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Editorial: "Skilled Action Control"

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1. Background: intellectualism vs anti-intellectualism about skilled action

One may be a skilled driver but a terrible cook, a skilled chess player and a poor dancer, a skilled cabinet-maker yet an indifferent tennis player, a skilled pianist while a mediocre teacher. What is it then that sets apart skilled from unskilled action, allowing one to excel in some domains but not in others? We take it that at the heart of skilled action is the high degree of control that an agent possesses over their activity in some domain, and which often necessitates years of practice and training to acquire. This just pushes the question back a step, however. For now we must ask, what are the hallmarks of the control that enables skilled performance? What forms of cognitive processing and psychological representation support such control?

Let us start with the hallmarks. There is a large consensus that skilled action control is highly intelligent and flexible (e.g., Fridland 2013; Levy 2017). It is acutely sensitive to the goals, plans and strategies of the agent as well as to the features of a given action context. Skilled agents are capable of implementing their goals and plans in nuanced ways in accordance with the particular circumstances they face, including in novel or unusual situations. A second important feature of skilled action control is its efficiency. Skilled agents are capable of rapidly selecting and executing appropriate actions with less cognitive effort than less proficient agents would. Thirdly, acquiring a high level of control with respect to some skill requires (lots of) practice, where practice leads to an improvement in both flexibility and efficiency (Haith and Krakauer 2018). Finally, a less often noted characteristic of skilled action control is its distinctive phenomenology (for exceptions, see especially Dreyfus & Dreyfus 1986 and Christensen et al. 2015). The subjective experience of agents engaging in skilled performance is dramatically different from that of agents engaging in unskilled behaviour. On the one hand, skill is often marked by a type of experience that has been termed "flow", a feeling of "effortless absorption" in one's present activity (Csikszentmihalyi 1975/2000). On the other hand, even when skilled agents do not experience flow, they typically have an exquisite sense of the respective contributions of self and external factors to action outcomes, prospective awareness of actions that are possible in a situation, and awareness of the limits of control (Christensen et al., 2015).

What the skilled action theorist must therefore explain is what the intelligence of skilled action control consists in, how it gets trained up and achieves its efficiency, how skilled actions come to possess their distinctive control phenomenology and how agents can in turn exploit different types of awareness to further tune up their skills.

One of the most debated issues in the philosophy of skill concerns how best to construe the intelligence or knowledge-how characteristic of skilled action. Ryle (1949), in the analytic tradition, and later Dreyfus (Dreyfus & Dreyfus 1980, 1986; Dreyfus 2002) in the phenomenological tradition, both held anti-intellectualist views of skilled action, rejecting the idea that knowledge-how is a form of propositional knowledge and that skilled action is driven by explicit propositional rules. Instead, Ryle argued that skill and knowing-how consist in complex sets of trained, multi-track dispositions. Similarly, Dreyfus argued that, in contrast to beginners and less proficient performers, expert performers need not consult rules and engage in deliberation in order to decide on their course of action. Rather than thinking, experts act intuitively through a holistic grasp of the situation.

Stanley and Williamson's (2001) paper challenged what had become an anti-intellectualist orthodoxy and changed the state of play. They offered responses to Ryle's anti-intellectualist arguments and developed a forceful defence of the intellectualist position, arguing that knowledge-how is a form of propositional knowledge that involves grasping the relevant propositions under a distinctive, "practical mode of presentation" (see Pavese 2015, 2019 for analysis and discussion of this notion). Since then, intellectualism has regained ground, fuelling a vigorous debate on the nature of the relations between knowledge-how and knowledge that (see, for instance, Stanley 2011, and the collection of essays in Benson and Moffett 2011).

However, the defence of intellectualism mounted by Stanley and Williamson (2001) and later Stanley (2011) rested largely on linguistic arguments, both syntactic and semantic. Several authors (e.g., Devitt 2011, Brown 2013; Levy 2017) have pointed out that the debate between intellectualism and anti-intellectualism is unlikely to be settled by linguistic analysis alone. Rather, it also needs to be informed by empirical work in psychology and the cognitive sciences.

