Not being there: An analysis of expertise-induced amnesia

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Abstract
It has been hypothesized that postperformance memory gaps occur in highly skilled individuals because experts generally perform their skills without conscious attention. In contrast, we hypothesize that such memory gaps may occur when performers focus so intently on their unfolding actions that their ongoing attention interferes with long-term memory formation of what was previously attended to, or when performers are highly focused on aspects of their bodily skills that are not readily put into words. In neither case, we argue, does performance proceed automatically yet both situations, we suggest, may lead to an inability to recollect performance.

KEYWORDS
attention, automaticity, bodily awareness, expertise-induced amnesia, memory

1 | INTRODUCTION

After a performance of Giselle—described by the New York Times dance critic Martin (1955) as one in which “the two [leading dancers] saw the work eye to eye, played together with a beautiful rapport and developed the dramatic theme with power and an irresistible poignance”—the male lead, Erik Bruhn, reported that he had no recollection of what he had done:

When I left the scene, I went to my dressing room, quite dazed. I was suddenly afraid. I had been so engaged in the performance that, when trying to recall what I had done, I was blank. I was terrified that I had done terrible things and that everything had gone wrong. (Meinertz, 2008, p. 117 [Høffding’s translation])
Other highly skilled individuals have described similar occurrences. For example, in an interview with Alex Zolbert (2012), tennis champion Maria Sharapova claims that she had no idea what happened when she beat Martina Navratilova; after Zolbert commented that without such knowledge, she is lucky that her groundstrokes did not go into the net, she countered, “maybe they were in the net.” Apparently, her ability to recollect was so impoverished, that she could not be sure. Violet Verdy, a former New York City Ballet Principle Dancer tells of a similar memory gap, claiming that after one performance, she had no idea what had happened because, as she put it, “I wasn’t even there” (quoted in Montero, 2016, p. 163). How could this be? It would seem that if one were to do something brag-worthy, one would remember it well enough to brag about it later. However, this wasn’t so for Bruhn, Sharapova and Verdy, who all performed exceptionally well yet failed to remember what they had done.

Did these three experts really have no recollection of their performances? If shown a video afterward, might they at least recognize some of what they had done and perhaps even be prompted to recall details of the performance that were not captured on the video? It may be that in certain cases of what we shall refer to as “postperformance amnesia,” video observation would cue recognition-memory and even recollection of aspects of the performance that previously were not readily accessible. However, the question still arises: Why are some performances recalled without prompting while others, unless prompted, seem to leave no trace? And, although we imagine that occasionally when a performer is interviewed after an extremely exhausting display, words to the effect, “I don't remember,” are simply a polite way to say, “leave me alone,” we shall assume that sometimes performers are reporting what, to the best of their knowledge, describes their epistemic state. In any event, our starting point is the assumption that postperformance amnesia occurs, and our question is: What explains it?

According to the standard account, memory formation requires conscious attention, thus, post-performance amnesia results when well-practiced skills have become so proceduralized, or automatic, that experts are not consciously attending to their actions as they unfold. Here, we offer two alternative possible explanations of postperformance amnesia that turn on the idea that experts' conscious minds are fully engaged in their actions. We hypothesize that postperformance amnesia may occur either when performers are focusing so intently on their actions that each moment of attention interferes with long-term memory formation of what was previously attended to, or when performers are highly focused on aspects of their bodily skills that are not readily expressible. In neither case, we shall argue, does performance proceed automatically without conscious engagement in the action, yet both situations, we suggest, may lead experts to feel as if they had not been there during their performances. On the standard account, postperformance amnesia results when experts' conscious minds are not engaged during performance. In contrast, on the two explanations we tender, postperformance amnesia occurs when the nature of the performers' conscious experience leaves them unable to recall what they had done; or, to put it somewhat paradoxically, on our two alternative accounts of postperformance amnesia, it is being there that precipitates not being there.

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1 Dow (2017) questions the extent of these memory blanks: while a runner, he points out, might deny that she actively made choices about how, say, to pace herself, she will still remember that she was running. Similarly, our three experts may still remember that they were engaged in the activity they had been doing. (See Brownstein (2014), however, for a more extreme view about the extent of post-performance amnesia.)

2 The psychology literature on post-performance amnesia sometimes uses “being conscious of” as a terminological variant for “attending to” (see, e.g., Beilock, Wierenga & Carr, 2003, pp. 319–320). Thus, some may find the phrase “conscious attention” redundant. Nonetheless, we employ this phrase to emphasize that our concern is with both consciousness and attention (leaving open whether these are two distinct phenomena). And, throughout the paper, we follow Beilock et al. (2003) and use the phrases as terminological variants.
How is it that consummate athletes and performing artists, upon completing actions in their domains of expertise, sometimes fail to recollect what they have done? The textbook explanation for such memory gaps emerges from a line of expertise research that emphasizes the role of automatization in high-level skill (Beilock & Carr, 2001). According to this line of research, highly practiced actions are automated; they are, as Beilock and Carr put it, “controlled in real time by procedural knowledge” (2001, p. 702). Procedural knowledge couples well-worn neural programs—programs which run without the intervention of conscious control, programs that run autonomously—with action. It is closely aligned with what philosophers refer to as “knowledge-how”: you might know how to ride a bike, it is often claimed, even if you cannot explain or say much about the way in which you do so. And since an automated action, as it is generally understood, “requires little attention, operates largely outside of working memory, and is substantially closed to introspection” (Beilock & Carr, 2001 p. 702), and since it is thought that long-term conscious memory formation requires attention (Fernandes, Moscovitch, Ziegler & Grady, 2005; Schacter, 1996), it follows that high-level skills ought to leave impoverished consciously accessible memory traces.

