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Sculpting the space of actions: explaining human action by integrating intentions and mechanisms

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INTRODUCTION: INTENTIONAL ACTION AND A SCULPTED SPACE OF ACTIONS

This dissertation will explore the explanation of intentional action and more in particular intentional action as carried out by an experienced agent or an expert. Imagine how an expert opera singer performing Don Giovanni is able to join in with his melody even when his Zerlina partly fails her line, avoiding to show his annoyance, to dance a short choreography simultaneously, to wink inconspicuously at Leporello, to attend to the conductor who is surprising him with novel tempo indications – behaving all the while as a somewhat ironical womanizer according to the stage directions. Clearly, such a singer does not have the time or the ability to carefully reflect and consider all these components of his performance. How is it possible that an agent – whether an opera singer on-stage or a citizen in the public domain – can act spontaneously, adequately and in line with his intentions and preliminary deliberations while also responding to unexpected events around him, without constantly interrupting his actions to reflect and decide on each successive step?¹

This example presents us with a paradox, as it appears to pertain to expert action. Usually, we expect an expert to act fast, appropriately and adequately without pausing for considering his action options, evaluating these and finally determining the action to be executed. However, his not pausing seems to suggest that expert action is not an intentional action, as it is not the actual outcome of a consciously deliberated choice. The conclusion would then be that an expert like our opera singer does not perform intentional actions on stage. In contrast, the novice who continuously and consciously considers and determines each single component action separately, as he cannot rely on his expertise and experience, would be performing intentional actions - even though they amount to a bad opera performance. Consequently, that novice would gradually lose his capability of intentional action as soon as he starts to rely on his gathered expertise. The aim of this dissertation is to solve this paradox of expert action by offering new insights into the nature and explanation of intentional action. While doing so, we will discuss intriguing similarities between the excellence that one may reach in artistic performance and in moral action.

¹ Wherever reference is made to a subject or agent in this book, both sexes are obviously implied although we will refer exclusively to the male or neutral in order to avoid politically correct, gender neutral constructions. Moreover, we have chosen to illustrate our arguments with an expert singer and opera roles are usually not gender neutral.

A concept that will be introduced to achieve our goal is that of ‘sculpting the space of actions’ leading to a ‘sculpted space of actions’. We will argue that the dynamic process of sculpting the space of actions can lead to relatively stable results, as when an expert’s performance is facilitated by his sculpted action space. It should be acknowledged right away that it is not new in cognitive neuroscience to explain a certain task with the help of a multidimensional space. Several proposals have been developed that use such a notion, one of the earliest being Munsell’s color sphere (Munsell 1912). Researchers have proposed to represent all colors at particular places in a space with particular dimensions and structure, as this allowed them to partly explain some peculiarities of color perception. This representational organization, mainly but not exclusively due to the photochemical properties of retinal cells and the physical properties of light, has been invoked to explain cases like the presence of an after-image with opposing color and the influence of contrast on color perception (Isaac 2009). Extending the notion to moral action, a multidimensional space has been proposed, in which moral significance and praiseworthiness are the main dimensions according to which actions are conceptualized. It was stipulated that such a space represents the results of a neural network that is trained to identify and discriminate moral actions (Churchland 1998). Extending it even further, the notion of multidimensional ‘concept spaces’ has been elaborated for the representation of particular informational domains that are employed by an agent’s various cognitive functions in parallel and respond dynamically to his ongoing activities and situational contexts (Gärdenfors 2004b). In sum, the multidimensional, spatial representation of colors, actions or other contents has proven to be valid and useful in the interpretation and explanation of several cognitive and behavioral processes.

‘Sculpting’, in turn, has elsewhere been articulated as a process that influences an agent’s responses, as was observable in the study of a language processing task. It was found that the ‘response space’ available to a subject for filling in the blanks in a sentence could be ‘sculpted’ or constrained by providing grammatical or other constraints on the number of answer options earlier in a text. With such ‘sculpting’ based upon a combination of the presented information and the subjects’ previous language expertise, subjects had an easier task in determining an appropriate response, as was evident from response time and correctness as well as from the amount of neural activation during the task (Frith 2000). We will contend here that a comparable process exists with regard to intentional action, that can help to explain the paradoxical properties of expert action, a process which we will refer to as ‘sculpting the space of actions’.

In this dissertation, it will be argued that intentional action rests upon a complex

process carried out by a complex and dynamic cognitive mechanism, responding to many internal and external factors, which employs a ‘sculpted space of actions’.² This cognitive mechanism itself consists of several component mechanisms, carrying out component tasks that contribute to the performance of intentional action like perception, emotion, intention, and motor action. Many different factors determine this comprehensive mechanism, some of which have an enduring influence on it, while other factors can influence it in a more momentary fashion. It will be argued that intentions – implicit and explicit – are among the factors that can have an enduring influence. More generally, the processes of development and learning leave an important structural trace on the mechanism responsible for an agent’s action. As a result, the action performed by an agent with experience in a domain of action is usually not a random response to an unanticipated situation. So instead of all potential action options having an equal chance of being determined as a response, an expert’s sculpted space of actions consists of a set of action options with differential probabilities that are dependent upon long-term and short-term influences.