During the last decade, greater attention to empirical research has led a number of theorists to the conclusion that neither the intellectualists nor the anti-intellectualists have gotten things quite right. They have proposed instead a range of hybrid views of skilled action meant to give a role to both propositional and non-propositional states in a full account of skilled action control. Empirically informed approaches to skill have also led theorists to broaden the terms of the intellectualism/anti-intellectualism debate and to challenge some of the dichotomies used to frame it. Initially focused on whether knowing how is or isn't irreducibly different from knowing that, the debate has now expanded to the broader issue of whether skill necessarily involves higher-level cognition, where higher-level cognition is understood to encompass more than just the propositional cognition of know-that and to include also mental capacities such as top-down attention and executive control (see Dayer & Jennings and Buehler, this issue). The dichotomies philosophers and psychologists theorizing about skills have sometimes been too prone to embrace have also been challenged. For instance, Fridland (2017a, 2017b) has called into question the equation of 'intelligent' processes with conscious, controlled, intentional processes and, conversely, of automatic processes with unintelligent, brute-force causal processes and argued that automaticity does not exclude intelligence. Similarly, in psychology, once popular (e.g., Posner and Snyder, 1975; Shiffrin and Schneider, 1977) all or none conceptions of the distinction between automatic and non-automatic processes that took both modes to be mutually exclusive and each to be associated with a set of perfectly correlated features have been increasingly challenged. As many studies have now shown, the features thought to be diagnostic of automaticity are far from being perfectly correlated and many of them come in degrees. Many psychologists now advocate a gradualist view of automaticity that takes automatic and intentional processes to form a continuum rather than be dichotomous. (For discussions of these empirical findings and of psychological conceptions of automaticity, see Moors and de Houwer 2006 and Moors, 2016).

While, as many of the articles in this issue illustrate, hybrid theories of skill are now on the upswing, hybrid accounts confront challenges of their own. The hybrid theories that have been proposed in recent years (e.g., Christensen et al. 2016; Fridland, 2014, 2017a, 2017b; Levy 2017; Montero 2016; Papineau 2013, 2015; Shepherd 2019; Pavese 2019) take a variety of forms and do not necessarily agree on the roles played respectively by personal-level cognitive states and control processes and by motor representations and automatic control processes. Nor do they agree on how the motor component of skilled action should be construed (see e.g., Levy 2017) or on the extent to which the motor and not just the cognitive component of skilled action contribute to explaining the intelligence of skill. For instance, some hybrid accounts (e.g., Papineau 2013, 2015) rest on a sharp division of labour in skilled action between intentional cognitive control processes, concerned with strategic decision-making, and motor control processes concerned with action execution. In contrast, other hybrid accounts insist that skilled action depends on a continued interaction between cognitive and automatic control processes and appeal to more highly integrated views of cognitive architecture (e.g., Christensen et al. 2016, Fridland 2017; Levy 2017; Mylopoulos and Pacherie 2020). Thus, while hybrid accounts all argue that skilled behaviour weaves together automaticity and higher-level cognition, they may still disagree on how best to characterize their weaving pattern.

2. Themes and controversies of this issue

There are three broad themes that the contributions to this special issue address. First, an understanding of the psychological representations that underlie skilled action control, as well as how they coordinate to produce successful action. Second, an account of the types of control processes that operate over these representations and how these are integrated. Third, a sharper view of the capacities that skilled agents employ to help secure and regulate control over their behaviour.