Whether it is correct to think of automatic actions as being entirely outside the realm of conscious (or intentional or deliberate) control, attention, working memory and, for the most part, introspection has been questioned by Ellen Fridland (2017). And it does seem reasonable to think that some actions naturally classified as automatic can be attended to; for example, you might automatically jump back from a falling object that startles you while being consciously aware of what you are doing. Moreover, it also seems reasonable to think that, as Fridland argues, the correct picture of the relation between consciousness and automaticity is likely complex (see Shepherd, 2015 for further discussion of this complexity). However, for terminological consistency, we follow Beilock and Carr and use the phrases “automatic actions” and “proceduralized actions” to refer to actions that require little attention, operate largely outside working memory and, (for the most part) introspection; such an understanding of the procedural and automatic can allow for at least some degree of the type of intelligence that Fridland argues is present in automatic skill.

With this terminology in place, it should be clear how the idea that expert level skills are automatized leads Beilock and Carr (2001) to what they refer to as the “expertise induced amnesia hypothesis,” which they explain as the view that “declaratively accessible episodic memories of any particular performance should decrease with increasing expertise” (p. 702). In other words, this hypothesis states, for example, that as your skill increases in putting a golf ball, you will be able to consciously recollect less and less about what you actually did during a put, less and less about such things as how your hands were positioned and when your weight transferred from one foot to the other. Or, as we will put it in slogan form:

**Expertise-Induced Amnesia hypothesis (EIAH): The better you are, the less you will recall about what you've just done.**

If the process of acquiring expertise entails becoming decreasingly conscious of one’s actions, then we would expect to find this inverse correlation between skill and recall. Or, more specially, since the hypothesis concerns consciously accessible and reportable (declaratively accessible) memories of occurrences (episodic memories), if EIAH is correct, we would expect to find elite athletes, performing artists

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3 The philosophical discussion of “know-how,” however, is complicated, since not all philosophers see it as outside the thinking, conceptual realm. For example, Jason Stanley (2011) and Pavese (2017).
and other experts retaining very little to no consciously accessible or reportable memories of their accomplishments; we would expect to find our three mavens, Bruhn, Sharapova and Verdy, whose skills were extremely well practiced, doing something bragworthy without being able to brag about it afterward.

In addition to being suggested by anecdotes, such as those of our three experts, EIAH is thought to garner support from two experiments that investigate the level of detail contained in experts' and novices' descriptions of how to perform a golf putt (Beilock & Carr, 2001). Prescinding away from the details, in one experiment, expert and novice golfers (identified, respectively, as members of an intercollegiate golf team and college students with no golf experience) attempted 70 putts from the same location. A little bit more than a third of the way through, both groups of participants were asked to provide a “generic description” of a golf putt (which is supposed to capture the steps of a successful putt). Then, after their final putt, they were asked to describe what they had done to achieve that putt (the “episodic description”). The result: experts' episodic descriptions were shorter than their generic ones, and, even though their generic descriptions of their putts were longer than those of the novices, their episodic descriptions were briefer than the novices'. If we assume the truth of EIAH, this result is to be expected; for if the more one is skilled at performing a task, the less one recollects about that task, then experts would have less to say about their putts than novices since the experts would, according to the hypothesis, remember less about them.

Another experiment testing the hypothesis similarly compared novices' and experts' generic and episodic descriptions of putts—this time from different locations—and added a trial involving “funny putters,” which are curved putters designed to add an element of novelty to the putt. The thought was that if EIAH is correct, then the experienced golfers would provide fewer details than the novices about a putt made with a regular putter but not necessarily about one made with a funny putter, as the funny putter was intended to un-proceduralize the experienced golfers' putts. And the outcome, again, was in line with EIAH: experienced golfers provided fewer details about their putts than the less experienced golfers when using the regular putter but not when using the funny putter. As Beilock and colleagues explain, the results of these two experiments “suggest that well-learned sensorimotor skill execution is controlled by proceduralized knowledge structures that are not attended to and hence not included in memories left over from task performance” (Beilock et al., 2003, p. 319).

What these experiments test is not whether a proceduralized skill is more poorly remembered than a consciously controlled one. That consciously controlled actions are better remembered than proceduralized ones, is something they, and we, assume is true. Indeed, a proceduralized action, as we have defined it, is one that, in contrast to a consciously controlled action, occurs with diminished attention and working memory; thus, given that attention and working memory are thought to be essential to the formation of conscious memories (Fernandes et al., 2005; Schacter, 1996), it follows that the conscious memory of procedural actions will be diminished relative to the conscious memory of consciously controlled actions. Rather, the experiments investigating EIA aim to test whether expert actions are more poorly recalled than novice ones; the participants in these studies are divided into two groups based on skill level and not on how proceduralized their domain-relevant skills are. In other words, the experiments aim to test whether the better you are, the less you will recall about you have just done (under the implicit presupposition that expertise consists in increased proceduralization).

