Unconscious Intelligence in the Skilled Control of Expert Action

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Abstract

What occurs in the mind of an expert who is performing at their very best? In this essay, I survey the history of debate concerning this question. I suggest that expertise is neither solely a mastery of the automatic nor solely a mastery of intelligence in skilled action control. Experts are also capable of performing automatic actions intelligently. Following this, I argue that unconscious thinking theory (UTT) is a powerful tool in coming to understand the role of executive, intelligent action control in the fluidly automatic performance of expertise. Relying on a body of empirical evidence concerning the cognitive structures and perceptual strategies employed by experts, I show that the realm of skilled action is an ideal environment within which the powers of unconscious cognitive processing can have positive effects on action. I conclude that experts rely upon unconscious thinking in the production of intelligently automatic skilled actions.

Keywords: Expertise, Attention, Automaticity, Skill, Unconscious Thinking

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I. Introduction

Philosophical perspectives on the forms of action control utilized by experts have been historically split between two camps of interpretation. The 'anti-intellectualists' argue that expertise amounts to a mastery of automaticity and capable mindlessness – where thinking and conscious representation gets in the way of doing well. To the contrary, the 'intellectualists' argue that mastery is a matter of intelligent capability and one's ability to bring that intelligence to bear in controlling the actions that they perform. The question at the heart of the disagreement between these two camps concerns whether or not conscious or thoughtful executive control is a necessary component of skillful performance, or rather just gets in the way. Hybrid, or 'dual process,' models of expertise suggest that both of the foregoing camps seem to have a part of the story of expert cognition right. Sometimes skilled actions are controlled with executive intelligence, and sometimes skilled actions occur automatically. According to the dual process views, being able to transition between both forms of control is essential to expertise.

Nevertheless, recent empirical evidence has inspired a new trend in hybrid modelling, claiming that skill is not always an either/or of automatic and intelligent control, but rather is sometimes a both/and. Sometimes experts are able to perform automatic actions in a way that can only be described as simultaneously intelligent. I call this trend the 'sophisticated hybrid model' and show why it is superior to its counterpart views in light of evidence concerning unconscious cognitive mechanisms of skilled action control. If intelligence is not necessarily thoughtful or intentional, then what is it and how can it operate in states of automaticity? In response to this question, I argue that when we take a closer look at the empirical evidence concerning the architecture of expert cognition, it is often the case that when experts proceed both automatically in what they do as well as engage in intelligently rich cognition, those intelligent

cognitive processes are able to occur *below the surface of conscious experience*. Following Dijksterhuis, Nordgren, & Strick's (2006, 2016) 'Unconscious Thinking Theory,' I suggest that unconscious cognitive processing is a locus of intelligent control in intelligently automatic action. Thus, as it turns out, through unconscious processing, experts are uniquely able to bring their intelligent and automatic capacities to bear in aid of one another to successfully perform their tasks. As will be discussed in this essay, this form of action control occurs when there is upstream and downstream communication between higher order intelligent action controls and their automatic counterparts through the tensile surface of consciousness.

II. Surveying the Debate

As popular belief would have it, when experts perform at their very best, they become perfectly absorbed in their activities. In this state of absorption, experts act with a form of concentrated mindlessness within which thought and ego take no part in decision making. What must happen does happen because the expert isn't overthinking it. To the contrary, as this view would have it - overthinking inspires 'The Yips' and encumbers the mind beyond the point of skilled ability. In this manner of speaking, to be an expert is to be a master of mindless absorption. As Eugen Herrigel says in *Zen and the Art of Archery*, the master archer simply allows "the bow to shoot itself." Likewise, Adam Ondra (the world's greatest climber) remarks that he "blacks out" during complicated series of maneuvers[1]. In a word, this 'anti-intellectualist' conception of expertise finds no place for conscious thought in peak performance. Athletes and experts of all sorts, on this account, do not think, they *just do it*.[2]

[1] See Ondra discussing his state of mind in his documentary on climbing "Silence," the most challenging route ever completed.

[2] Which is, of course, Nike's famous tagline – more evidence as to the popularity in common culture that anti-intellectual views of expertise enjoy. Additionally, as it happens, Nike's tagline is also the moniker that Montero (2016) gives to these views of expertise.

This 'just do it' (Montero, 2016) view of expertise is relatively common among researchers of skilled action control (Ratcliffe, 2007; Masters & Maxwell, 2008; Di Nucci, 2013; Brownstein, 2014; Bergamin, 2017). Perhaps the most influential of these is Hubert Dreyfus' notion of expert activity as 'absorbed coping.' What it means to Dreyfus to 'just do it' is that 'the mental' (believing, desiring, intending, etc.) is not present in expert performance – that experts can and often do perform expertly without actively reasoning about or conceptualizing the form of their actions (Dreyfus, 2005; 2007; 2013). Further, according to Dreyfus, the presence of 'the mental' in action is the enemy of optimal expert performance. "There is no place in the phenomenology of highly skilled action for conceptual mindedness" (Dreyfus, 2007 p. 361). And while Dreyfus does admit of an expert's *capacity* to step back and mindfully reflect on one's activity, he further claims that this reflection is a hindrance to optimal performance. "I grant that, when we are absorbed in everyday skillful coping, we have the *capacity* to step back and reflect but I think it should be obvious that we cannot exercise that capacity without disrupting our coping" (*ibid* p. 354). Or in other words, the more we think as we act, the less absorbed we can be in our actions.

In contrast, intellectualists argue that conscious control is not only a necessary condition for the development of expertise, but for the performance of an action at all (Ericsson, 1993, 2008, 2018; Yarrow, 2009; Stanley, 2013; Montero, 2016; Bermudez, 2017; Pavese, 2019). For instance, Stanley and Krakauer (S&K) (2013) discuss the case of a patient, 'HM,' who suffered from significant anterograde amnesia as a result of an invasive brain surgery to treat crippling epilepsy. Although HM could not remember anything longer than a few minutes, HM was still able to learn and improve upon a mirror-drawing task over the course of several days. This result was often thought to be evidence that propositional attitudes about action control were unnecessary to performance. However, S&K argue to the contrary. They point out that every morning HM

required instructions for performing the drawing task. Because so little instruction was required to direct the simple task, HM could follow. However, if HM were asked to perform a task that required more than just a few minutes of propositional learning, or a task that required the combination of several instructions (e.g., riding a bike), HM would have failed (Krakauer, 2019). Hence, in order to perform actions – and especially complex ones (like expert-actions) – propositional instructions are at least partly necessary to get the wheels turning. And further, continued practice in giving the *right* commands to appropriately guide actions makes those actions more efficient and skillful (Haith & Krakauer, 2018). In other words, intelligent and conscious control is essential to being skilled and to the development of expertise at all.