One central issue related to the first theme concerns what Butterfill & Sinigaglia (2014) have dubbed 'the interface problem'. In its original formulation, the problem concerns how it is that intentions and motor representations, if indeed they are encoded in different representational formats, can coordinate to produce successful exercises of agency. Since skilled action control is an instance of agency *par excellence*, this question comes to be even more pressing for theorizing in this domain. How can we make progress here? As **Fridland** points out, a proper answer requires that we understand the content of motor representations how best to characterize the personal-level intentions with which they interact. To address this requirement, Fridland draws a distinction between what she calls 'general intentions', which play major roles in planning, organizing, and motivating action, and 'practical intentions', which coordinate between more general plans and their implementation in the situation of action. These intentions are related hierarchically, with the former type of intention specifying the end or outcome for the agent to pursue (e.g., hit the bullseye), and the latter specifying the means by way of which it is to be pursued (e.g., throw the dart). Fridland emphasizes that practical intentions are not to be construed, as they sometimes have been, as having the function of initiating, guiding, or monitoring action implementation, at least in the sense of modifying and adjusting the kinematic details of an action during its execution. Rather, this task falls to control structures realized in the motor system. Importantly, on Fridland's view, the point of contact between cognition and motor control is provided by practical intentions, insofar as motor processing calculates means for ends that are determined by practical intentions, and in particular the closest one in the action hierarchy.

While Fridland focuses on the distinction between practical intention and motor representation in terms of their respective contents and functional role, **Burnston** articulates the contrast in terms of a difference in format. In particular, he maintains that while intentions are "discursive, language-like representations comprising amodal conceprs [i.e., those nout couched in any sensory format]", as their constituents, sensory and motor representations involved in the learning and execution of skilled action are multi-dimensional representations that define values along a set of parameters. Burnston makes a case for the holistic and multi-scale associationist character of sensorimotor learning, and proposes to call the outputs of such learning '*structured sensorimotor representations' (SSRs)*, which are in turn responsible for one's ability to recognize relevant features of their surroundings, including action affordances, and to flexibly organize one's action in those surroundings in the service of their goals.

Having laid out this model, Burnston then offers reasons for thinking that intellectualist strategies for explaining skill are incompatible with it, and thus defective. Such strategies attempt to treat skill as a function of what the agent knows, either in a way such that the agent's propositional knowledge (i) constitutes skill itself, when accessed under a practical mode of presentation (e.g., Pavese 2018, 2019), (ii) is "baked in" (Krakauer 2019) to the representations of the motor system, or (iii) is what enables skilled agents to deploy their skills. None of these approaches is successful, Burnston argues, since they all suppose determinate propositional content for the representations responsible for skill execution and SSRs lack precisely such contents. Rather, the content *in*determinacy of SSRs enables them to account for both the variance and invariance of skilled performance.

In their own discussion of the cognitive architecture of skilled action, **Schack & Frank** join Fridland and Burnston in distinguishing among two different types of representation involved in skilled action control ("mental" and "sensorimotor"), and also emphasize a distinction between two different types of control ("mental" and "sensorimotor"). The level of sensorimotor control is driven by environmental stimuli and enabled by modality-specific representations of the sensory effects of particular movements. By contrast, "mental control" is is driven by an agent's intentions, and enabled by mental representations that relate to the functional and perceptual dimensions of movements and body postures and are tied to sensory movement effects rather than muscle-oriented commands as some other frameworks have held. These the authors call "basic action concepts" (BACs) and they view them as "building blocks" that group together to form representational structures that are stored in long-term memory (LTM) and guide skilled action execution. Indeed, they describe empirical work that suggests that among high-level experts these representations are well-matched to the functional and biomechanical demands of the task, organized in a hierarchical tree-like structure, and largely invariant across individuals. In low-level players and non-players, however, they exhibit less hierarchical organization and are variable.

While there are differences in terms of how they understand the contents and formats of intention and sensorimotor representation, and the ways in which they interact, Burnston, Fridland, and Schack & Frank, can all be seen as presenting versions of what **Christensen**, in his contribution, calls the "Classical View" of the boundary between cognition and the motor system. According to such a view, cognition and the motor system are to a large extent functionally segregated, with cognition being primarily responsible for setting an agent's goals and sometimes the action types by way of which to achieve them, while the motor system typically takes care of the programming and control of movements that achieve those goals.