### 3 PUTTING PRESSURE ON EIAH: MIND-WANDERING AND EXPERTISE-HEIGHTENED MEMORY

Perhaps because EIAH coincides with the commonly accepted view that expert action, when free from unusual interferences, is performed without conscious intervention, it has rarely been questioned. But
we think that it should be. This is in part because of a possible tension between EIAH and two other
features of expert performance—mind-wandering and what might be called “expertise-induced height-
ened memory”—and in part, as we'll go on to address in the next section, because the empirical support
for EIAH is open to alternative explanations.

Mind-wandering is the spontaneous shift of attention from one's task to personal and other goals. And, as Randall, Oswald and Beier (2014) explain in their meta-analysis of the empirical literature
on the phenomenon, mind-wandering is generally found to increase with automatization and to coincide with decreases in performance. Indeed, according to their meta-analysis of the empirical litera-
ture, “increases in mind-wandering, were generally associated with decreases in task performance, whereas increases in task-related thought[s] were associated with increased performance” (p. 1411).

Thus, the mind-wandering research suggests that automatization leads to performance decrements while on the standard explanation for postperformance amnesia, automatization is associated with
high-level skill. As such, the data on mind-wandering is consistent with the existence of expertise-
induced amnesia. What it casts doubt on is the standard explanation of expertise-induced amnesia as it suggests that actions that are performed automatically are not, at least sometimes, optimal.

That said, it is not clear how significant this doubt should be. Support for the idea that expert
actions are highly proceduralized comes from a wide range of experiments (Beilock, Carr, MacMahon & Starkes, 2002, Beilock & Gray, 2007; DeCaro, Thomas, Albert & Beilock, 2011; Jackson, Beilock & Kinrade, 2013), yet most of these experiments investigate physical skills while the effect of mind wandering on performance has been tested primarily in the domains of reading comprehension, sustained attention, working memory and performance on various other cognitive skills, many of which have success conditions defined in terms of memory: if you fail to recall that you performed a stunning quadruple pirouette, your pirouette will be no less stunning, but if you fail to recall what you have read, your reading comprehension will plummet.4 Moreover, assuming that
mind-wandering need not accompany all automatically performed actions, then (even if both cogni-
tive and physical highly practiced skills tend to be more susceptible to mind wandering than less
practiced skills) if mind-wandering occurs infrequently during the performance of highly practiced
skills, expert action could, consistent with the automatization explanation of postperformance amne-
 sia, be automatized (and therefore not readily recalled) and generally highly proficient. In other
words, even if it is true that, in general, as skill increases, proceduralization and thus impaired mem-
ory for performance increases (as is mandated by EIAH), it could also be true that such
proceduralization facilitates mind-wandering (and its associated memory gaps) which, when it occasion-
ally occurs, results in a suboptimal performance. In this way, the data indicating that mind-
wandering is associated with both automaticity and poor performance can be seen as consistent with
the view that EIAH is explained by the automaticity account of expertise.5

Perhaps a more serious tension, however, exists between EIAH—not just the explanation for it, but the hypothesis itself—and the prevalence of what might be thought of as expertise-induced heightened recollection. Expert's heightened recollection of skill-relevant information has been demon-
strated in chess (e.g., Chase & Simon, 1973; Ericsson & Lehmann, 1996) and in a number of other
skills, such as, miniature golf (Backman & Molander, 1986), waiting tables (Ericsson & Polson,
1988; Huet & Marinié, 2005) architectural drawing (Akin, 1982), hiking (Kawamura, Suzuki &

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4 However, Kam et al., 2012 indicate that mind-wandering negatively impacts visuo-motor tracking tasks, which might count
as a physical skill. Explaining just what counts as a physical as opposed to cognitive skill is beyond the scope of this
(or perhaps any) paper; however, see Montero (2016) for a discussion of the fuzzy distinction between what are typically
referred to as “physical skills” and “cognitive skills.”

5 For another take on the relation between mind-wandering, expertise, and EIAH, see Hoffding, 2018, Chap. 5.
Morikawa, 2007), and computer program coding (McKeithen, Reitman, Rueter & Hirtle, 1981). Indeed, improved memory for domain-relevant information is sometimes thought of as a “hallmark of expertise” (Herzmann & Curran, 2011). To be sure, the empirical evidence for heightened memory primarily concerns recollection of domain relevant information rather than recall of what one did during a performance in one’s domain of skill (e.g., the ability to remember a long list of drink orders, in contrast to the ability to recall what orders one took). However, many experts are phenomenally good at remembering the actions they have performed in their domains of skill. For example, as Alfred Binet (1893) noted, many of the top chess players can recall every move of games they played even long ago. And there are reports of athletes, such as Pete Rose who, according to Steve Blass (Blass & Sherman, 2012), “doesn’t just remember every hit he ever got but probably every pitch he ever saw”; Rose, according to Blass, “had total recall of his career” (p. 7). Presumably this is an exaggeration, nevertheless, the empirical data on expertise-heightened recollection combined with what we know about expert chess players and others’ skills suggests that EIAH is at best too sweeping, as it implies that the crème of the crème should generally remember less about their performances than the mere crème. Yet given the data on expertise-facilitated memory and given what at least seems apparent about great chess players and other experts’ memory of their domain-relevant actions, it is difficult to see how EIAH could be true.