Even so, there are good reasons to think that both states of automaticity and intelligent control are essential to skilled performance. Sometimes actions and reactions must come more quickly than thought or decision-making can – as when a goalie must anticipate, dive, and block an incoming penalty kick, all in the blink of an eye. Similarly, executive, conscious deliberation is an essential feature of successful chess analysis (de Groot, 1978) – players ought to ensure whether intuited sequences, attacks, and defenses are sound or bust.[3] In order to make such a determination, they should think carefully, consciously, and deliberately through their options. Further still, if some forms of expert action require intelligent, thoughtful control and others require automatic and reactive control, perhaps expertise isn't so much about the mastery of one or the other kind of control but rather of the ability to utilize both.

[3] Montero (2016) provides some interesting experimental anecdotes in her book suggesting that even in speed chess where play is near completely automatic, chess masters still employ forms of intelligent, conscious control. The idea is that even in speed chess, where moves happen fast and by intuition, actions are still guided by some form of propositional knowledge. This is discussed further in Section V.

Those who argue for the foregoing kind of hybridized position forward what are called "Dual Process" models of action control. According to these dual process models, expertise is a matter of interplay and exchange between forms of action control. These models claim that actions fall into two distinct and opposite types. Type 1 controls are *fast, automatic, nonconscious, intuitive, and independent of cognitive ability.* On the other hand, Type 2 controls are *slow, controlled, conscious, rule based,* and *correlated with cognitive ability* (Stanovich, 1999, Kahneman, 2011; Evans & Stanovich, 2013; Papineau, 2013; Furley, 2015). Thus, skilled actions will be either Type 1 or Type 2 and often fluctuate between the types as is necessary for success. For example, a form of the dual process model – default interventionism – has it that experts default into Type 1 fluid automaticity until they are presented with a problem that requires Type 2, deliberate and conscious effort. As soon as the problem is resolved, they default back to Type 1. What makes an expert for the default interventionist and dual process theorists more generally is that experts are able to masterfully flex between the two types of action control as is required by the challenges they face in performing.

Hybridizing the lessons from anti-/intellectual views of expertise is a fruitful path forward in coming to better understand how actions are controlled throughout a skilled performance. Expertise and skilled action control involves *both* automatic and intelligent mechanisms, and it is up to the expert to make these forms of action control operate flexibly, fluidly, and well together. However, as I argue in section III, where hybrid models are committed to a diametric opposition of Type 1 and Type 2 action controls, they lose the narrative of a functional model of expert performance. Although expert performance is sometimes dominated by Type 1 and other times by Type 2 action controls, the boundaries between these forms of control can break down when experts act with *intelligent automaticity.*

III. The Sophisticated Hybrid Model

As demonstrated above, dual process views define the two types of action control in contrast to another. These mutually exclusive divisions between Type 1 and Type 2 are consistent with much of the research on expertise dating back to some of the very first major studies on the subject. Schiffrin & Schneider (S&S) (1977), for instance, defined action control along a spectrum with automaticity on one end and conscious control on the other. As they say, automatic actions are - "the activation of a series of nodes that nearly always becomes active in response to a particular input configuration and the sequence is activated automatically without the necessity of active control or attention by the subject." Hence, the more automatic an action is, the less an agent will employ active control and attention when performing it. Automatic actions, then, are understood to be mechanical, ballistic, and something like loaded springs waiting for the appropriate signal to be fired. Similarly, Fitts and Posner (1967) argue that the development of a skill is correlative with the overall automation of its activity. The less an expert must think about what they're doing, the more adeptly that they can automatically perform their tasks; likewise, the more skillful they should be (Anderson 1982; Tenison & Anderson 2016).

The diametric opposition of automaticity with conscious control, which dates back to F&P and S&S's original research, follows through the history of the debate. Anti-intellectualists locate expertise at the automaticity end of the spectrum and intellectualists at the opposite end in conscious control. Further, the advent of dual process theories helps to take a step away from this spectrum, but still remains tied to it. For a hybrid view, expertise is a matter of mastery of both ends of the automaticity-intelligent control spectrum. For this reason, however, dual process views are prone to an unsophisticated or dichotomized picture of cognition. In instances of skilled performance in which experts act automatically, and those automatic actions are simultaneously

sensitive to shifts of affordance and the expert's knowledge of how to do well, the division of Type 1 and Type 2 breaks down. Experts are also able to perform with a third type of action control called 'intelligent automaticity' (Fridland, 2015, 2017).

Fridland (2015), for instance, argues that some automatic processes "bear robust, systematic relationships to personal-level contents." There are, of course, automatic actions that are ballistic, reactive, and mechanistic – performed without intelligence. Likewise, there are purely intelligently controlled actions that are deliberate, thoughtful, and consciously represented – performed non-automatically. But there is also a third class of action that occurs automatically, but not as unintelligently as say digestion or mere physical reflex. As Mylopoulos (2020) says of these forms of action: "Motor mechanisms flexibly adapt to ongoing changes in the environment in a way that does not conform to a pattern of brute reflexes." In these forms of skilled action there is a sensitivity within automatic performance to an expert's ideals for how to perform well (Papineau, 2013; Riggle & Hopkins, 2021; Ivy, 2022), to their goals (Marien et. al., 2012), and to their skills which have been deliberately trained through time (Runswick et. al., 2018). Thus, what unifies the sophisticated hybrid views is the idea that some forms of expert action control can be both automatic *and* intelligent. Type 1 and Type 2 actions are not always so opposed to one another.

In order to better understand what the foregoing form of 'intelligently automatic' action control might look like in the environment of a skilled performance, research on anticipation in expertise makes an excellent example (Gray, 2018; Muller & Abernethy, 2012; Loffing & Hagemann, 2014; Murphy et al., 2016; Runswick et al., 2018). For instance, Runswick et. al. (2018) compared professional cricket batsmen to novices in a series of visual time-based occlusion conditions. The data show that even when there was as little as 80ms to react to a pitch, experts

still significantly outperformed the novice control. 80ms is nearly half the time it takes for the eyes to fixate once upon a target – far too fast to consciously represent and propositionally decide to adjust to the new information. And even in the throes of an already automatic action, without propositional representation of the 80ms of visual information, experts adjusted and outperformed novices. Significantly, the apparently automatic adjustments occurred in a way that was sensitive to the experts' intelligence, to what they know about how to swing well, and was able to do so by utilizing intelligent automaticity.

For the expert batters' swing, the Type 1 – Type 2 dichotomy fails to apply *because there is no break between the automatic and the intelligent*. The whole process of action-anticipation-adjustment is an automatic one, but even within that automaticity there are intelligent and expertise-sensitive adjustments affecting how the action is performed. Where intelligent skills and the qualities of expert performance operate both flexibly to environmental information and automatically at speed, traditional models of expertise that contrast automaticity and intelligent control are left confounded. To the contrary, a new form of sophisticated hybrid model – one that champions the addition of intelligently automatic action control in our understanding of expertise – fills in the gap left incomplete by the traditionally dichotomous models. Thus, what makes these new hybrid models *sophisticated* is that they reject the idea that intelligence and automaticity come at the mutual exclusion of one another in skilled action control (Fridland, 2015; Levy, 2017; Shepherd, 2017; Christensen, 2016, 2021; Mylopoulos, 2020; Pacherie & Mylopoulos, 2021; Ivy, 2022, *just to name a few*).