By contrast, Christensen presents an "interactive, multi-level architecture" (IMLA) that posits multiple levels of processing dedicated to action control, as well as rich functional integration among them, which allows for the sharing of representations in different formats to participate in a common planning process for action. At the top of the hierarchy is the general reasoning system, which is devoted to practical deliberation about what goals to pursue and how. The next level down is occupied by the situated action system (SAS), followed by the integrated motor system (IMS), which jointly coordinate to manage action execution. The former is responsible for planning the action contextually, taking features of the agent's current situation into account, while the latter takes care of "high level motor planning," which includes identifying objects and features to act on, and selecting appropriate action types in relation to them. All three of these levels interact with a shared working memory space. Finally, there is the modular motor system (MMS), which handles the details of motor implementation with the help of dorsal stream vision. These systems are all yoked together, at least partially, by neural plasticity and the "meta-representational rules" for constructing links between representational systems that this plasticity is governed by.

Like Christensen, **Toner and Moran** argue for a tightly integrated view of the processes shaping skilled action. They take issue with traditional models of skill acquisition (e.g., Shiffrin and Schneider, 1977), according to which it involves a progression from more deliberate and effortful controlled processing to effortless, unconscious and fast automatic processes. They argue that this traditional approach rests on two mistaken assumptions: that cognitive processes form a single continuum ranging from fully controlled to fully automatic and that automaticity is a defining feature of optimal performance. In contrast, Toner and Moran propose that automated and controlled processes must operate synergistically if performers are to continue to develop their embodied capacities and maintain performance proficiency in face of the huge variety of challenges they face. Following Bebko et al. (2005), they argue that controlled and automatic processes operate in an orthogonal manner, with automaticity existing on one continuum (ranging from non-automatic to automatic processing) and control on a separate, orthogonal continuum ranging from low to highly controlled processing. In support of this orthogonal view of the relationship between controlled and automated processes, they marshal evidence from a variety of situations in the sport domain that show how skilled performers use controlled processes to update and improve motor execution in training contexts.

Toner and Moran also take it that the interaction between automated and controlled processes is not restricted to practice contexts leaving optimal performance untouched and fully automatic. They propose a reassessment of flow experience, a state that often accompanies optimal performance and is usually presented as a paradigmatic example of the automaticity and mindlessness of skilled action. Against this traditional conception of flow states, they appeal to a range of neuroimaging and experimental evidence suggesting that supervisory attentional and cognitive control systems of the brain are highly active during flow and that flow states require more attentional effort than previously thought and therefore cannot be considered fully automatic. Toner and Moran also note that these findings are mirrored by qualitative research indicating that optimal performance states in sport are characterised not by the mindlessness of full automaticity but, rather, by high levels of automaticity and high levels of control. In particular, evidence suggests that athletes deploy high levels of control to combat the deleterious consequences of performance pressure and produce clutch performances.

While **Bicknell** shares the view that skilled action involves a tight and flexible integration of automatic and controlled processes, her focus is on the inherent instability and variability of bodily capacities and psychological states, their impact on the reliability and safeness of performance, and the strategies skilled practitioners develop and rely on to maintain consistent performance bodily and affective fluctuations in vulnerable circumstances. She argues that intelligently responding to dynamic fluctuations of bodily and psychological capacities is a *vital*, though often overlooked feature of skilled action processes. In particular, her emphasis on the positive role emotions such as anxiety may play in responding to these fluctuations contrasts with approaches that stress the deleterious influence of negative emotions on performance (e.g., the experiences of choking and its link to anxiety related thoughts, discussed by Toner and Moran).

Bicknell suggests that multiple and interconnected forms of awareness, including kinaesthetic awareness, affective awareness, situation awareness, and prospective awareness, that together constitute what she calls "embodied intelligence", play an important role in assessing and responding to the potential impacts of variability and vulnerability. To investigate the resources skilled practitioners draw on and the strategies they develop to deal with these fluctuations, Bicknell employs a cognitive ethnographic method. Drawing on her experiences as an expert mountain biker learning new skills in a different domain, static trapeze, she presents two case studies detailing the strategies she developed and used to deal with apprenticeship on the static trapeze to produce two 'experience near' case studies. Her two case studies document the role of kinaesthetic and affective awareness in assessing and responding to instability and vulnerability, revealing strong connections between a reflective awareness of bodily vulnerability and variability and self-regulatory processes. In particular, her first case study shows that, contrary to received wisdom, anxiety is not necessarily detrimental to performance. Up-regulating anxiety when risks are high and the body vulnerable can also increase focus and attention, prompt strategic reflection and decision-making and thus facilitate optimal performance. Two main lessons can be drawn from the rich set of insights her ethnographic method provides. The first is that skill development is not linear and that variability and vulnerability are intrinsic to high-performance situations, suggesting that skill theory should investigate not just the processes by which people achieve success but also the processes by which people navigate instability and failure. The second, related conclusion, is that learning to deal with this instability and developing fine-grained ways of modulating multiple, connected factors that impact performance is itself a "meta-skill" and a crucial component of expertise.