To show the important contribution that this process of sculpting the space of actions can make to explaining intentional action, this dissertation will cover three quite different topics. First, we will engage with the method of explanation in cognitive neuroscience. Next, we will investigate processes of development and learning while using the method of mechanistic explanation. Finally, we will use the insights derived from these preparatory parts in a discussion of both philosophical and cognitive neuroscientific studies of intentional action. It is in that last part that the notion of ‘sculpting the space of actions’ helps to understand some characteristics of intentional action that otherwise appear to defy explanation.

Although we will refer for the greater part to recent studies and publications, our discussion is in fact partly motivated by a long-standing debate on expert action. Before presenting an overview of the dissertation, let us provide a sketch of this background.

² The type of mechanistic explanation discussed in this dissertation is essentially different from mechanistic explanations offered by Descartes, Newton and others and has been developed over the past decades particularly as a valuable method in the life and cognitive sciences. Extensive treatments can be found in (Bechtel 2008 ; Bechtel and Richardson 1993 ; Craver 2007 ; Wimsatt 2007). Explicit discussion of the application of this model to the explanation of human action like we are doing here, however, has been very limited to date.

³ The study of music as practiced in ancient Greece involves a much wider domain than in modern times, for example by including the performance of theatrical and epic texts, assuming music to have medical and moral value in creating balance in a person’s body and soul and considering it to be a topic for mathematical and philosophical studies (cf. (West 1992)).

How Aristotle avoids the paradox of the expert by accepting causal pluralism

The ancient debate between Aristotle and Plato on moral action provides an early example of how the paradox of expert action can be handled differently. Interestingly, in that context Aristotle also notes the similarity between musical and moral performance.³ In Plato's dialogue 'The Republic', Socrates famously describes how philosopher-kings are exclusively capable of rationally determining their moral actions, with all others being limited in this regard. Music may offer some help in preparing the city's guardians for prescribed moral habits, because it is pre-eminently able to influence someone's feelings by providing mere imitations of real actions. Yet it is only of limited value, as it is crucially distinct from the essentially rational skills that philosopher-kings must learn in order to decide rationally about the – moral – goals of the polis (Republic, book VI-VII).⁴ Musical activities and reasoning, so we are told, rely on distinct capabilities and have different effects, with the former being much less relevant than the latter. As a result, there is hardly any interaction between the two, rendering their comparison hardly useful.

Aristotle's position is very different in several respects. Rejecting the idea of a rational deduction of moral actions from a supreme and single good, he criticizes Socrates because the latter allegedly "thought all the excellences to be kinds of knowledge" and only "inquired what excellence is, not how or from what it arises" (Ethica Eudemia 1216 b 6-10).⁵ In contrast, Aristotle held that regarding excellence "not to know what it is, but to know out of what it arises is most precious" (Eth. Eud. 1216 b 20-21). This critique amounts to at least two different points: first, excellences might well differ in their nature, second, the source and process of developing excellence are important to know. With the recognition of these points, Aristotle is able to avoid the paradox of expert action.

Reason is not rejected as a determining factor of expert action, yet it is robbed of its exclusivity, being only one determining factor alongside several others, to which it is often related. For example, in the Rhetorics Aristotle mentions as much as seven factors that co-determine action: "Thus every action must be due to one or other of seven causes: chance, nature, compulsion, habit, reasoning, anger, or appetite" (Rhet. 1369 a 5-6). These factors are quite different from each other, even though some are

⁴ Musical performance as discussed by Plato generally includes text and therefore 'logos', because it concerns songs and choral parts (cf. Republic 398 C). It is with regard to the specifically musical components that strong reservations are made.

⁵ Unless stated otherwise, all references to Aristotle's works are to the revised Oxford translation, edited by Barnes (Aristotle 1984).

related, as we will learn below. In the case of excellent or expert action, the number of determining factors seems to have decreased, for it is argued that “there are three things which make men good and excellent (‘agathos kai spoudaios’); these are nature, habit, and reason” (‘physis, ethos, logos’ - Pol. 1332 a 38-39). Apparently, among other things expertise amounts to gaining some control over factors like chance, compulsion, anger and appetite. Leaving aside for a moment the developmental process involved, the message from these remarks is that Aristotle upholds a causal pluralism with regard to action.⁶

With regard to moral action, Aristotle explicitly rejected the attempt to ground moral action in purely rational decision-making, as its implications were not acceptable to him (cf. *Ethica Nicomacheia* III, 5). One of those implications would amount to the paradox noted above, which would apply to our opera singer as well as to a moral agent: if it is only through rational decision-making that good performances can be made, does that imply that an expert performer or seasoned and brave citizen deserves less praise from us than a novice? Is it less of an accomplishment if the expert acts in a seemingly natural way without apparent conscious efforts, reliant as he is upon previous reflections and practice, which have instilled in him several acquired habits and dispositions? Should we praise the novice instead, even though he must continuously pause to consider his actions, explicitly remember earlier exercises, reason about the consistency of his performance, meanwhile losing sight of his fickle environment? Aristotle clearly denounces such conclusions, which would render intentional expert performance a. Part of his strategy to avoid these implications of the paradox of expert action is to convince us of a causal pluralism involved in it.⁷ In addition, he underlines the importance of developmental processes.