This is all to say that the dual process as well as anti-/intellectual models of expertise *do* fruitfully explain some ecologically valid forms of action control. However, as was the case of the cricket batsmen, neither a straightforward accounting of executively represented control, nor a

purely mechanistic automaticity is able to explain their behavior. Intelligent automaticity becomes a necessary addition to the researcher's explanatory toolkit. Thus, the *sophisticated* hybrid model of expertise is not so much a rejection of the foregoing views, but is rather their natural evolution inspired by the development of our contemporary empirical understanding of expert action control and cognition. Sometimes actions controls are directly intelligent and executive, sometimes they are straightforwardly automatic, and sometimes they are a blend of these forms of control in intelligent automaticity. Consequently, the contribution of sophisticated hybrid models to a novel understanding of expertise is highlighted by three tenants: (1) The intellectualists are right that skilled actions need intelligent control to operate well; (2) the anti-intellectualists are right that skilled actions sometimes occur too quickly to consciously represent action controls; yet, (3) those actions may nevertheless remain intelligent because the conscious or executive representation of an action control is not necessary for its corresponding action to operate *as if* it were intelligent. Thus, the sophisticated hybrid development upon dual process models is that there isn't always a clear switch from intelligent control to automatic control in skilled performances, but rather that the two forms of control can operate together in tandem.

What remains to be seen, however, is *how* intelligence is able to remain operative within states of automaticity that occur without the conscious representation of executive action controls. Thus, in what follows, I argue that unconscious cognitive processes can operate as a form of intelligent control without executive or conscious representation. I argue that there is good reason to think that much of what intelligently influences skilled action is never consciously represented, but still has strong empirical corelates for measuring and understanding an expert's intelligence in action control. This is not meant to replace or supersede alternative conceptions of intelligent

automaticity, but rather to be its own independent understanding of the peculiar form of skilled action control associated with sophisticated hybrid models of expertise.

IV. Unconscious Cognition and Intelligent Control

Over a decade ago, Dijksterhuis & Nordgren (2006) forwarded a view of unconscious cognitive processing which they named *Unconscious-Thought Theory*. According to this theory, cognitive processing can be divided between two sorts – the sort upon which our attention is typically directed (conscious thought) and the sort upon which our attention is not typically directed (unconscious thought). Now, it is worth noting that this definition is due an update. Attention and consciousness can come apart and what is attended to may not always be attended to *consciously* (Jiang et al. 2006).[4] Moreover, from a neurological perspective, consciousness can even be wedged apart from working memory. Lamme (2006, 2010) has compellingly forwarded an interpretation of "consciousness" that is inclusive of perceptual phenomena that are not encoded by working memory, but do have neurological correlates. In cases of fine-grained perceptual phemomena, blindsight, inattentional blindness, and the like - Lamme demonstrates that although we cannot report on or cognize over certain perceptual qualia, those qualia often still have measurable neurological and phenomenal properties. The result of Lamme's demonstration is a call for clarification between types of consciousness akin to Ned Block's (1995) distinction between "phenomenal (P)" and "access (A)" consciousness. According to Block, whereas P-consciousness amounts to mere experience, A-consciousness "…is represented by a perceptual state, is processed via that information-processing function, [and] its content gets to the Executive

[4]Attention and consciousness can come apart, as was demonstrated in the famous Jiang et al. (2006) study in which participants were shown a nude image too fast to be aware of having consciously seen, but whose attention was nevertheless significantly affected by the images. Although this study is a challenge to the simple distinction presented by Dijksterhuis & Nordgren regarding the relationship between attention and consciousness, it does remain in support of the theory generally. Attention isn't the determiner of conscious thought, but rather can shift into a process of unconscious thinking which affects otherwise conscious processes.

System, whereby it can be used to control reasoning and behavior" (*ibid*, p. 229). Importantly, although P-consciousness involves experience, it is "distinct from any cognitive, intentional, or functional properties" (*ibid,* p. 230) and is thus unavailable to the Executive System. This distinction is what I have in mind for offering a re-rendering of Dijksterhuis & Nordgren's original formulation of conscious and unconscious cognition. What amounts to consciousness is A-consciousness *vis a vis* accessibility to the Executive System of cognition and control, and what is not accessible by the Executive System (what may be P-conscious or otherwise) is unconscious.[5] Thus, an updated interpretation of Dijksterhuis & Nordgren's findings is that they demonstrate how intelligent control can proceed in the absence of A-consciousness.

Accordingly, the researchers showed that unconscious thought (UT) had a significant effect on decision making generally (Wilson & Schooler, 1991; Dijksterhuis & Meurs, 2006), but they also boldly claimed that UT was superior to conscious deliberation in solving complex problems. This second claim remains controversial. Many studies have successfully replicated the superior effects of unconscious processing on complex cognitive decision making, and many others have been unable to replicate those effects (*see* Dijksterhuis & Strick, 2016 *for a review of these findings)*. The jury is still out on whether UT is superior to conscious thought in *all* instances of complex problem solving, but it is well-established that there is a positive effect from the unconscious on cognition generally (Strick et. al., 2011).

[5] It is hopefully uncontroversial enough to locate unconscious cognitive processes outside of the domain of A-conscious states. However, it is an interesting and important issue whether the 'unconscious' mechanisms and cognitive functions described by the researchers cited here (and later on demonstrated in section V) should be characterized as P-conscious or as something else. In other words, are the relevant 'intelligently automatic action controls' sufficiently described as P-conscious states analogous to Lamme's perceptual categories, or are they a form of cognitive process that lacks the appropriate phenomenal content to be called 'conscious' even of the P-variety? For the sake of this essay, I shall remain neutral to this question and count it as an interesting avenue for future research.

Nevertheless, if there is an effect of UT on cognition, is it right to call it *intelligent* in the sort of way that would be required of skilled action on a sophisticated hybrid model? It would seem so given the foregoing evidence, but this question is also controversial – it largely depends on the scope of 'intelligence' as an explanandum. If intelligence is to be equated with conscious intentionality, then of course unconscious processing could would not fit that definition. However, this intuition misses out on the great practical value of intelligently automatic action control as an empirical concept – even action controls that don't represent propositionally (because they are automatic) *can count* as intelligent when skillfully performed – as in Runswick's cricket example. With respect to intelligent automaticity then, the important features of skillful control that typically indicate intelligence on sophisticated hybrid models include (1) an acute sensitivity to environment, (2) a capacity to shift automatic behavior to match broader intentional goals, and (3) active reflection through fast decision making.[6] Unconscious Thinking Theory and its supporting empirical research program substantiates each of these conditions, giving reason to think that its effects should count as intelligent, though unconscious.