The contribution by **Dayer and Jennings** continues in this line, arguing that skill involves a rich interplay between cognitive control and automatic processes -- a view they call "pluralist" to refer to its hybrid intellectualist/anti-intellectualist nature. They further highlight that the precise nature of this interplay depends on the *level* of the skilled performer (level pluralism), the *aspect* of the skilled performance in question (synchronic pluralism), and the *temporal stage* of the performance (diachronic pluralism).

When it comes to level pluralism, they endorse the common view that skilled performers that have reached a certain level of expertise are able -- by virtue of their increasingly automatized action routines -- to free up cognitive resources that they can then redeploy to other aspects of the task. As a novel example of such redeployment, they appeal to the phenomenon of mind wandering during skilled action performance. They point out that such activity can often result in "prospection and creativity" in a way that facilitates skilled behaviour, as in cases where the performance involves approaching a novel problem with insight, or rumination of possible future scenarios. In this way, at least once a certain level of expertise has been reached, mind wandering might offer up a case of weaving higher-level cognition with automatized routines in a way that can increase an agent's capacity for situation-specific responses in skilled performance.

In order to illustrate synchronic pluralism, Dayer & Jennings point to Papineau's account of how top-down attention can either facilitate skilled performance, or serve as a detriment, depending on the aspect of the action to which one attends. If one attends to the "basic" action that one intends to perform (e.g., composing a sentence in typing), thus "keeping one's mind right" and maintaining the appropriate level of focus and concentration during performance. If, however, one attends instead to the "components" of one's intended action (e.g., typing the letter 'p' with one's pinky finger), then one's performance will likely degrade. Dayer & Jennings further suggest that empirical work that indicates better skilled performance when one maintains a distal focus (e.g., fixating the target location on a dartboard) vs. proximal focus (e.g., attending to the exact way one throws the dart) may be a way to explore the variable benefits of top-down attention on skilled action control.

Finally, for their proposal that higher-level cognition is involved at different temporal stages of a skilled performance, Dayer & Jennings combine the insights gleaned from their discussions of level and synchronic pluralism, suggesting that attention during skilful performance "naturally fluctuates" along with task-unrelated moments of mind-wandering. Since these brief episodes of mind wandering are not beneficial to the task at hand, they do not count as contributions of higher-level cognition to skill, as in the type of case discussed under the label of level pluralism. Still, they are important to an account of the temporal flow of skilled behaviour and the periodicity of attention that accompanies it.

In his contribution, **Buehler** also emphasizes the role of attention in skilled performance, and in particular the importance of determining what it is for an agent to guide their attention shifts. This question arises because, as Buehler points out, attention is sometimes *drawn away* from the activity with which one is engaged, or in a "default" state, shifting without any immediate purpose. So we must determine when it is that attentional shifts are due to the guidance of the agent, and when they are not. Only the former, on Buehler's view, are cases wherein they contribute to the exercise of skilled action control.

A potential strategy for how to do so exploits the common distinction in attention research (see, e.g., Posner 1980) between two attentional systems responsible for orienting attention:

endogenous and exogenous. Endogenous attention can be accessed and influenced by the individual's beliefs and goals, whereas they have no effect on exogenous attention (e.g., in cases where one intends to ignore an irrelevant cue, but finds oneself attending to it anyway). This suggests that when an agent guides their attention shifts, their endogenous system alone drives these shifts them.