4 | QUESTIONING THE EMPIRICAL SUPPORT FOR THE EXPERTISE INDUCED AMNESIA HYPOTHESIS

Difficult, however, does not mean impossible, and if there were strong empirical support for EIAH, we might need to figure out what all these grandmasters are actually doing when they seem to be able to recount games from long ago. However, we think that a careful look at the empirical support for EIAH reveals some possible confounds. One concern with the experiments testing EIAH relates to that looming issue of what is referred to in the psychology literature as “ecological validity.” Research that fails to mirror real-life settings in a sufficient number of relevant respects may be charged with “ecological invalidity” (Neisser, 1976). Of course, all experiments diverge from real-life settings to some extent. Thus, it is difficult to say precisely how much and in which ways an experimental set up must be ecologically wanting before we should question its validity. Nonetheless, we think that the EIAH experiments may get at least dangerously close to the too-divergent camp. In the first experiment, the participants provided episodic reports after 70 repetitions of the same putt. Thus, it might be that although the novices in this situation still found the task engaging, as it remained challenging for them, the more experienced participants may have switched to autopilot, not because this is how they usually perform, but because they were bored. Yet in a tournament, with its greater variability, boredom, if it were to occur at all, might not occur to such a degree that it would lead to the type of fully proceduralized actions that result in EIA. Or if it did, it might be time to leave the circuit (see also Christensen, Sutton & McIlwain’s, 2015, criticism of these experiments, which focuses on the idea that the tasks that led to reduced recollection were, compared to tournament conditions, easy).

In the second experiment, some variability was worked into the design as the participants putted from nine different spots. But even so, after 70 puts, it still may have felt repetitious. Thus, we question whether the iterative and mundane nature of the task made the experienced golfers go offline, and thus not recollect their putt more than would occur in an actual tournament.6

6 We suggest this as only a possibility. If the golfers were very skilled, perhaps they could have kept interest going by fiddling and fine-tuning technique (and the relatively brief episodic description of the putts indicates that such fine tuning was, at most, minimal).
A related factor that makes it difficult to achieve ecological validity in the lab is that the stakes are much lower, and with lower stakes, the higher-level participants may have been less consciously engaged with their actions since they were not motivated to optimize their performance. Did the higher-level participants manifest a lack of drive or at least less drive than they would if they were to play in a tournament? We do not know, but one indication that they were not playing at their best is that their performance did not decline with the funny putter. Golf players go to great pains to procure the ideal putter. That it makes a difference, could, of course, be a myth. Perhaps the only advantage the “ideal” putter offers is not that it improves performance, but it allows for cognitive ease. However, it also could be that performance did not decline with the funny putter because players were not playing at their best with the regular putter.

That their performance did not decline with the funny putter is, however, an incomplete description of the experiment. Besides looking at performance with normal and funny putters, the experiment also compared performance in single-task trials, where participants were not being distracted by an extraneous task and compared this with performance in double-task trials in which participants needed to putt while listening to recorded words and, when they heard the word “cognition,” to repeat it aloud. The result was that under single-trial tasks the accuracy of the expert golfers’ puts with the funny and regular putters was the same while performance with the funny putter declined in the double task trials. The researchers take this to show that highly skilled athletes can compensate for problems (the unusual putter) by concentrating on their task, but that when things are normal, their conscious attention can, at least partially, go on holiday. We agree that athletes can compensate for problems by concentrating on their task, and we think it is likely that in the laboratory the more-skilled players' attention partly went on holiday. However, we think that the reason why it did might have to do with the mundane nature of the task. In other words, we think that it might be that, in the lab, cognitive resources were not being called upon to a sufficient degree during single-task because players did not care that much about how they did; they were confident enough to think that even without paying much attention to what they were doing, they would do well enough. But in the wild, doing well enough is not, for experts, good enough. In the wild, it is possible—and, we hypothesize, likely—that experts would be much more driven and that this drive would facilitate both better performance and better recollection.

To be sure, it is, perhaps, too easy to quibble over whether an experiment attains ecological validity. However, even putting aside the question of whether the high-level players in the EIAH experiments were sufficiently motivated, there is room to doubt that these experiments provide strong support EIAH, as it is not clear that the question that was intended to elicit episodic memories, elicited the full range of episodic memories that the more experienced participants had of their last putt; for the question wasn't, “What do you remember about your last putt?” Rather it was this:

Describe the last putt you took, in enough detail so that your friend could duplicate that last putt you just took in detail, doing it just like you did. (Beilock et al., 2003, p. 304)

But asking for “enough detail” is not the same as asking for “all the details.” In contrast, the “generic” question did ask for all the details:

Certain steps are involved in executing a golf putt. Please list as many steps that you can think of, in the right order, which are involved in a typical golf putt. Beilock et al., 2003

Furthermore, the fact that some details are left off when you aim to provide enough information for a friend to duplicate your action, does not mean that those details were forgotten. Certain aspects of a
task might be remembered but might seem so obviously necessary to complete the task that one need not explain them to someone who would like to duplicate the task.

The researchers were aware that the episodic question might not elicit a full account of what their more experienced participants remembered about their putts. And thus, to supplement the episodic question, they note that participants were provided with additional instructions that were intended to make clear that they were to provide a description that “would allow the putt to be duplicated in all its details by someone who had not seen it … and was not an expert golfer, but someone with an ordinary knowledge of the game.” But we venture that an individual who is highly skilled at performing a task—especially someone who has not taught the task at issue before—may assume that those with “ordinary knowledge” of the task know more about how to perform the task than they in fact do. (Even those of us who teach often realize after that first exam that our lessons, which we thought had been aimed at those with no background, were still pitched at much too high a level.) And thus, it is still not clear that even with the additional prompts, that the episodic question elicited reports of all that was recalled. (At the same time, the episodic question may have elicited more than what was recalled as the experienced group may at times have filled in components of their putt in order to provide the information necessary for the purpose of duplicating the put even if they did not remember doing this component of the putt. But we take it as open whether the possibly of over-describing what was recalled balances out the possibility of under-describing it.)