For instance, UT has been shown to affect perceptual and attentional judgment based on existential details like sexual orientation (Jiang et. al., 2006), as well as creativity in unconscious incubation (Sio & Omerod, 2009; Stokes, 2011; Gilhooly, 2016; Ivy, 2022), and even improves lie detection (Reinhard et. al. 2013). Moreover, UT has been shown to have an effect on executive function by recruiting attentional resources below the surface of consciousness. Marien et al. (2012) found that by priming unconscious goals in study subjects, those subjects would do worse when asked to perform an executive control task outside the scope of the goals. The researchers

[6] I do not mean to set the foregoing conditions up as *sufficient* for intelligence in action control, but rather as strong empirical correlates. Any sort of cognitive process (including unconscious ones) that satisfies those three conditions is very probably also one closely related to the performing agent's intelligence, broadly construed. UTT understands unconscious cognitive processes as functional in these ways.

concluded that UT was appropriating attentional resources for its own goals which had a negative effect on simultaneous conscious tasks. What each of these foregoing findings share is an inclusion of higher order, personal level information (intelligence) in the processing of unconscious cognitive cues. Hence, the processing that occurs through the modality of UT from the background of a person's mind relies upon that person's intelligence and executive control.

According to Dijksterhuis & Strick (2016), the important lessons from Unconscious Thinking Theory and the research that has been done since its inception are that:

> (1) "UT organizes (i.e., clusters, polarizes), weights, and extracts gist from decision information" (Bos et. al., 2011; Usher et. al., 2011; Li et. al., 2014);
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> (2) "UT operates on holistic representations of the options rather than on recollection of individual attributes" (Marien et. al., 2012; Abadie et. al., 2015); and
>
> (3) "UT seems to work best on high-quality information in complex judgment situations with high ecological validity" (Ham & Van den Bos, 2011; Bargh, 2011; Gao Zhang Wang & Ba, 2012).

Each of these features of UT gives reason to think that cognitive processes that are unavailable to the Executive System are intimately related to intelligent processes of mind and cognition: UT affects associative judgments, decision making, attention, and is sensitive to existentially qualitative features of perceptual information. Furthermore, each are features of cognition that become accented in the development of expertise. Experts rely on associative cognition to form holistic judgments in visual search as well as in motor-mechanical practices. 'Action gist' in decision making is an essential feature of intelligently automatic control according to Christensen's *mesh* model (2016). And finally, UT has the greatest effect on improving decision making when the information afforded to it is of high quality and of greater ecological validity – for which an expert's perceptual capacities are especially trained to afford.

In the final section of this essay, I survey a series of empirical data showing that the environment of expertise overlaps with the ideal environment within which UT may have a

positive effect on problem solving. The purpose of this analysis is to show that in modes of skillful performance wherein experts utilize intelligently automatic action controls, UT is an operative force at play in decision making; and moreover, that experts are likely to benefit from the positive powers of UT within the ecosystem of their skill.

V. The Role of Unconscious Thinking in Expertise

Up to this point I have forwarded two arguments. The first of these is that what I have called *sophisticated hybrid models* of expertise are superior to their counterparts which dichotomize automatic and intelligent control in all forms of skilled action. The reason for this is that these models of expertise make sense of action control as simultaneously intelligent *and* automatic – a mode of control which appears to be present in much of the empirical research done on experts. The great benefit that sophisticated hybrid models have over their counterparts is a reimagining of intelligence and automaticity such that they are not mutually exclusive with one another. Rather, according to these models, experts are masters of *intelligently automatic* action control wherein both intelligence and automaticity harmonically function together within the fluid production of skilled behavior.

The invocation of 'intelligence' as operative within the automatic environment of skilled behavior presents us with a puzzle: it appears that automatic actions are often intelligent via their outward expression, but what are we to make of the internal representation of the intelligence under the surface of these forms of action? What are the cognitive underpinnings of intelligent control in automatic skilled behavior? As one (of perhaps many possible) answer(s) to this question, I have forwarded the beginnings of a second argument. I have suggested that unconscious cognitive processing intelligently operates within the background of an expert's automatic performance, affecting that performance despite being unavailable to the Executive System. Consequently, the

'intelligence' in intelligently automatic action control may not ever need to be consciously represented at all – it is able to do its work from the obscured, unconscious shadows of an expert's mind. And further, as I shall develop in greater detail below, the ecology of expertise affords the ideal environment within which unconscious cognitive processing is able to offer its greatest benefit to skilled action and problem solving. Using research concerning the linguistic, cognitive and perceptual strategies of experts, I show that each of the foregoing three 'lessons' from Dijksterhuis & Strick's (2016) Unconscious Thinking Theory are also features of expertise; and, in the presence of one another, enable experts to thrive with intelligent automaticity.

i. The Cognitive Structure of Expertise

(1) "Unconscious Thinking organizes (i.e., clusters, polarizes), weights, and extracts gist from decision information"

Studies in the cognitive structures of expertise offer some insight into the unconscious, intelligent processing of experts in the flow of their action. One significant cognitive difference between experts and novices is a form of short-term memory association called 'memory chunking.' The memory chunking theory holds that experts have superior pattern recognition within a domain of expertise than do novices. Simon and Chase's famous study (1973) followed up on de Groot's findings that chess masters are able to remember board positions with a much higher degree of accuracy than novices. However, when the positions of chess pieces were placed randomly on the board – in sequences that do not represent how actual games turn out – the master's ability to recollect was on par with that of the novice.

The participants of Simon and Chase's study were recorded during their recollection-task and shown to spend a longer time reconstructing clusters of pieces than individual pieces within each cluster. Simon and Chase called these clusters of pieces 'chunks' and attributed the masters'

superior capacity for sorting objects within chunks to their likewise superior ability to recognize patterns in board positions. Furthermore, Simon and Chase concluded from their study that chess master's superior ability to *play* chess (rather than simply reconstruct positions) had to do with an associative power to infer ideal chess moves from associated 'chunks,' or perceptions of commonly clustered pieces. In other words, chess masters have internalized, unconscious heuristics for piece-movement based on pattern recognition of clusters of pieces on the board. Should a cluster visually associate with a pattern of success for a particular move, then the master is likely to automatically select that move in virtue of their associative intuition.

However, there have been objections raised against the sufficiency of the perceptual chunking theory to fully explain expert behavior that have led to the theory's amendment. For instance, one objection is that if pattern recognition is the seminal virtue of expertise, then "skilled players should suffer the least from the ageing process, as they will rely more on pattern recognition and less on search relative to less-skilled players" (Chabriss, 1999). Further, there is an objection to the memory chunking theory whereby the relation between chunks and decisions are disjoined from one another.

> Small chunks do not appear to have enough independent functional significance to be linked directly to specific moves. In particular, by making a database of visual patterns the exclusive locus of skill differences, the standard theory starkly omits any role for higher-level conceptual thinking. (Chabriss, 1999)

The problem noted here is that experts are precluded from thinking conceptually in general terms about the games they play when they rely only on the intuitive pattern recognition of memory chunks. This is because the patterned chunks that are stored in long term memory are *automatically* activated by visual processes. If a memory chunking theory were sufficient to explain how chess players decide to make their moves, then the associative visual strategy would *just happen* automatically leading to the choice of an ideal move What is missing in the chunking theory,

therefore, is room for the 'human chess cognition' that plays an essential role in the development of tactical play and choice – perhaps what de Groot would have called the 'second stage' of deliberation. In other words, not only visual association but also holistic and general forms of conceptual thought are essential to chess player's success (Chabriss 1999; Gobet 2012; Montero & Evans 2011).