Buehler argues that this preliminary condition on the guidance of attention is not adequate, however, since it does not account for the interactions between endogenous and exogenous attention, and further does not say enough about the endogenous factors that implement an agent's guidance. Some endogenous factors (e.g., priming) may interfere with an individual's guidance of attention, and so cannot be credibly identified with it. In order to remedy these shortcomings, Buehler proposes instead that when an individual guides their attention-shifts toward some goal, their executive system regulates processing across relevant sub-systems. He further elaborates that the executive system is a psychological sub-system that governs other psychological sub-systems by way of allocating resources and managing information storage via the exercise of executive functions. These include task switching, maintenance, resource-allocation, and inhibition. This leads ultimately to the insight that understanding the role of a control structure in skill requires understanding its connection to executive regulation.

Of course, skilled agents not only excel at successfully producing action that accords with their goals, they are also acutely sensitive to reasons for acting in certain ways in certain situations -- they excel at practical rationality. **Shepherd** explores this important overarching capacity of skilled agents, suggesting that reasons can be viewed as three-place relations between some consideration, an agent, and a mode of response (see Dancy 2018), and that sensitivity to reasons can be divided into behavioural, psychological, and cognitive sensitivity. Shepherd's focus is on the latter two types of sensitivity, the first of which is characterized in terms of an agent's key psychological capacities (e.g., perception, emotion, attention) reliably tracking reasons that are available for action, and the second of which is characterized in terms of the agent's tendency to recognize available reasons as reasons as well as this tendency driving and guiding the agent's further reasoning, planning, and behaviour. When both types of sensitivity are operative, these are cases of "reason-handling". Reason-handling can be further divided into five phases: reason finding, reason recognition, reason assessment, reason response, and reason implementation.

Importantly, a skilled agent must navigate a trade-off between a flexible, reason-sensitive mode of responding, and a more rigid, efficient automatic mode, in a way that is sensitive to a number of factors including the complexity and stability of the domain, the agent's level of ability, and fluctuations in this ability over time and across circumstances. This highlights, from a different angle, the importance of meta-control in regulating the interplay among cognitive and automatic control processes, as other contributors (e.g., Toner and Moran, Bicknell) also emphasize.

Shepherd also notes that it remains an open question how exactly to draw the line between "mere" psychological sensitivity to some reason and cognitive sensitivity, allowing that forms of the latter may occur both consciously and not. This point touches on a broader issue regarding the relationship between skilled action and consciousness, and brings us to the final contribution by **Brozzo**, who addresses an important question regarding this relationship. On Brozzo's view, forming an intention to perform a certain action requires having conscious access to its content, which enables one to ensures consistency between that content and those of other personal-level states of the agent. But then a challenge emerges: how it is that a skilled agent can be said to intend to perform some aspect of their action, while not being consciously aware of that aspect. She uses as an example a case of executing a particularly impressive golf swing in large part due to the particular way in which you orient your right hand, despite not being aware of this feature of your movement. How can we view the movement as intended if this is the case? The solution, according to Brozzo, is to distinguish between aspects of skilled performance that are *temporarily* inaccessible, and those that are *permanently inaccessible* to consciousness. Many aspects of skill that are intended by the performer fall only under the former category, since the agent is not focusing their attention on those aspects during performance, or they have been automatized. In both cases, Brozzo argues, there is a case to be made that conscious access can be recovered. Thus, at least for these particular cases, skilled action is rescued from the central challenge.

3. Outlook

Many of the contributions of this special issue can be seen as breaking away from modes of thinking that had previously dominated theorizing about skill. The conceptualization of skills proposed in these contributions move us beyond the terms of the traditional intellectualist vs. anti-intellectualist debate about skill. They reflect the abandonment of dichotomous thinking regarding propositional vs. motoric format, automatic vs. cognitive control processes, and attended vs. unattended processing modes in favour of a richer and more nuanced picture. In emphasizing the diverse array of capacities and processes that together contribute to skilled action, these contributions also raise new issues about the boundary between cognition and the motor system and the functional integration of cognitive and motor, automatic and cognitively controlled, processes.