5 | EXPERTISE- FACILITATED AMNESIA AND MESH

Because the experimental support for EIAH is open to the alternative interpretations mentioned above and because we are inclined to accept that some experts experience heightened recollection rather than diminished recollection, we suggest that EIAH be replaced by a weaker hypothesis:

Expertise Facilitated Amnesia hypothesis (EFAH): Expertise facilitates the ability to perform skill-relevant actions without the performance leaving a declaratively accessible, episodic memory trace.7

Or in slogan form: the better you are, the more able you will be to perform without recalling what you have just done.

The EFAH has the virtue of being consistent with the phenomenon of expert’s heightened recollection, and like EIAH, it is intimated by the anecdotes of our three experts (and other similar cases). Moreover, to the extent that the experimental support for EIAH stands, it stands behind EFAH as well. But is EFAH true? Could it be that, although experts experience postperformance amnesia, having expertise does not make it any more likely that one will have such an experience? Perhaps, one might argue, the media reports cases such as Bruhn’s and not cases of individuals with beginning

7 A couple qualifications and a terminological note are in order. The EFAH should be understood to apply only to linguistically competent beings; very young children might be terrible at tying their shoes without afterwards being to express much if anything about what they had done. We are also most confident about EFAH in domains in which one already has at least a modicum of training. Thus, someone who, picks up a tennis racket for the first time and by chance returns a serve might have no recollection of what he or she just did would not fall under the scope of the hypothesis. As for terminology, our use of the word “amnesia” here is, at best, a stretch. According to EFAH, expertise facilitates the ability to perform in such a way so that no memory trace of the performance results. As such, someone who experiences EFA may have been able to remember what they had done had they engaged with their actions differently. Yet someone who suffers from amnesia is typically thought to be incapable of forming certain types of memories. Nonetheless, for ease of expression we will refer to the type of facilitated memory loss at issue as a form of amnesia.
skills who fail to recall their performances not because there are fewer of them but merely because people aren't interested in reading about beginners.  

Although we think that feats that result in postperformance amnesia may be facilitated by expertise, we leave open the question of whether it is an expert-centric phenomenon. Since EIAH implies EFAH (but not vice versa), it is clear that EFAH is more likely true than EIAH, but our goal is not to defend EFAH. Rather, our goal is offer two possible explanations—explanations that do not turn on the idea that expert action generally unfolds without conscious attention—for why postperformance amnesia occurs in experts, when it does occur (regardless of whether it also occurs in nonexperts). If postperformance amnesia is not always accounted for in terms of an expert's actions proceeding automatically, what accounts for it in these other situations? Or, more specifically, assuming that the situations that our three experts found themselves in were challenging ones that called for conscious attention, what could explain the fact that they surmounted the challenges yet had no memory of having done so?

John Sutton (2007) proffers a possible explanation of why some experts seem to recall their performances in great detail while others occasionally experience memory blanks. In reference to cricket players, he tells us,

> Among top players, some remember their innings in great, laborious detail, while others take pride in not caring or being able to recall particular episodes. It can be no more than speculation at present, but perhaps there is some systematic connection between different players' batting psychology and the kind of memory they retain: crudely, the more effortful, attentive or deliberately focused a batsman is in style and in building an innings, the richer and more extensive might be their episodic memories. (Sutton, 2007, p. 771)

And Christensen, Sutton and McIlwain (2016) expand on this in addressing how their proposed theory of skill, Mesh—according to which almost all skilled action has a significant cognitive component, encompassing, among other things conscious control—can accommodate postperformance amnesia:

> To account for [cases of memory failure in expert performance] Mesh proposes that memory encoding is affected by more than just attention…. In particular, it proposes that memory encoding is affected by the relevance of information for future control … Broadly speaking, it is more likely that there is something to be learned in challenging conditions as compared with easy conditions, and so situational information in challenging conditions is more likely to be relevant to future control …. In general, Mesh would not expect reduced memory in challenging conditions (though this is modulated by future relevance), so cases of reduced memory in challenging conditions would be problematic. (Christensen et al., 2016, p. 51)

Memory, we agree, is affected by the relevance of information for future control—in as much as we think that in many domains, if information is stored so that it can be called upon for future control, then it is likely to be remembered—and we agree that in easy conditions wherein one does not need to rely on information about actions that have already transpired in order to proceed effectively, there might not be anything sufficiently memorable about an action for it to leave an imprint. Where no challenge is present, postperformance amnesia may occur when actions are so fully automated that

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8 Anecdotally, we have heard of cases where similar memory gaps occur in beginning skills.
an expert can let her mind wander to unrelated matters (which might lead to a memory of thinking about those unrelated matters) or perhaps even “zoning out” (which might lead to a more or less complete memory blank.) In other words, in unchallenging situations, the standard explanation of postperformance amnesia may be correct. But in the situations that interest us—those of our three experts—challenges are present: The leading male role in the ballet Giselle is one of the most challenging in the classical repertoire, and Navratilova is a fierce opponent. Do memory blanks of demanding performances, such as these, conflict with Mesh?