Whereas the original perceptual chunking theory limited the master's decision for how to move to an automatic process of visual association, Chabriss (1999) emphasizes the importance of 'general thinking' in expert decision making. His theory amends perceptual chunking by incorporating holistic cognitive judgments in the causal space between associative pattern recognition and decision making. Heuristics for expert decision making, in other words, are the result of an automatic visual association *in addition to* a deliberate inference from the intuited pattern to a cognitively chunked representation. Hence, perceptual chunks are importantly general and a person's capacity for expertise is proportional not only to their ability to automatically recognize the associative patterns in their domain of activity, but also to cognitively generalize from that automatic association to an ideal choice. Importantly for UT, it is the first associative chunk from which the relevant information and gist is extracted for conscious thought and decision making

(2) "UT operates on holistic representations of the options rather than on recollection of individual attributes"

The virtue of an expert's general analysis on this hypothesis is that expert forms of cognition remain holistic and associative – the thoughts which surface up and into the conscious experience of an expert's mind are represented in broad strokes rather than in particulars. This enables experts to allow their associative intuitions to run (successfully) wild in unconscious

thought. Then, after a period of incubation (Dijskterhuis & Meurs, 2006), the expert cognition consciously represents the resultant objects of intuition in several possible patterns for problem solution. In short, the expert (in this case, a chess master) selects the ideal course of action in virtue of their intelligent and holistic cognizing over the intuitive possibilities that automatically pop-out to them, but have been pre-processed by unconscious cognitive processes (like incubation); and it is because experts do so with reliable success that they are masters as such.

The general cognitive analysis of experts is not only dependent on holistic pattern recognition, but also on the expert's ability to anticipate future outcomes to a degree greater than the novice. Chess masters and, indeed, experts across domains have been studied to *analyze deeper* than their novice counterparts. A study run by Charness (1981) showed that chess masters searched for moves on average 45% more extensively and deeper than novices when considering potential outcomes. Similarly, a study done on expert snooker players (Abernathy, 1994) attributed, in part, the superior capacity for play to experts' deeper analysis of future moves. Whereas novice snooker players think on average four moves ahead, the expert snooker player, in contrast, considers anywhere from seven to ten moves ahead. So, cognitively speaking, we see from these studies that experts think farther ahead *in anticipation* than do novice counterparts.

In the foregoing set of studies concerning the cognitive structure of experts, there is again evidence for the effects of unconscious thinking on the processes of intelligently automatic action control. When experts cognize over the domain of their activities, they do so with holistic incubation and anticipation, loading the spring for automatic performances sensitive to those anticipatory controls. But this does not mean that experts cognize or anticipate with any less precision or depth; rather, the second set of studies indicate that experts anticipate to superior degree and in deeper detail than novices. Hence the expert intuition flows automatically by

recognizing general patterns derived by unconscious thinking, and the expert cognition engaged in holistic judgment operationalizes these intuitive pop-outs as possible future developments of their decision space.

ii. The Perceptual Powers of Expertise

(3) "Unconscious Thinking seems to work best on high-quality information in complex judgment situations with high ecological validity"

Thus far I have surveyed two sets of evidence showing how the interplay of automatic and intelligent action controls in skilled action are consistent with the operations of unconscious thinking developed by Unconscious Thinking Theory. This, however, is not the full story of the virtues of unconscious cognitive processing within expert performance. Unconscious thinking has its most beneficial effect on problem solving when the information afforded to it is of high quality – exactly the sort of perceptual information that the visual systems of experts collects. By understanding the way in which the expert eye sees as it does, we gain insight into the harmonic function of intelligent and automatic action controls influenced by unconscious processing. Consequently, what the following studies I present show is that visual experts see the 'phenomenological field' of their domain as a general whole while simultaneously analyzing the objects in that domain as relevant parts constitutive of that greater whole. This is evidence for a *perceptual* power employed by experts in which automatic processing and intelligent cognitive work operate together to produce superior forms of expertise.

It is a well-documented phenomenon that radiologists perceive x-rays differently from novices as evidenced by both eye tracking and visual reports. The model of perceptual expertise in radiology has been described as a 'holistic visual processing model,' corresponding to the distinct forms of perception that expert radiologists exhibit (for reviews, see Sheridan & Reingold,

2017; Waite et. al., 2019). The holistic visual processing model defines expert perception as the co-occurrence of two distinct perceptual forms. First, experts engage in a global search task, constructing a phenomenologically *whole* image of their target. Second, experts engage in a focal feature analysis of the holistic perception, selecting out the relevant targets for fixation and action (Drew, 2013; Kundel, 2007; Nodine & Mello-Thoms, 2000; Ivy et. al., 2021).

In eye tracking studies Kundel (2007) showed that expert radiologists exhibit the two foregoing perceptual skills:

> The holistic mode… depends on an initial global analysis of the retinal image that leads to the identification of image perturbations that are consistent with abnormality – basically, distinguishing between normal and abnormal. The gaze is then directed to the perturbations, and focal feature analysis either incorporates the perturbation into the perception of the image or disregards it. (*ibid*, p. 397)

The radiologist's first perceptual act is a "global-focal" search wherein a holistic perception of an image is analyzed. Then, from the holistic perspective, radiologists engage in a second visual task to seek out aberrant objects within the image. Consequently, radiologists, by virtue of their dual-focal searches, are more accurate in finding their targets and significantly faster than novices (Drew, 2013).[7] Hence, expertise in radiology is, in part, understood in terms of the unique attentional forms of perception that enable them to be so successful and efficient in their domain.

Additionally, radiologists in eye tracking studies use less eye movement than novices overall and tend to focus their gaze in areas more likely to contain cancer and like 'perturbations' (Drew, 2013; Waite et. al., 2019). This is likely due to radiologists' expert knowledge as concerns the probable locations of perturbations. Yet, given the speed with which radiologists engage in image searches, it is unlikely that there is time for a conscious cognitive control to intervene in the

[7] Not all cases of success in expert visual object search require the second search for particular targets. Often enough expert radiologists just see their target immediately. However, when they do not, the dual-pattern is exhibited.

process of the global-level visual search. In fact, expert radiologists often report "knowing" that something is wrong in an x-ray even before they visually fixate on the target (Drew, 2013). Presumably, through unconscious intelligent control expert radiologists have trained themselves to globally scan the most relevant areas of an x-ray so well that the original propositional heuristics for a global search operate automatically. Accordingly, these findings are evidence for a non-conscious perceptual strategy that occurs automatically.