These exciting new developments in empirical and philosophical research and theorizing on skill also open new questions for future research. To conclude, let us outline three such questions.

Firstly, while recent conceptualizations of skill emphasize the great variety of processes and capacities that contribute to skilled performance, the precise contributions of some of these processes still need to be investigated in more detail. For instance, most of the work on the role of emotions in skilled action has focused on their detrimental effect on performance. As Bicknell (this issue) points out, there is as yet little research on the positive roles that emotions may play in skilled performance and on the unique ways in which experts modulate certain affective experiences to facilitate performance. Similarly, while Buehler (this issue) emphasizes the role of attention and attention guidance in skilled performance, it is important to also gain a more precise understanding of the roles of other components of the executive system in skilled action and how these play out in skilled performance versus everyday activities.

Secondly, as Toner and Moran (this issue) point out, if skilled performance is characterized by the tight integration of automatic and cognitive control processes, the question arises of how skilled agents identify appropriate modes of control as action unfolds. Toner and Moran propose that metacognitive monitoring and regulation are key features of psychological flexibility and that metacognitive feelings arising from the monitoring of internal sensory and environmental sources of information play a key role in signalling changes in the demands of the task and the need to engage conscious control processes. Whether, as Toner and Moran suggest, metacognitive processing is necessarily involved in skill or whether, as Dayer & Jennings argue, the coordination of processes in skill behaviour depends on associative links between processes and thus does not require the involvement of metacognition is an issue still in debate that certainly warrants further investigation.

Thirdly, in addition to examining the richness and diversity of the psychological representations and capacities involved in skilled action control, future work should also explore the potentially multifaceted nature of the accompanying phenomenology. It may no longer be appropriate to characterize the experience involved in skilled action as unitary, i.e., a flow experience of "effortless absorption". Indeed, flow experiences themselves appear to be more complex than has been typically recognized. Toner and Moran (this issue) discuss qualitative research indicating that they can take at least two forms: "letting it happen" experiences and "making it happen" experiences. The former experience is associated "with a gradual build-up of confidence", where control over performance and fluency of motor execution slowly improve to a point where everything falls into place, giving agents the confidence to let motor execution unfold automatically. The latter experience, "making it happen", is a state where task execution continues to unfold in an automatic manner, but the agent intentionally devotes additional cognitive and attentional resources to the performance. This experience is characterized by complete and deliberate focus, intense effort, heightened awareness of self and situation, heightened arousal and automaticity of skills. Contrary to received wisdom, Toner and Moran suggest that the flow states that accompany optimal performance are more often of the "making it happen" than the "letting it happen" variety.

In addition, Bicknell (this issue) points to the importance of a variety of interconnected experiences that go beyond flow for appropriate decision-making and control during skilled performance: A finely-tuned kinaesthetic awareness of how one's body feels as one engages in skilled action helps the agent assess their physiological state and capacities; affective awareness of one's "shifting feelings and emotions" provides information to the agent about their state of arousal and mental clarity, which can serve as important cues for risk assessment; and prospective awareness allows the agent to a anticipate likely action outcomes and plan accordingly.

Relatedly, we must be cautious not to make assumptions about the psychology of skill based only on a crude or limited characterization of its phenomenology. Indeed, Toner and Moran (this issue) point out that recent neuroscientific and experimental findings suggest that supervisory attentional and cognitive control systems of the brain are highly active during flow and that flow states require more attentional effort than previously thought and therefore cannot be considered fully "effortless", though some flow experiences may subjectively seem that way.

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References

Bebko, J.M., J.L. Demark, N. Im-Bolter, and A. MacKewn. 2005. Transfer, control, and automatic processing in a complex motor task: An examination of bounce juggling. *Journal of Motor Behavior,* 37: 465–474.

Bengson, J., & Moffett, M. A. (Eds.). (2011). *Knowing how: Essays on knowledge, mind, and action*. Oxford University Press.