The importance of development and learning in Aristotle’s account

Let us return once more to the musical domain to articulate why development and learning are so important for the explanation of expert action and for solving its

⁶ Aristotle’s philosophy of action has received separate attention only relatively recently. Publications of Charles and Sorabji have helped to develop this domain, both offering comparisons between Aristotle’s and contemporary – analytic – approaches. Both publications demonstrate the strength of Aristotle’s approach in its being embedded in a more comprehensive systematic philosophical position than its successors are (Charles 1984 ; Sorabji 1980). Given his systematic interest in empirical knowledge, it may not be surprising that Aristotle’s analysis of intentional action lends itself well for both ethical reflection and naturalistic explanation.

⁷ Causal pluralism is especially hard to avoid in the life sciences in general because organisms are subject to a large variety of determining factors. Generally, it is associated with a theoretical pluralism as well (Mitchell 2002). Since cognitive neuroscience is part of these life sciences, causal and theoretical pluralism reign in its domain, too.

apparent paradox. Having ourselves practiced and performed a couple of opera roles – like Aeneas (Dido and Aeneas), patron Uberto (La serva padrone) and Don Jose (Carmen) - as an amateur, our admiration for accomplished opera singers has only grown. It is especially the stacking and integration of all mastered component tasks of such performances that is hard for a novice or amateur to reach: memorizing large amounts of foreign texts, innumerable notes, harmonizing with an accompanist or ensemble, responding to a conductor's baton, impersonating a character as interpreted together with a stage director, interacting plausibly with other personas on stage. Given the necessary amounts of education, practice and reflection, it is hard to believe that all of this can still result in a convincing, spontaneous and emotionally arousing performance. Nonetheless, for an accomplished opera singer, to perform a new and difficult role like Saint François might be as challenging as it is for an amateur singer to perform just a single aria from Aeneas or for a novice to sing a birthday song.⁸ Apparently, as humans we are capable of gradually familiarizing ourselves with actions or action features, seemingly performing them without requiring our attention or reflection or conscious decision-making, even though they originally did depend upon such capabilities. What this capability shows us is that with increasing expertise, an agent's actions are determined by different factors.

Aristotle acknowledges the importance of development and learning in many different contexts, including the context of intentional action. During the process of learning to judge and act morally, the interaction between reason and other determining factors of these capabilities is important. Increasing interaction can be observed, for example, when someone's character determines how things or goals appear to him (*Ethica Nicomacheia* 1114 a 9 ff.). Interestingly and in contrast to Plato, music can positively contribute to such interaction and thus support the development of an agent's excellence. These benefits of engaging with music are not only available for the less rationally inclined agents, but even for those who are capable of the highest form of a reflective life. For music does not only have an impact on the non-rational parts of our soul but on the rational part as well. Indeed, it contributes to the listeners' acquiring the "power of forming right judgements, and of taking delight in good dispositions and noble actions" (*Politics*, 1340 a 16-19).⁹ Apparently, both musical and moral actions invoke a whole range of capabilities that must somehow be integrated with each other. Furthermore, both rely upon processes

⁸ It must be noted, though, that our accomplished opera singer should be taken as an ideal-type in a Weberian sense. Other than instrumentalists, singers tend to have less insight in their score, for example.

⁹ Depew fleshes out how Aristotle conceives of the relation between music and contemplation, both playing an important role in his ideal of a flourishing polis (Depew 1991).

of development that are partly even continuous with each other. This makes their combined investigation for us all the more relevant.

Most significantly, musical and moral actions as performed by experts are partly determined by habits and dispositions, which are lacking in novices according to Aristotle. These habits and dispositions are the result of extended periods of education, exercise and deliberate practice, even though we may not immediately recognize this. Indeed, the fact that exercise and habituation play a role in learning to do virtuous acts is reason for Aristotle to deny that excellences come naturally ('*physei*') (*Ethica Nicomacheia* 1103 a 21). The paradox of expert action rests to a large extent on ignoring this fact.