However, it is important to keep in mind that the automatic global search is not a radiologist's only perceptual tool for success. The global search is accompanied by a deliberate visual search that guides the radiologist to perceptually analyze the perturbations present in x-rays. And it is argued that this latter search form occurs *simultaneously* with the global one.

> Global retinal analysis and focal feature analysis are simultaneously active during the fixations; the global analysis maintains the stability of the perception and discovers new perturbations that require analysis, while the focal feature analysis resolves the perturbations. (Kundel, 2007, p. 397)

In addition to being *simultaneous*, it has also been argued that the 'focal feature analysis' and 'global retinal analysis' are *recursive* upon one another. With a global image in place, radiologists proceed to focally select targets, analyzing each as a possible object of relevance (cancer, etc.); then:

> The outcome of each test is either a positive or negative fit to the abnormality being tested. In either case, the testing is recursive. If a positive fit is found, the object is scrutinized by multiple eye fixations resulting in a buildup of visual dwell in the region of interest. If a negative fit is found, attention shifts back to the medical image for a new global impression [and the cycle continues]. (Nodine & Mello-Thoms, 2000)

Hence, a radiologist's automatic, global visual processing and their deliberative focal analysis are distinct processes that inform one another, occur simultaneously, and each enables the success of the other recursively.

What we stand to learn from these studies in the perceptual powers of experts is that automatic global imaging and intelligently guided target searches happen in tandem with one another (whether simultaneously or merely in close conjunction). Experts cope with the visual affordances of their domain through an automatic and global search, thereby enabling speed and accuracy in searches. Likewise, experts focally search by employing deliberate focal control enabling them to specifically conclude that a particular perturbation is, in fact, a positive result of their search. Expert radiologists, therefore rely on both unconsciously automatic and consciously deliberate controls in their expert performance. Significantly, these processes represent themselves as attentionally and structurally distinct, but do not get in the way of one another. To the contrary, what is consciously controlled informs what occurs automatically and unconsciously (and vice versa). Insofar as the expert is able to bring to bear their intelligent judgments in their automatic interactions with the affordances from their *visual* domain of expertise, they can be said to be performing with *intelligent automaticity*.

VI. Concluding Remarks

We are now finally in a position to answer the question posed at the heart of this paper. That is: Do cognitive processes that remain unavailable to the Executive System play an influential role in the production of intelligently automatic action? As I've shown above, the answer is, in a word – yes. Expertise is a complicated phenomenon that does not admit of clear boundaries between the intelligent and automatic controls in expert performance. There are many cases in which intelligent control, just as well as automaticity, is necessary to the successful mastery of an expert's domain. Accordingly, new sophisticated hybrid views do away with the idea that automaticity and intelligence are mutually exclusive in skill.

Given the foregoing insight, the sophisticated hybrid models of expertise are an evolution of their traditional dual process and anti-/intellectual counterpart views. Of course, some forms of skilled action control will be intelligent and executive, others will be ballistic and automatic, but as I have argued here, there is also reason to think that in the gray area between these forms of control, there is the likelihood of an intelligent automaticity undergirded by the unconscious mechanisms of cognition associated with UTT. Further, the conditions under which unconscious cognitive processing has been shown to have its greatest effect on problem solving are also conditions idealized in the developed ecology of expertise. Thus, one form of intelligently automatic control can be understood in terms of the effect of the unconscious on automatic activity.

In the spirit of the complexity of expertise generally, there are likely as many ways of modelling 'intelligently automatic' control as there are models of expertise. Thus, for all of the conceptual and empirical power of 'intelligent automaticity,' measuring the interplay of skillful habit and intelligence within controlled lab conditions is much like trying to catch lightning in a bottle. Consequently, making sense of expert action control from this 'sophisticated hybrid' perspective presents a problem in empirical measurement. The direction forward should not be to take on the problem all at once, but rather piece by piece. Unconscious cognition is one such piece that, through the lens of the cognitive science of expertise and skill, is likely to inspire a richer conception of intelligent automaticity. For example, it would be quite insightful to run iterations of the many classic studies done within the Unconscious Thinking Theory paradigm on experts. To date, there has been some research paring expertise and unconsciousness in creativity, but focusing entirely on the unconscious cognitive processing of experts would go a long way toward acquiring a greater understanding of both skill and unconscious cognition. Thus, the role of

unconscious thinking in skill is a step in the right direction towards a more complete understanding of expert action performed at its very best.

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References

Abadie, M., Waroquier, L., & Terrier, P. (2015). Information presentation format moderates the unconscious-thought effect: The role of recollection. *Memory*, **6**, pp. 1–11. https://doi.org/10.1080/09658211.2015.1070179

Abernethy, Bruce, et al. (1994). Visual–Perceptual and Cognitive Differences between Expert, Intermediate, and Novice Snooker Players. *Applied Cognitive Psychology*, **8**(3), pp. 185–211. https://doi.org/10.1002/acp.2350080302

Anderson, J. R. (1982). Acquisition of cognitive skill. *Psychological Review,* **89**(4), pp. 369–406. https://doi.org/10.1037/0033-295X.89.4.369

Bargh, J. A. (2011). Unconscious thought theory and its discontents: A critique of the critiques. *Social Cognition,* **29**(6), pp. 629–647. https://doi.org/10.1521/soco.2011.29.6.629

Bergamin, J.A. (2017). Being-in-the-flow: expert coping as beyond both thought and automaticity. *Phenom Cogn Sci* **16,** pp. 403–424. https://doi.org/10.1007/s11097-016-9463-1

Bermúdez, J. P. (2017). Do we reflect while performing skillful actions? Automaticity, control, and the perils of distraction. *Philosophical Psychology,* **30**(7), pp. 896–924. https://doi.org/10.1080/09515089.2017.1325457

Block, Ned. (1995). "On a Confusion about a Function of Consciousness." *Behavioral and Brain Sciences*, **18**,(2), pp. 227–247., https://doi.org/10.1017/s0140525x00038188.

Bos, M. W., Dijksterhuis, A., & Van Baaren, R. B. (2011). The benefits of "sleeping on things": Unconscious thought leads to automatic weighting. *Journal of Consumer Psychology*, **21**, pp. 4–8. https://doi.org/10.1016/j.jcps.2010.09.002

Brownstein, M. (2014) Rationalizing flow: agency in skilled unreflective action. *Philos Stud* **168**, pp. 545–568. https://doi.org/10.1007/s11098-013-0143-5

Chabris, Christopher Fitzgerald. (1999). *Cognitive and Neuropsychological Mechanisms of Expertise: Studies with Chess Masters*. Harvard University. pp. 1–131.

Charness, Neil. (1981). Search in Chess: Age and Skill Differences. *Journal of Experimental Psychology: Human Perception and Performance*. **7**(2), pp. 467–476. https://doi.org/10.1037/0096-1523.7.2.467

Christensen, Wayne & Sutton, John & McIlwain, Doris. (2016). Cognition in Skilled Action: Meshed Control and the Varieties of Skill Experience. *Mind & Language*. **31**. pp. 37-66.