Brown, J. (2013). Knowing-how: Linguistics and cognitive science. *Analysis*, 73, 220–227.

Christensen, W, Bicknell, K. McIlwayn, D., & Sutton, J. (2015). The Sense of Agency and Its Role in Strategic Control for Expert Mountain Bikers. *Psychology of Consciousness: Theory, Research, and Practice*, 2, 3: 340-353.

Christensen, W, Sutton, J. & McIlwayn, D. (2016) Cognition in Skilled Action: Meshed Control and the Varieties of Skill Experience, *Mind & Language*, 31, 1: 37–66.

Csikszentmihalyi, M. (2000). *Beyond boredom and anxiety*. San Francisco: Jossey-Bass. (Original work published 1975)

Dancy, J. (2018). *Practical shape: A theory of practical reasoning*. Oxford University Press.

Devitt, M. (2011). Methodology and the nature of knowing how. *Journal of Philosophy*, 108, 205–218.

Dreyfus, H. L. (2002). Intelligence without representation–Merleau-Ponty's critique of mental representation. The relevance of phenomenology to scientific explanation. *Phenomenology and the cognitive sciences*, *1*(4), 367-383.

Dreyfus, H., & Dreyfus, S. E. (1986). *Mind over machines*. New-York: Free Press.

Dreyfus, S. E., & Dreyfus, H. L. (1980). *A five-stage model of the mental activities involved in directed skill acquisition*. California Univ Berkeley Operations Research Center.

Fridland, E. (2013). Problems with intellectualism. *Philosophical studies*, *165*(3), 879-891.

Fridland, E. (2014). They've lost control: Reflections on skill. *Synthese*, 91(12), 2729–2750.

Fridland, E. (2017a). Automatically minded. *Synthese*, *194*(11), 4337-4363.

Fridland, E. (2017b). Skill and motor control: intelligence all the way down. *Philosophical Studies*, 174(6), 1539-1560.

Haith, A. M., & Krakauer, J. W. (2018). The multiple effects of practice: skill, habit and reduced cognitive load. *Current Opinion in Behavioral Sciences*, *20*, 196-201.

Levy, N. (2017). Embodied savoir-faire: knowledge-how requires motor representations. *Synthese*, *194*(2), 511-530.

Montero, B. (2016). *Thought in Action*. Oxford, UK: Oxford University Press.

Moors, A. (2016). Automaticity: Componential, causal, and mechanistic explanations. *Annual Review of Psychology*, *67*, 263-287.

Moors, A., & De Houwer, J. (2006). Automaticity: a theoretical and conceptual analysis. *Psychological Bulletin*, 132(2), 297.

Pacherie, E., & Mylopoulos, M. (2020). Beyond automaticity: The psychological complexity of skill. *Topoi*, 1-14. DOI: 10.1007/s11245-020-09715-0

Papineau, D (2015). Choking and the Yips. *Phenomenology and the Cognitive Sciences*, 14: 295–308.

Papineau, D. (2013). In the zone. *Royal Institute of Philosophy Supplement*, 73, 175–196.

Pavese, C. (2015). Practical Senses. *Philosopher's Imprint*, *15*(29).

Pavese, C. (2019). The psychological reality of practical representation. *Philosophical Psychology*, 32(5), 784-821.

Posner, M.I. & Snyder, C.R.R. (1975). Attention and cognitive control. In R. L. Solso (ed.) *Information processing and cognition: the Loyola Symposium* (pp. 55-85). Hillsdale, NJ: Erlbaum.

Ryle, G. (1949). *The concept of mind.* Chicago: The University of Chicago Press

Shepherd, J. (2019). Skilled action and the double life of intention. *Philosophy and phenomenological research*, *98*(2), 286-305.

Shiffrin, R. M., & Schneider, W. (1977). Controlled and automatic human information processing: II. Perceptual learning, automatic attending and a general theory. *Psychological Review*, *84*(2), 127.

Stanley, J. (2011). *Know how*. Oxford: Oxford University Press.

Stanley, J., & Williamson, T. (2001). Knowing How. *Journal of Philosophy,* 98: 411–44.