Nonetheless, although they don't come naturally and need a lot of consideration and attention, Aristotle contends that virtuous habits can still become 'like nature' ('*tei physei eoiken*' - *Eth. Nic.* 1152 a 30-31). One sign of the naturalness of such learned activities and moral habits is the fact that they are quite enduring and provide pleasure to the agent (*Eth. Nic.* II, 3). In a way, then, the acquisition of habits and dispositions builds upon an agent's natural capabilities, like his capability of experiencing pleasure and pain under certain conditions. Education and practice aim then to shape or sculpt this natural capability of experiencing pleasure in such a way that an agent feels pleasure when performing a certain action appropriately and pain when he performs awkwardly.

The lesson from the preceding sections is that it is not just the plurality of determining factors of expert action that is accepted by Aristotle, it is especially their interaction during development and learning that is underlined in his analysis. Over time and with sufficient diligence, the influences of these factors merge in such a way that an agent can be said to have developed a 'second nature' – even if Aristotle didn't use that word (McDowell 1994).¹⁰ It is with this (implicit) idea of a second nature that Aristotle aims to avoid Plato's position of only recognizing someone as performing good actions if he has explicitly and rationally chosen them.¹¹ The result is a complex account that challenges both our existing conceptualization and explanation of such action performances.

¹⁰ Forman correctly notes that McDowell tends to overlook the distinction that Aristotle upholds between someone's second, acquired nature and his original natural state. For example, Aristotle accepts that habits remains easier to change than someone's nature (Forman 2008).

¹¹ According to Aristotle, one way in which such an interaction occurs is in the establishment of a '*hexis prohairetike*' – an agent's state that concerns his deliberate choice and which is characterized by his desires being in accordance with his standing practice of making such choices (*Eth. Nic.* 1106 b 36). State and character are important notions in Aristotle's account and allow him to develop a moral psychology that is richer than Plato's, enabling him to steer free from the paradox mentioned earlier, cf. (Sherman 1989).

Conceptual innovation in Aristotle's account of the development of expertise

Phenomenologically sound as Aristotle's analysis of virtuous and skilled action may be, it does raise several questions that have proven hard to answer or to push aside. These questions have among other things to do with the nature of intentional action and with attempts at explaining intentional action. The fact that intentional action appears to be a moving target seriously complicates both issues. First, how can we determine what an intentional action is or whether a particular behavior should be recognized as such, if novice and expert actions are distinguishable in so many respects? Even with regard to their being intentional actions, we may be able to note relevant differences, since an expert may have performed an action – sung his Don Giovanni canzonetta – rather automatically, yet still be better capable of explaining afterwards how and why he adjusted his dynamics and vocal timbre than his novice colleague might be. So the expert may rely initially more on his implicit, automatic expertise while on a second note be very able to articulate and explicate his performance, while conversely the novice may plan in detail to perform his aria in a particular way but be unable to explain why it went so embarrassingly wrong. Second, given these and other differences between intentional actions as performed by experts and novices, should we even try to offer explanations of these actions? Or should we acknowledge that intentional actions are to be subdivided between those performed by experts and others performed by novices? If we were to do so, however, we would also need to account for the fact that experts inevitably started out as novices, gradually gathering expertise of a certain domain of action. Apart from the fact that experts and novices alike would contend to engage in intentional action, creating two classes of intentional actions would conflict with their being developmentally connected with each other.

Aristotle, being a philosopher with an extraordinary interest in phenomena from living organisms, appreciated the conceptual and explanatory difficulties that stem from such issues as discussed above. Indeed, the introduction of the concept pair 'dynamis' and 'energeia', or potentiality and actuality, was meant to avoid the paradoxes that easily surface in the context of such phenomena. Indeed, in his discussion of 'becoming' he gives an example that merits mentioning here: "We can say the man becomes musical, or what is not-musical becomes musical, or the not-musical man becomes a musical man" (Physics, 189 b 35 – 190 a 1). Firm in avoiding the unsatisfactory solution that Plato – characterisable with his predilection for the immutable domain of mathematics - proposed when understanding dynamical phenomena, Aristotle developed such innovative concepts, offering new perspectives

and articulating previously implicit features of these phenomena. A seed somehow potentially contains the tree that grows out of it, a child has the potential to become a fully developed citizen, and a novice can after time become an actual expert in a certain skill: two categories of living beings that appear in many ways different from each other are then conceptually united in a novel sense.¹² Although this helps us to escape from some of the difficulties mentioned earlier, other challenges lie just around the corner.

In particular, by placing novice and expert actions on a continuum and within the same class of phenomena, their explanation becomes more complex. Instead of producing separate explanations for two distinct classes of actions, the explanation of intentional action must now be such that it can cover a range of actions. If the explanation of novice action relied on ingredients that are distinct from those included in the explanation of expert action, it would be rather difficult to demonstrate how the latter might have developed from the former. Conversely, we shouldn't expect that the explanatory ingredients of the two are identical. For example, returning to Aristotle's 'habit' as one of several determining factors of action, we shouldn't expect it to be as important for novice action as it will become for expert action, given the latter's expertise that provides such habits in the first place. Apart from being able to rely upon his habits, an expert is also capable of intentionally modifying his habitual performance in subtle ways, by carefully articulating what features he would like to adjust in the future – his tone of voice, his posture, his taking the hand of Zerlina. So even though he started out as a novice, after a long while an expert can switch between different modes of performing his action that employ the resources that are available to him in different ways and yield actions with different properties, even though we agree to treat them as belonging to the same class.