Christensen, W. (2021). The Skill of Translating Thought into Action: Framing the Problem. *Rev. Phil. Psych.***12**, pp.547-573. https://doi.org/10.1111/mila.12094

De Groot, Adriaan. (1978). *Thought and Choice in Chess*. Mouton Publishers.

Di Nucci, Ezio. (2013). *Mindlessness*. Newcastle, UK: Cambridge Scholars Publishing.

Dijksterhuis, A., & Meurs, T. (2006). Where creativity resides: The generative power of unconscious thought. *Consciousness and Cognition: An International Journal*, **15**(1), pp. 135–146. https://doi.org/10.1016/j.concog.2005.04.007

Dijksterhuis, A., & Nordgren, L. F. (2006). A theory of unconscious thought. *Perspectives on Psychological Science*, **1**, pp. 95–109. https://doi.org/10.1111/j.1745-6916.2006.00007.x

Dijksterhuis, A., & Strick, M. (2016). A case for thinking without consciousness. *Perspectives on Psychological Science*, **11**(1), pp. 117–132. https://doi.org/10.1177/174569161561531

Drew, Trafton, et al. (2013). "Informatics in Radiology: What Can You See in a Single Glance and How Might This Guide Visual Search in Medical Images?" *RadioGraphics*, **33**(1), pp. 263–274. https://doi.org/10.1148/rg.331125023

Dreyfus, Hubert. (2005). "Overcoming the Myth of the Mental: How Philosophers Can Profit from the Phenomenology of Everyday Expertise." *APA: The American Philosophical Association*, **79**(2), pp. 47–65.

Dreyfus, Hubert. (2013) "The Myth of the Pervasiveness of the Mental." *Mind, Reason, and Being-in-the-World: the McDowell-Dreyfus Debate*, by Joseph K. Schear, Routledge, pp. 15–40.

Dreyfus, Hubert. (2007). The Return of the Myth of the Mental. *Inquiry*, **50**(4), pp. 352–365. https://doi.org/10.1080/00201740701489245

Ericsson, K. Anders, et al. (1993). The Role of Deliberate Practice in the Acquisition of Expert Performance. *Psychological Review*, **100**(3), pp. 363–406. https://doi.org/10.1037/0033-295X.100.3.363

Ericsson, K. Anders. (2008). Deliberate Practice and Acquisition of Expert Performance: A General Overview. *Academic Emergency Medicine*, **15**(11), pp. 988–994. https://doi.org/10.1111/j.1553-2712.2008.00227.x

Ericsson, K. Anders, (2018). "The Differential Influence of Experience, Practice, and Deliberate Practice on the Development of Superior Individual Performance of Experts." *The*

Cambridge Handbook of Expertise and Expert Performance, by Anders Ericsson, Cambridge University Press.

Evans JSBT, Stanovich KE. (2013). Dual-Process Theories of Higher Cognition: Advancing the Debate. *Perspectives on Psychological Science*. **8**(3), pp. 223-241. https://doi.org/10.1177/1745691612460685

Fitts PM, Posner MI. (1967). *Human Performance.* Brooks/Cole Pub. Co; Belmont, CA.

Fridland, E. (2015). Automatically minded. *Synthese*. **194,** pp. 4337–4363. https://doi.org/10.1007/s11229-014-0617-9

Fridland, E. (2017). Skill and motor control: Intelligence all the way down. *Philosophical Studies*, **174(**6), pp. 1539–1560. https://doi.org/10.1007/s11098-016-0771-7

Furley, P. et al. (2015). The two modes of an athlete: dual-process theories in the field of sport. *International Review of Sport and Exercise Psychology* **8**, pp. 106 - 124. https://doi.org/10.1080/1750984X.2015.1022203

Gao, J., Zhang, C., Wang, K., & Ba, S. (2012). Understanding online purchase decision making: The effects of unconscious thought, information quality, and information quantity. *Decision Support Systems*, **53**, pp. 772–781. https://doi.org/10.1016/j.dss.2012.05.011

Gilhooly, K. J. (2016). Incubation and intuition in creative problem solving. *Frontiers in Psychology*, **7**, Article 1076. https://doi.org/10.3389/fpsyg.2016.01076

Gobet, Fernand. (2012). Concepts without Intuition Lose the Game: Commentary on Montero and Evans (2011). *Phenomenology and the Cognitive Sciences*, **11**(2), pp. 237–250. https://doi.org/10.1007/s11097-011-9246-7

Gray, R. (2018). Comparing cueing and constraints interventions for increasing launch angle in baseball batting. *Sport, Exercise, and Performance Psychology,* **7**(3), pp. 318–332. https://doi.org/10.1037/spy0000131

Ham, J., & Van den Bos, K. (2011). On unconscious and conscious thought and the accuracy of implicit and explicit judgments. *Social Cognition,* **29,** pp. 648–667. https://doi.org/10.1521/soco.2011.29.6.648

Haith, A.M., and J.W. Krakauer. (2018). The multiple effects of practice: Skill, habit and reduced cognitive load. *Current Opinion in Behavioral Sciences* **20**. pp. 196–201. https://doi.org/10.1016/j.cobeha.2018.01.015

Herrigel, Eugen. (1953). *Zen in the Art of Archery*. Vintage Books.

Ivy, S., Rohovit, T., Lavelle, M. *et al.* (2021). Through the eyes of the expert: Evaluating holistic processing in architects through gaze-contingent viewing. *Psychon Bull Rev* **28**, pp. 870–878. https://doi.org/10.3758/s13423-020-01858-w

Ivy, S. The role of creativity in expertise and skilled action. *Synthese* **200**, 456 (2022). https://doi.org/10.1007/s11229-022-03822-8

Jiang, Y., Costello, P., Fang F., Huang M. He, S. (2006). A gender- and sexual orientation – dependent spatial attentional effect of visual images. *PNAS.* **103**(45), pp. 17048-17052. https://doi.org/10.1073/pnas.0605678103

Kahneman, D. (2011). *Thinking, fast and slow.* Farrar, Straus and Giroux.

Krakauer, J.W. (2019). The intelligent reflex. *Philosophical Psychology* **32** (5), pp. 822–830. https://doi.org/10.1080/09515089.2019.1607281

Kundel, Harold L., et al. (2007). Holistic Component of Image Perception in Mammogram Interpretation: Gaze-Tracking Study. *Radiology*, **242**(2), pp. 396–402. https://doi.org/10.1148/radiol.2422051997

Lamme, Victor A.F. (2006). "Towards a True Neural Stance on Consciousness." *Trends in Cognitive Sciences*, **10**(11), pp. 494–501., https://doi.org/10.1016/j.tics.2006.09.001.

Lamme, Victor A.F. (2010) "How Consciousness Will Change Our View on Neuroscience." *Cognitive Neuroscience*, **1**(3), pp. 224–225., https://doi.org/10.1080/17588928.2010.497585.