We do not think that they do. Mesh proposes that if information is needed for future control, then that information will likely be remembered, or in other words, if it is not remembered, then it probably was not needed for future control. And, according to Meshonites, if an action is challenging, one needs to store some information about what has already transpired in order to control that action when it occurs. However, although we think that when experts store declarative information in long-term memory (longer than 30 s), then that information will likely be remembered, we would like to suggest that experts sometimes confront difficulties that do not demand that they store declarative, consciously accessible information in long-term memory. What we offer is speculative, however, in the next two sections we investigate two different forms of attention, both of which can help performers navigate difficulties: deep engagement, wherein challenges demand that one plans ahead, but not further ahead than what can be kept in short-term memory, and bodily immersion wherein the challenge of performing a bodily skill fluidly, efficiently, and, if it is called for, in an aesthetically valuable way, calls for thinking and planning in the language of the body, which, as we shall suggest, does not always result in declarative memory reports. Neither of these explanations depend on the automatic body taking over and leaving the conscious mind behind; rather, they allow, as Mesh proposes, for experts to think in action. Yet both deep engagement and bodily immersion, we hypothesize, may precipitate postperformance amnesia.

6 | DEEP ENGAGEMENT

The existence of postperformance amnesia is sometimes taken as evidence for the view that highly skilled performance proceeds without or at least with reduced conscious attention (Beilock et al., 2003; Beilock & Carr, 2001; Dreyfus & Dreyfus, 1986). But, of course, it does not imply this view: It is possible to consciously attend to one's actions yet forget them immediately after completing them. For example, individuals with anterograde amnesia—a condition which renders its victims unable to form new long-term memories despite their ability to retain short-term memories—appear to have abundant conscious declarative thoughts that quickly vanish from their minds, but not so quickly that they preclude short bursts of planning (Baddeley, 2014). Moreover, it is known that a distraction task immediately following a memory task, interferes with long-term memory formation. An early illustration of this comes from Muller and Pilzecker's (Müller & Pilzecker, 1900) pioneering study in which participants, after they attempted to memorize a list of syllables, were presented with a new syllable list either 17 s or 6 min later. In the 17-s condition, participants recalled 28% of the syllables whereas in the 6-min condition this increased to 49%. This and numerous recent studies of both humans and nonhuman animals, using both behavioral and neuroimaging approaches, are thought to support the idea that retroactive interferences can impede long-term memory formation (see, e.g., Dewar, Garcia, Cowan & Della Sala, 2009 and, for a review, Wixted, 2014). Our lives are, of course, filled with distractions, and normally they present no impediment to remembering what

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9 The explanations for post-performance amnesia that we proffer are also in line with the view of expert attention put forth in Montero (2016) and Bermúdez (2017).
we need to remember. However, according to the retroactive interference account of anterograde amnesia (according to which anterograde amnesia is due to a heightened susceptibility to retroactive interference) the injury or illness that results in retrograde amnesia renders individuals unable to do this (Cowan, Beschin & Della Sala, 2004; Dewar et al., 2009).

That said, the experts we are considering do not have the kinds of global impediments to memory formation exhibited by amnesiacs. Moreover, whether the retroactive interference account of retrograde amnesia is correct is an open empirical question. Nonetheless, we posit that occasionally one is able to enter into, or perhaps finds oneself in, a situation that has some affinities to anterograde amnesia, especially when this condition is understood in terms of the retroactive interference account of amnesia; in other words, we think it is possible that some cases of postperformance amnesia may occur because retention of new information is blocked by attending to subsequent information. Our claim is not that postperformance amnesia has the same origin as retrograde amnesia. Rather, our claim is that it is in some ways analogous; for we hypothesize that when experts are extremely focused on the moment, each moment of attention serves as a kind of retroactive interference with respect to the prior moment of attention, in as much as it interferes with it being stored in long-term memory, and that it is this interference that precipitates postperformance amnesia.

Taking a cue from Bruhn’s comment that he was “so engaged in the performance” that he could not recall what he had done, we refer to this as “deep engagement”:

**Deep Engagement:** Long-term memory failures can occur when an expert’s attention is so keenly focused on what she is doing in the moment that long-term memory formation is impeded.

On the automaticity account of postperformance amnesia (Beilock et al., 2002; Beilock & Carr, 2001), memory gaps of the sort experienced by our three experts are explained in terms of expert actions being so fully automated that the conscious mind is not present during performance. The deep engagement account of postperformance amnesia does not deny that expert actions are proceduralized to a large degree. A selective focus on one aspect of a skill, for example, is only possible if the other aspects of the skill proceed automatically. However, it does not require the type of full proceduralization of action that is required to explain postperformance amnesia on the automaticity account. Rather, the deep engagement account maintains that when challenges are present and surmounted with aplomb, yet rapidly forgotten, conscious attention is so keenly focused on the moment that each subsequent period of attention impedes memory formation of the previous period.

Høffding’s (2014, 2018) interviews with members of the Danish String Quartet (DSQ) (https://danishquartet.com/) suggest that the type of postperformance amnesia experienced by our three experts (i.e., postperformance amnesia after performances that are generally thought of as exceptional or at least up to par rather than ho-hum) rarely happen to musicians. Over the course of a nearly 20-year career, the DSQ members each report that they have undergone no more than a handful of experiences of postperformance amnesia. However, it might be much more common in other endeavors, particularly those that call for deep concentration on short-lived actions, such as juggling. Here, information might be needed for future control, yet the future is so close that the information need only be held in short-term memory.