This short discussion of the paradox of expert action and of Aristotle's approach to it has yielded several insights. Before introducing the reader more specifically to this dissertation, let us review the main ones. To begin with, as our comparison of artistic and moral action and the comparison of novice and expert performance have shown,

¹² Although this is not the place to discuss the revolutionary nature and importance of this conceptual innovation of Aristotle, it should be noted that it has also been an important source of inspiration for Hegel's (often misunderstood) approach to conceptual logic – which was in part meant to account for developmental and historical phenomena. Going into Hegel's own explicit statements of admiration for Aristotle, Hartmann's lecture of 1923 has been influential in further analyzing this important connection, emphasizing the relevance of this conceptual innovation (Hartmann 1957 [1923]). Similarly, Ricoeur argues for the importance of the Aristotelian notion of 'capacity' in his discussions with neuroscientist Changeux (Changeux and Ricoeur 2000). For a more general appreciation of Aristotle as an empirically minded philosopher, see (Lloyd 1982) and our (Keestra 2000).

it is quite difficult to define the concepts involved in and required for the study of such complex phenomena. Second, a phenomenon like an expert's opera performance is determined by a variety of factors. This implies that any account has to provide room for a causal pluralism, usually associated with a theoretical pluralism. Third, and related to the previous insights, the dynamic aspect of the process of expertise acquisition adds another challenge. It not only implies that the phenomenon under scrutiny behaves like a moving target, it also requires that we develop and employ the necessary resources for understanding and explaining precisely these dynamic aspects of it, how the changes occur. Indeed, we have introduced and elaborated on the concept 'sculpting the space of actions' which we argued is a new and useful resource for understanding and explaining human action.

All in all, we will need an interdisciplinary investigation of expert action and offer the resources to integrate the different disciplinary insights pertaining to it. This dissertation intends to present both the necessary insights and the resources for their integration and will do so in the following three parts.

Part I: Investigating four methods of explanation in cognitive neuroscience

Part I of this study offers an investigation of four different methodologies that are used for the investigation and explanation of cognition and behavior in cognitive neuroscience and argues that the method of mechanistic explanation is best suited for our goal. Each of the explanatory methodologies suggests a way to connect a conceptual delineation of a particular psychological function with the ingredients that we usually employ in its explanation: cognitive processes, representations of the information that is processed, and neural activities underlying these processes. However, the methodologies differ starkly from each other in how they conceive of this connection between concepts and explanations.

The first methodology we discuss - as presented in the book "Philosophical Foundations of Neuroscience" (Bennett and Hacker 2003) - defends a strict separation of conceptual analysis from empirical research, claiming that it is possible to agree upon neatly distinguished concepts for psychological functions and that empirical scientists merely have to find novel facts about those functions. We argue that the idea of such a consensus is unwarranted and defend a more complex interaction between conceptual and empirical investigations, offering a better chance for the explanation of complex phenomena.

A more complex interaction between explanatory ingredients is included in the second approach, David Marr's conception of computational cognitive neuroscience.

It breaks the comprehensive task of cognitive neuroscientific explanations down into three distinct tasks, implying the need for three different theories, each offering a different perspective on the function at stake: a ‘computational theory’ that describes the task that is carried out (and is an alternative for a conceptual analysis of the task), an ‘algorithmic theory’ aimed at clarifying the representations of information and their transformation as used in the task, and finally, a ‘neural implementation theory’ that considers the neural components that may be responsible for the function (Marr 1982). Although these theories can be developed relatively independently from each other, a result regarding one theory can often be used to constrain the options available for the other two, thus enabling scientists to contribute to each other’s work. Useful as this subdivision of the explanatory task is, this methodology is hampered by some of its assumptions and has difficulties with the complexity and dynamics of a task like our topic: the determination of intentional action.

The third methodology to be discussed, which is used in the search for neural correlates of the complex and multifaceted phenomenon of consciousness, takes the relation between its delineation and explanatory facts for it to be looser (Chalmers 2000). Indeed, it is even suggested that the dispute over a definition of consciousness might be solved by the discovery of a neural correlate that is shared by different phenomena in the domain of consciousness (Lamme 2006). Although such a solution to conceptual problems appears tempting, we will discuss some objections that show how these problems nonetheless affect empirical results. Apparently, looking for mere correlates of a phenomenon that lacks a clear delineation may at most be useful as a first step in developing a cognitive neuroscientific explanation for it.