Levy, N. (2017). Embodied savoir-faire: Knowledge-how requires motor representations. *Synthese* **194** (2), pp. 511–530. https://doi.org/10.1007/s11229-015-0956-1

Li, J., Gao, Q., Zhou, J., Li, X., Zhang, M., & Shen, M. (2014). Bias or equality: Unconscious thought equally integrates temporally scattered information. *Consciousness and Cognition*, **25**, pp. 77–87. https://doi.org/10.1016/j.concog.2014.01.012

Loffing, F., & Hagemann, N. (2014). Skill differences in visual anticipation of type of throw in team-handball penalties. *Psychology of Sport and Exercise*, **15**(3), pp. 260–267. https://doi.org/10.1016/j.psychsport.2014.01.006

Marien, H., Custers, R., Hassin, R. R., & Aarts, H. (2012). Unconscious goal activation and the hijacking of the executive function. *Journal of Personality and Social Psychology*, **103**, pp. 399–415. https://doi.org/10.1037/a0028955

Masters & Maxwell (2008). The theory of reinvestment. *International Review of Sport and Exercise Psychology*. **1**(2). pp. 160-183. https://doi.org/10.1080/17509840802287218

Montero, Barbara, and C. D. A. Evans. (2011). Intuitions without Concepts Lose the Game: Mindedness in the Art of Chess. *Phenomenology and the Cognitive Sciences*, **10**(2), pp. 175–194. https://doi.org/10.1007/s11097-010-9192-9

Montero, Barbara. (2016). *Thought in Action: Expertise and the Conscious Mind*. Oxford University Press.

Muller, Sean & Abernethy, Bruce. (2012). Expert Anticipatory Skill in Striking Sports: A Review and a Model. *Research quarterly for exercise and sport*. **83**, pp. 175-87. https://doi.org/10.1080/02701367.2012.10599848

Murphy, Colm P., et al. (2016). Contextual Information and Perceptual-Cognitive Expertise in a Dynamic, Temporally-Constrained Task. *Journal of Experimental Psychology: Applied*, **22**(4), pp. 455–470. https://doi.org/10.1037/xap0000094

Mylopoulos, Myrto (2020). The Intelligence of Motor Control. *The Routledge Handbook of Philosophy of Skill And Expertise*, Routledge. pp. 258–268.

Nodine, Calvin, and Claudia Mello-Thoms. (2000). The Nature of Expertise in Radiology. *Handbook of Medical Imaging*, edited by Richard Van Metter et al., vol 1, SPIE Press, pp. 859–894. Physics and Psychophysics.

Pacherie, E., Mylopoulos, M. (2021). Beyond Automaticity: The Psychological Complexity of Skill. *Topoi* **40,** pp. 649–662. https://doi.org/10.1007/s11245-020-09715-0

Papineau, D. (2013). In the zone. *Royal Institute of Philosophy Supplement,* **73**, pp. 175–196. https://doi.org/10.1017/S1358246113000325

Pavese, C. (2019). The psychological reality of practical representation. *Philosophical Psychology,* **32(**5), pp. 785–822. https://doi.org/10.1080/09515089.2019.1612214

Ratcliffe, M. (2007). *Rethinking commonsense psychology: A critique of folk psychology, theory of mind and simulation.* Palgrave Macmillan.

Reinhard, M.-A., Greifeneder, R., & Scharmach, M. (2013). Unconscious processes improve lie detection. *Journal of Personality and Social Psychology*, **105**, pp. 721–739. https://doi.org/10.1037/a0034352

Riggle, Nick & Hopkins, Robert (2021). Artistic Style as the Expression of Ideals. *Philosophers' Imprint* **21** (8), pp. 1-18. http://hdl.handle.net/2027/spo.3521354.0021.008

Runswick, A. Roca, A.P. McRobert, A.M. Williams, J.S. North. (2018). The temporal integration of information during anticipation. *Psychology of Sport and Exercise*, **37**, pp. 100-108. https://doi.org/10.1016/j.psychsport.2018.05.001

Shepherd, J. (2021) Intelligent action guidance and the use of mixed representational formats. *Synthese.* **198 (**Suppl 17), pp. 4143–4162. https://doi.org/10.1007/s11229-018-1892-7

Sheridan, Heather, and Eyal M. Reingold. (2017). The Holistic Processing Account of Visual Expertise in Medical Image Perception: A Review. *Frontiers in Psychology*, **8.** https://doi.org/10.3389/fpsyg.2017.01620

Shiffrin, R. M., & Schneider, W. (1977). Controlled and automatic human information processing II: Perceptual learning, automatic attending and a general theory. *Psychological Review*, **84**, pp. 127–189. https://doi.org/10.1037/0033-295X.84.2.127

Simon, H. A., and W. G. Chase. (1973). Skill in Chess. *American Scientist*, **61**, pp. 394–403.

Sio UN, Ormerod TC. (2009). Does incubation enhance problem solving? A meta-analytic review. *Psychol Bull*. Jan;**135**(1), pp. 94-120. https://doi.org/10.1037/a0014212

Stanley, Jason. *Know How*. (2013). Oxford University Press.

Stanley, J., & Krakauer, J. (2013). Motor skill depends on knowledge of facts. *Frontiers of Human Neuroscience*. **7.** https://doi.org/10.3389/fnhum.2013.00503

Stanovich, K. E. (1999). *Who is rational? Studies of individual differences in reasoning*. Lawrence Erlbaum Associates Publishers.

Stokes, D. (2011). Minimally Creative Thought. *Metaphilosophy*, **42(**5), pp. 658–681. https://doi.org/10.1111/j.1467-9973.2011.01716.x

Strick, M., Dijksterhuis, A., Bos, M. W., Sjoerdsma, A., Van Baaren, R. B., & Nordgren, L. F. (2011). A meta-analysis on unconscious thought effects. *Social Cognition*, **29**, pp. 738–763. https://doi.org/10.1521/soco.2011.29.6.738

Tenison, C., & Anderson, J. R. (2016). Modeling the distinct phases of skill acquisition. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, **42**(5), pp. 749–767. https://doi.org/10.1037/xlm0000204

Usher, M., Russo, Z., Weyers, M., Brauner, R., & Zakay, D. (2011). The impact of mode of thought in complex decisions: Intuitive decisions are better. *Frontiers in Psychology*, **2**, pp. 37. https://doi.org/10.3389/fpsyg.2011.00037

Waite, Stephen, et al. (2019). Analysis of Perceptual Expertise in Radiology – Current Knowledge and a New Perspective. *Frontiers in Human Neuroscience*, **13**. https://doi.org/10.3389/fnhum.2019.00213

Wilson, T. D., & Schooler, J. W. (1991). Thinking too much: Introspection can reduce the quality of preferences and decisions. *Journal of Personality and Social Psychology*, **60**, pp. 181–192. https://doi.org/10.1037/0022-3514.60.2.181

Yarrow, Kielan, et al. (2009). Inside the Brain of an Elite Athlete: The Neural Processes That Support High Achievement in Sports. *Nature Reviews Neuroscience*, **10**(8), pp. 585–596. https://doi.org/10.1038/nrn2672