm, and the different parts of the hand, including those of each finger. From the position of each part of the arm and hand, for example, the motor system computes a representation of their goal-state. If the individual's finger was straight, a representation may specify its goal-state as being bent at some angle. If the wrist was relaxed, a representation may specify the degree to which it must be turned. The representations that specify the goal-state of the movement can be conceptual *or* non-conceptual.[221] Representational goal-directing states contribute to individuals' passive processes, too. Passive shifts of attention, for example during default attentional activity, are computed from perceptual information about the saliency of locations, and from scene gist. The priority map specifies, for these passive shifts, where attention is to shift next.

Plausibly, not all these states constitute the individuals' guidance. We need to distinguish between representational states directing a process toward a goal – conceptual or other – that do, and that do not, constitute the individuals' contribution. The intuition that the individual is the source of her action underlies, I believe, Frankfurt's question about individuals' guidance. Earlier I explained how my proposal

[221] Shadmehr, R. & Wise, S. 2005, Chapter 12, especially p. 225.

contributes to understanding this idea. According to my proposal, representational states – conceptual or non-conceptual – partly constitute individuals' guidance only if the central executive system controls the processes these states partake in. Thus my proposal can help advance some of the salient debates in recent action theory.

My proposal may serve as a compromise between the first four action theories. Intention-based theories and higher-order theories may specify important ways in which the central executive system can implement individuals' guidance. What unifies the different proposals may be that intentions or higher-order states alone would not constitute an individual's guidance. Individuals guide only when the central executive system controls, whether on the basis of an intention, a higher-order state, or a non-conceptual state. Trying-based accounts have disappointed by not illuminating the nature of tryings.[222] Central executive control may be a way of explaining what a trying is. Agent-causation views rejected criticism for not providing an event-causal account of action. Proponents of such views pointed out that event-causal accounts could not explain in what sense individuals are the sources of their actions. Without offering a reduction of individuals' guidance to psychological events, my proposal can help illuminate individuals' contribution to their acts from an event-causal perspective.

[222] Trying-based accounts have one major flaw. These accounts claim that tryings are themselves acts or agential events. So they explain actions in terms of actions. This approach is problematic, in this case, because trying-based theories leave the nature of tryings frustratingly underspecified. The accounts often explicitly deny that our intuitive grasp of trying yields understanding of the technical notion of a trying. They often seem to merely postulate that tryings are whichever agential state makes an event an exercise of agency. Trying-based theories of this kind have often seemed empty, to critics, when offered as explanatory accounts of agency. As I point out in the main text, my proposal might be offered as a specification of a trying.

I now want make some very tentative remarks on how my proposal might relate to responsibility-based accounts of action. These accounts have it that individuals act just in case they are responsible for events in specific ways. The approach stems from G.E.M. Anscombe who claimed that for intentional actions, it is constitutive that they open their agents to certain kinds of why-questions. In Pamela Hieronymi's terms, the agent must be "vulnerable to certain sorts of criticism and open to certain kinds of questions – in particular, one is open to questions and criticisms that would be satisfied by reasons that (one takes to) bear positively on whether to φ."[223] She elaborates that "to be responsible, in the sense at issue, is to be rightly open to a certain range of evaluations and reactions – to be open to evaluations such as kind, greedy, malicious, spiteful, and to reactions such as distrust, admiration, resentment, and gratitude."[224]

I want to point out one restriction of such responsibility-based accounts that does not equally apply to my proposal. And I want to highlight a lesson that these accounts teach, which my proposal may help draw more fully.

I conjectured that control by some form of central executive system might constitute guidance in a wide range of animals. Most of these animals do not ask why-questions in the way humans do. Many of these animals do not have conceptual capacities. They plausibly do not engage in any form of reason-giving. It is doubtful that all mammals and birds, much less insects, have reactive attitudes. The

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223 Hieronymi, P. 2009a, 138.

224 Hieronymi, P. [Ms], 2; Strawson, P. 1974.

responsibility-based account would have to either deny that these animals act, or restrict its account to animals with the relevant psychological competencies. It seems that my proposal can account for the guidance of a wider range of animals. In their restricted form, responsibility-based accounts may help understand an important sub-species of psychologically guided agency.

One important insight of responsibility-based accounts is that intentional agency should be understood to be much broader than traditional action theory may suggest. On a natural view, we are responsible for our intentional actions and for events that we can control through our intentional actions. The standard picture of intentional action, as discussed by Hieronymi, holds that these actions can be performed for any reason that the agent considers fit. And they are actions that the agent represents as to-be-performed.[225] We can hence understand conditions on responsibility in general, if we understand why we are responsible for our intentional actions. Hieronymi points out that we can understand our responsibility for intentional actions by understanding our responsibility for our intentions to act. But intentions are not themselves intentional actions, on pain of infinite regress. Nor can we plausibly explain our responsibility for our intentions by appealing to intentional actions that we perform on our own intentions. Hieronymi concludes that our responsibility for our intentions must be grounded in the exercise of a different type of intentional agency. Hieronymi identifies the exercise of evaluative control, or the settling of a question, as the relevant, non-

225 Hieronymi, P. 2014, 9ff.

standard type of intentional agency.

My proposal might contribute to the project of broadening our understanding of responsible intentional agency beyond the standard picture. Individuals' non-conceptually guided acts might be acknowledged as a further, non-standard, type of intentional agency, if certain further conditions are met. An individual who attends to the wrong thing or to something that she is not supposed to attend to might be held responsible for doing so. Standards of responsibility might apply to the individual because she is capable of reasoning and reflection. My proposal might contribute to explaining why the individual is responsible for her attending, even in cases when central executive system and priority map alone controlled the shift. She might be responsible for that event because she is the kind of individual that can be responsible for her acts, and because the attention-shift was an act of hers.

5.6

Conclusion

In this chapter I explained why central executive control is plausibly actually constitutive of individuals' guidance when these individuals' psychologies are sufficiently similar to that of actual primates. Harry Frankfurt pointed out that in order to advance our understanding of agency, we must understand what it is for an individual to guide her acts. Reflection on empirical psychology furthers our understanding of the nature of guidance. Such reflection hence yields a deeper understanding of the nature of agency.

Action theory has, in recent decades, not made much progress in illuminating the nature of agency. Most of its proposals, I have suggested, are insufficient. Partly, this failure is due to an almost exclusive reliance on armchair reflection as a method for achieving philosophical insight. My proposal contributes not only to a fuller understanding of agency. It partakes a growing movement in philosophy that abandons such exclusive reliance on armchair methods in favor of empirically informed reflection.

A full understanding of agency cannot ignore the empirical knowledge we have of it. Novalis once said: "Philosophie ist eigentlich Heimweh, ein Trieb, überall zu Hause zu sein."[226] To truly be everywhere at home we cannot just import what we are familiar with, wherever we go. We have to get up close, and make a serious effort to learn what we can – especially about the more remote parts of reality.

[226] "Philosophy is properly home-sickness, a drive to be everywhere at home." Cf. Novalis 1923, 179.

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