Part I closes with the exposition of the fourth method, so-called ‘mechanistic explanation’. Recognizing the difficulty of explaining cognition and behavior, which are often hard to define and are characterized by causal pluralism, it offers several heuristics that together can help scientists to develop an increasingly comprehensive and detailed explanation in terms of a mechanism that is responsible for the phenomenon under investigation (Bechtel and Richardson 1993). A definition of the phenomenon should be followed by its decomposition in terms of the sub-tasks that appear through their interaction and in response to environmental conditions to produce it. Each of those sub-tasks in turn is somehow carried out by explanatory mechanisms that can be localized in an organism at several levels, for instance at the level of synaptic processes or neural network activations. The mechanistic explanatory approach explicitly provides the resources to integrate insights from many different disciplines and allows mutual constraints between them (Craver 2007). In addition, we point out how this approach offers the resources to explain

dynamical changes such as they occur during the acquisition of expertise, in terms of modifications of the ‘explanatory mechanism’ responsible for the agent’s performance. Notwithstanding some limitations, we will conclude that mechanistic explanation is the most promising method for the current topic, given that intentional action is characterized by causal pluralism and developmental aspects.

Part II: Dynamic cognitive mechanisms and their stable adjustments due to development and learning

A complex and modifiable explanatory mechanism can be invoked if we aim to account for dynamic changes that happen during the developmental trajectory along which an infant learns to speak, to sing, and then to grow into an expert singer, or more generally for the variability of cognition and behavior. After the methodological Part I, we turn to the central topic of this study, which is the complex and dynamic processes involved in forms of intentional action by an expert or experienced agent. Part II focuses on aspects of development and learning, taking up three theories that employ the resources that we will find to be included in the mechanistic explanation in Part I. These three theories are neuroconstructivism, dual-process theory and a particular simulation theory, which will be clarified below.

Part II starts by discussing more generally why and how a dynamic mechanism acquires an increasingly complex structure, in which new components develop from already existing components. These new components become stably and generatively entrenched in the mechanism and thus influence its future development (Wimsatt 1986). Such new components can be considered as being ‘cobbled together’ and can accordingly be called ‘kludges’ (Clark 1987) – a term that we will use for components established during development and learning which subsequently affect the results of the associated explanatory mechanism’s activities. We will present several characteristics of such ‘kludges’ that are relevant for the investigation and explanation of a certain function as it changes over time. A kludge is usually observable in changes of an agent’s performance and is associated with a difference in the cognitive processes involved in that function. As for a kludge’s neural implementation – the domain of Marr’s third perspective – there are usually several options available. Given the complexity and dynamics of the mechanism in which a kludge emerges, we should expect variability in performance between the stages of individual development and between individual subjects, as is the case when we observe performances of the same opera aria by different singers. This expectation is examined with regard to three different cognitive neuroscientific theories.

The first theory is neuroconstructivism, which connects child development

and learning in general with the increasing complexity of the brain's networks, in which modular structures emerge. The initial formulation of neuroconstructivism distinguished between two processes that can be observed in child development and take place largely in parallel: the proceduralization of a skill which renders it more automatic but less accessible for control and articulation, and the explicitation of the skill which, step by step, offers a child new ways of memorizing, adjusting and correcting its performance (Karmiloff-Smith 1992). The process of 'representational redescription' – an algorithmic theory in Marr's terms – that corresponds with learning, eventually yields several representations of one and the same task for an agent. These representations, together with their underlying modified mechanisms correspond to the kludge formation that we use to account for some of the variability observable in performances of that task.

The second theory – or set of theories - testifies even in its name, 'dual-process theory', that different yet related explanatory mechanisms must be invoked to explain the differences in action performance by humans. For aside from the controlled processing with which human agents can carry out a task, experienced agents often also perform in an automatic fashion, allowing a fast and flexible performance even of complex tasks. Such automatized actions employ representations that are stored in memory and rely upon distinct neural processes that implicitly use these, together presenting another example of kludge formation. The use of these action representations easily escapes control, which raises questions about the intentionality of actions performed in this manner. Yet even though some theories suggest otherwise, the controlled and automatic processes are related to each other in several ways. To begin with, the acquired action representations can to a limited extent be influenced – or sculpted – by explicit, conscious control during learning. Even after an agent has reached the stage where he commonly performs a task through automatic processing, there are means available for self-regulating his automatic task performance. For instance, he can use his explicit understanding of the representation involved in a task and attend to specific features of the action representation that will adjust his eventual performance. Indeed, we also recognize an expert's performance by his adequate shifting between these two modes of processing.