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10 Another group of experts who may systematically experience something similar to post-performance amnesia is seasoned football players (in the American sense of the term “football”). However, this, sadly, seems due to the high incidence of repeated concussion in football (Clay, Glover & Lowe, 2013).
An example might help clarify the idea. The mathematician and juggler Allen Knutson (who from 1990 to 1995 shared the world record for passing balls between two people: 12 balls, 68 catches), reports that he usually does not remember much about his passes. In his words:

I and a partner may make hundreds of attempts at a pattern, in a session. If he or she asks, after a failed attempt, what went wrong, s/he'd better do it quick; after about three seconds I will have forgotten. (Knutson, 2016)\(^\text{11}\)

Since Knutson does remember passes that he is asked about immediately after completing them yet otherwise does not, his comment intimates that conscious, declarative thoughts may be present during challenging performances yet fail to become encoded in long-term memory.\(^\text{12}\) It is difficult to explain what Knutson reports, if one maintains that postperformance amnesia is the result of automaticity. If his juggling were fully proceduralized and, thus, ensued without conscious attention, then one would expect that Knutson would be unable to remember what he had done even immediately afterward. Deep engagement, however, allows for this, as it allows for information to enter short-term memory and it attributes the memory gaps to Knutson's present-directed attention acting interfering with the process that transforms short-term memories into long-term ones.

On the deep engagement account of postperformance amnesia, an action may be challenging yet long-term memories are not laid down for future control. And juggling might be a perfect example of this. With 12 balls being passed back and forth between two people, each throw is challenging, however, one does not need to store information about prior passes in long-term memory in order to control subsequent passes. The challenges ensue one after the other, but they are considered so briefly that, unless the juggler is asked about it immediately afterward, they are forgotten.

Could deep engagement account for the rare instances of postperformance amnesia experienced by our three experts and the members of DSQ? It could if very occasionally such experts put themselves in a juggling mind-set where only the present moment matters. And, although one cannot place much weight on what someone says about an experience that he cannot remember, Bruhn's comment that his is memory black-out came about because he “so engaged in the performance” is suggestive of such a mind-set.

7 | IMMERSION

Deep engagement, we have argued, may lead to postperformance amnesia regarding actions that were not autonomously guided. Another possible cause of postperformance amnesia that may allow performers to at least consciously attend to and perhaps even guide their actions is what we refer to as “immersion,” which we understand as an all-encompassing conscious awareness of components of actions that are not readily verbalizable, in the sense that one lacks words to describe them. Although such immersion, arguably, may occur with a variety of foci, we are going to narrow our

\(^{11}\) Though this remark was made merely in a comment on a blog, in follow up discussions over email, we have found that he is fully committed to this view. Follow up discussions also aimed to uncover whether part of the reason for the memory gaps is the high-degree of similarity between each throw. And our conclusion from these follow ups is that it is not clear that it is. “Of course, the goal is to make them all identical,” he points out, yet “what will typically happen is that one ball will get tossed a little bit outside, and will continue to ping-pong back and forth on the outside, and that will be memorable.” At least it will be memorable, he says, if “you commiserate with your partner after.”

\(^{12}\) Is conscious thought present only when something goes wrong? We do not think so, but let us not enter into that debate here. We bring up Knutson's experience to illustrate how conscious thought may fail to be encoded in long-term memory even if it is present as skill unfolds.
purview to “bodily immersion,” and try to make a case for the view that when experts are immersed in their bodily movements and positions, they may not form declaratively accessible memories about what they have done.

When you close your eyes and feel your right arm extend so that it forms a $90^\circ$ angle with your torso, your sense of proprioception along with a declarative conceptualization of your position, helps you to judge the angle formed by your torso and arm; you might think, “my arm is at a $90^\circ$ angle from my body.” And if you conceive of your arm position in this way, you will likely be left with a declarative memory of having assumed that position. If someone later asked you what position you were in a few minutes ago, barring intervening distractions (e.g., barring situations where you continually moved into other angles) you will be able to report that you had assumed the position in question. But if awareness of our movements and positions outstrips what we can presently put into words, it may be that an exclusive focus on nondeclarative elements or qualities of our movements and positions will result in our inability to say anything, or at best very little about what had just transpired. And when this happens, a performer might feel as if she “wasn't there” because whatever memory remains lacks so much declarative content that it is not recognized as a memory; or at least, if asked, “what do you remember about the performance,” a performer who was immersed in her bodily positions and movements will have little or nothing to say. In this way, bodily immersion could provide another route to postperformance amnesia and the experience of not-having-been-there that is consonant with attention to movement as it unfolds, or, in other words, with having been there.

But why think that experts are deeply immersed in their movements during these performances? Why not think that the mind, instead, was blank? Although, our main goal is to lay out the possibility of deep immersion, we think that one indication that it sometimes occurs comes from the contradictory way in which performances that lead to postperformance amnesia are sometimes described. For instance, the DSQ cellist, Fredrik Sjölin explains an experience he had once when rehearsing a Bach cello suite on his own:

The deeper you are in, the less you observe the world around you… and I had this especially powerful experience… where I completely disappeared. I remember that it was an incredibly pleasant feeling in the body. And it was incredibly strange to come back and at that point I spent a few seconds to realize where I had been. I had been completely gone with no possibility of observing… When I came… back to normal consciousness again, I had an immensely light feeling in the body, a feeling of exaltedness. And I was extremely awake, as if the tiniest of sounds, I would catch it or the most minute movement in the corner of my eye, I'd see it. There was an immense presence. I remember it. Immensely present… Like joyful. A bit like after you have had sex. The joy hormones are racing in the body. You feel invincible. You feel that you can do anything (Høffding, 2018, pp. 66–67).