The third theory of learning and development to be discussed also points to kludge formation, underlining the influence of cultural symbols, language or artefacts on the representations processed during cognition and action. Observation of expert singer performances, which are partly determined by these kludges, demonstrates how such represented contents, too, can become integrated in the operations of a complex and dynamical system like the brain. According to Barsalou's simulation

theory, such representations are not memorized as a whole but its components are distributed across the brain, waiting to be employed again. Kludge formation here refers to the emergence of a specific simulator, which is a 'distributed multi-modal system' that flexibly draws together component representations containing sensory, motor or cognitive information related to a particular content, experience or action – like performing an opera role (Barsalou 2009). The automatic or controlled activation of such a simulator enables an agent to re-enact in a rich and multi-modal sense a previous experience, to imagine a future action, and so on. This idea of a simulator containing representation components that refer to contents from the environment, concurs with the theory of extended cognition which holds that the brain can even integrate objects and tools that exist outside of the skull, in cognitive routines (Clark and Chalmers 1998). These two theories of learning again confirm an agent's capability of establishing complex and hierarchically structured representations associated with his cognitive processes and actions, in which heterogeneous elements can be integrated. Such kludges build upon each other with subsequent learning, facilitating an expert's increasingly complex performance.

Part II confirms that the explanatory mechanisms that produce our cognition and action are modifiable through learning and development. Learning and development lead to kludge formation, which involves the activation of richly structured representations and the neural activation patterns associated with these, both in an automatic or controlled way. As a result, an agent can usually learn to perform a particular, complex action in multiple ways and increasingly control and determine the mechanism that produces it. This learning process can be considered as a process of 'sculpting the space of actions', a space from which an agent's actions subsequently come forth.

Part III: Sculpting the space of actions for the performance of intentional expert action

Part III more specifically scrutinizes how actions are determined by various types of intentions that contribute to kludge formation and thus enable expert action or an expert singer to perform in a stable, flexible and fast way his complex opera roles according to his interpretation. Earlier, we rejected the paradox of expert action, because we agreed with Aristotle that an expert should be recognized for his excellent performance even though he relies upon his acquired skills, habits, and dispositions that relieve him of continuous conscious and rational decision making during his performances. Indeed, we learned that the explanatory mechanisms that produce cognition and action are modifiable and develop kludges as a result of learning

and development, which facilitate expert performance. In addition, we learned that intentional control exerts some influence upon his performance by influencing the formation of these kludges and their subsequent activation. That gave us a first indication of how an agent's intentions can be among the multiple causes that together determine his actions. In Part III of this dissertation, we will discuss more in detail how different levels of intention can contribute to stable modifications of the explanatory mechanisms that produce an expert's performance. In doing so, we will introduce and define in section III.1.1 the notion of a 'sculpted space of actions', mentioned in a more general sense earlier.

It is important to realize that for an agent to respond with an appropriate act in any given situation is a complex task, and suggests that devising or selecting such a response must be constrained. What features of the situation are relevant to act upon, which desire might now be fulfilled, what action goals can be realized and what consequences should be avoided, what is the cost-effectiveness of one action option compared to another? Consciously and rationally deciding about all these issues and weighing many others would cost a lot of time and resources, impeding his adequate and appropriate interactions with his constantly changing environment. Fortunately, thanks to the modifiable mechanisms that underlie his actions and the generatively entrenched kludges with which these have become equipped as a result of his growing expertise, he has a 'sculpted space of actions' at his disposal. No longer are all possible response options equally likely to be performed, as his response space has become sculpted, pushing some action options to the center and others to the periphery. Similarly, within a sculpted space there are dissociations or associations between some actions, external conditions have become integrated and many other factors have influenced it. Indeed, we will argue that this sculpting process integrates not just representational contents referring to relevant environmental conditions and the agent's expertise with these, but also representations corresponding to his long-standing intentions. An expert opera singer's sculpted space of actions is thus determined by the opera roles he has practised, his vocal and acting experience, his artistic and moral convictions and so on. Consequently, unlike his novice colleague, he is able to perform his roles fast and flexibly, while paying attention to his colleagues on stage and in the orchestra pit and the stage directors' seat and responding to them in a way that is coherent with his multi-faceted intentions. How these intentions become integrated in this sculpted space and correspondingly influence the mechanisms responsible for his actions will be discussed in the remaining part of this study.

Becoming an expert singer requires careful long-term planning, persistent

learning, a lot of deliberate practice, and increasing control of the complex musculature involved in singing and acting. The differences between all intentions involved, which figure at several levels of specificity, together with their necessary interactions will here be analyzed according to a conceptual framework presenting them as an ‘intentional cascade’ (Pacherie 2008). This framework allows a parallel discussion of philosophical analysis and empirical results pertaining to intentions. The philosophical analysis focuses mainly on the contents, representational format and functional role of each level of intentions and the interactions between the levels. Our discussion of the empirical, cognitive neuroscientific results will be constrained by the results of our philosophical analysis, which is being used as a heuristic for that discussion – as learned previously from the methodological Part I. Starting with the motor intentions, we will continue with the intermediate level of the proximal intentions, eventually arriving at distal intentions. Concurring with our methodological observations, each of these levels can be described in terms of the task for which they are responsible, the representations and operations involved in that task, and the neural mechanisms in which representations and operations are implemented. Furthermore, development and learning have differential effects on these levels of intentions, modifying both underlying mechanisms and the action representations, confirming the results of part II.

Contrary to what looks to many like an expert’s performance of mere automatic, implicit and unconscious motor movements, philosophical analysis of action points out the crucial fact that such an agent is actively guiding his movements, as is visible in his continuously correcting and adjusting these in response to environmental changes (Frankfurt 1978). The representations involved in these motor intentions contain not just non-conceptual information about stimuli and motor responses, but must be much richer and more complex to enable the guidance an expert visibly exerts on his actions. Since such complexity would put a large burden on his resources, it is welcome that these representations are compressed or ‘chunked’ in an expert (Gobet and Simon 1996 ; Miller 1956). As he can rely upon thousands of such chunked representations that were stored during his long-term absorption with his art, the cognitive and neural processes are different for an expert compared to a novice. Indeed, those representations can be processed with limited neural activations, consequently allowing additional cognitive processes to occur simultaneously, which is why an expert appears to be less consumed by his own actions than a novice is.

Kludge formation modifies the mechanisms that we refer to when explaining an expert’s performance, but not only with regard to motor intentions. Chapter III.3 is devoted to proximal intentions, which mediate between the implicit and situation-

specific motor intentions and the distal intentions, which are explicit, conceptual in nature and future-directed. A philosophical analysis of the roles of proximal intentions teaches us that it is more difficult than just yielding a specification of a distal intention, or anchoring it in an appropriate situation such that corresponding motor intentions can be determined. For in exceptional situations, like in an avant-garde stage direction, an expert might want to block his habitual action as a competing distal intention may need to overrule the intention that is habitually realized under particular environmental conditions (Bratman 1987). The complex task of proximal intentions can be considered the result of not just one but rather two distinct processes, one interacting with the other, similar to the dual processes discussed in chapter II, 3. Connecting the two are complex action representations that are automatically put together in response to multiple factors by a 'contention scheduling' process. This process can be modulated by a supervisory process, granting the agent some control over his automatic action if necessary (Norman and Shallice 1986). With reference to these two component mechanisms and a large set of stored action representations, all subject to change as a result of expertise, cognitive neuroscience can explain how the intricate roles of proximal intentions are realized and how these contribute to an expert's sculpted space of actions.

Although Aristotle did reject the paradox of expert action mentioned above and contended that causal pluralism should be recognized with regard to action, it is still not obvious how distal intentions can contribute to what appears like an expert's automatic actions. How is it possible that we can recognize an expert singer's moral convictions and artistic style even when he tries out a new role, and not catch him in an awkward and hammed up performance? Surprising as this may seem, it is important to realize that counterproductive actions will likely occur and produce costly incoherencies if an expert's comprehensive long-term intentions were not capable of constraining his ongoing performance. Consequently, we can expect that mechanisms are in place that are responsible for doing just that, for constraining his actions in line with his distal intentions. These distal intentions, then, perhaps not so much determine in detail an upcoming action but can rather be considered as constraints or filters that co-determine the action options available to an agent (Bratman 1987). A human agent typically integrates his multiple distal intentions in a complex and hierarchically structured narrative and shares this with other agents, adjusting it carefully when necessary. In doing so, he can employ the stable narrative configurations that are part of his cultural environment, deviating from them inevitably and sometimes at wish (Ricoeur 1992). Engaging in such narratives amounts to simulating actions similar to what was discussed before. Though the

action representations involved in these narratives are more comprehensive and stretch out further into the agent's past and future, such simulations build upon the action representations at several levels of specificity that the agent has assembled over time as part of his expertise. Indeed, evidence confirming the 'constructive episodic simulation hypothesis' confirms that there is a strong interdependence between the cognitive and neural processes for such simulation of a complex action and the processes responsible for the component representations involved in that simulation (Schacter and Addis 2007a). As a result, such action simulation not only allows an agent to consider the coherence between his intentions consciously and rationally, but in itself also influences the mechanisms that implicitly co-determine his future actions – again, contributing to the sculpted space of actions that enables an expert to act promptly and flexibly in a coherent and stable manner.

Putting the reader's perseverance to the test, this dissertation thus ends its long trajectory with a more specific investigation of the relation between on the one hand, the different levels of intentions that are the subject of philosophical analysis and on the other hand, the cognitive and neural processes involved in realizing these intentions in actions. Equipped with our preparatory methodological results and with the insights about the dynamics of mechanisms as a result from learning and development, we are able to integrate the philosophical and cognitive neuroscientific approaches to intentional action. By mutually constraining each other, these approaches help us to understand and explain the amazing and admirable properties of expert action – be it the action of an opera singer who moves us when he embraces as Saint François the leprous man, or the action of a seasoned fellow citizen who courageously and carefully manages to defuse a public strife.