What strikes us about this comment, as we interpret it, is Sjölin's attempt to negotiate his inclination to describe the experience as being one in which he disappeared and could not observe what he was doing and his inclination to describe the experience as one in which he had an incredibly pleasant feeling in his body; he seems to want to say that he remembers nothing about it but also remembers

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13 When “performance” is understood to apply to what goes on in front of an audience or a crowd of spectators (rather than in the broader sense in which there can be a performance of any action) this is not an instance of post-performance amnesia, as Fredrik here is rehearsing and not performing. However, there is no reason to think that there is a significant difference between such post-performance amnesia and the in-front-of-the-crowd post-performance amnesia.
the bodily sensations (and emotions) he experienced. Similar contradictory tendencies can be seen in comments by other members of the DSQ when they tried to describe the type of not-being-there that leads to postperformance amnesia. For example, the violinist Frederik Øland claims that “it is exactly both being present and not being present simultaneously” and the violinist Asbjørn Nørgaard reports being “both less conscious and a lot more conscious” (Høffding, 2018, p. 50 and p. 60, respectively). Such descriptions may indicate that these performers are attempting to use words to latch on to an experiential quality that is beyond language.

This resulting state might best categorized as an inability to express a memory, rather than a type of memory loss, or blank out if the experience of bodily immersion leaves you with a recollection of exactly that which was the focus of your attention: the nondeclarative bodily sensations of movement. In this sense, you aren’t left without memories of the performance but rather simply with nothing to say about what you remember having done. On the other hand, it could be that the nondeclarative format of the information makes it difficult to retrieve and hence strengthen through reactivation and consolidation, resulting in what might more rightly be thought of as a type of memory loss. We hope that future empirical work on the relationship between expertise and memory failures will eventually help us to determine which, if any, of these explanations for cases such as Bruhn's, Sharapova's, and Verdy's is correct. In the meantime, however, we shall continue to use the term “postperformance amnesia” as a blanket term to describe reportability failures, regardless of whether nondeclarative memory is present.

Our proposal in this section, then, is that in expert actions that depend (in part) on bodily movements (such as the actions of our three experts), when one’s attention is directed at elements of movement that one cannot put into words (or at least cannot be put into words given one’s current range of vocabulary), bodily immersion can be a route to postperformance amnesia. Julia Annas (2011) points out that in English “we lack a vocabulary for explicating just what is enjoyable about the exercise of experience” (p. 81, though see Cole and Montero (2007) for an attempt at such an explication). And the difficulty that the members of the DSQ have in moving beyond contradictory language illustrates that it is not merely English that is lacking in this respect. Aristotle, in the opening lines of the *Metaphysics* comments that, of all the senses, it is in the experience of vision that we take the most delight. This may be true, however, we aver that proprioception, at least for the trained athlete, dancer or musician, is at least a strong contender for second place: we close our eyes when playing an instrument or moving our bodies, not to decrease our pleasure, but to elevate it. Some of the pleasure in these cases may be derived from audition, but, we submit, that some is derived from proprioception. Arguably, the memory of painful experiences is the converse of the memory of pleasure in bodily immersion, for with intense painful experiences one is often left with declarative memory of the experience (I felt it snap and then a sharp pain shot up leg) but with little recollection of what the sensation, itself, felt like (Morley, 1993; Rainville, Doucet, Fortin & Duncan, 2004). If this contrast holds, it would follow that the type of bodily immersion that is particularly conducive to postperformance amnesia is an immersion in the pleasurable qualities of movement.

Bodily immersion, however, if it is to do the work Mesh needs it to do, must both result in postperformance amnesia and allow experts to perform in challenging situations that require storing information for future control, as it is thought postperformance amnesia following such a situation would be problematic for Mesh (Christensen, Sutton, & McIlwain, 2013, p. 17.) We have suggested that because of its nonverbal content, bodily immersion does the former, but can it do the latter? Can we think and plan during periods of bodily immersion? The answer to this question will depend, of course, on just what sorts of cognitive processes bodily immersion comprises. For example, if it is

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14 On the role of proprioception in musical communication, see Salice, Høffding & Gallagher, 2019.
simply a receptive, unconceptualized openness to what, one might want to say, one's body is doing on its own, this might result in postperformance amnesia (in much the way that mind-wandering results in postperformance amnesia) but it might not allow for the sort of control that is necessary, according to Meshonites, when experts confront challenges. Rather, it seems to be a type of bottom up, conscious attention to one's movements that are, more or less, proceeding automatically.

Bodily immersion, however, we would like to suggest, need not be thought of as exclusively bottom-up. Following Colombetti, it could be thought of as a “pre-reflective” bodily awareness, in which “one's self is experienced or lived through as the subject of awareness, without any process of reflection on itself” (Colombetti, 2011, p. 303, see also Legrand, 2007 and Legrand & Ravn, 2009). Such awareness, as Colombetti (2011) sees it, dissolves the distance between the moving body and the reflective mind and, arguably, may allow for a type of information storage that Meshonites posit as necessary in demanding contexts (in addition to Colombetti, 2011 see, also Toner, Montero & Moran, 2016. Or, going further, it could be thought of as a reflective form of awareness though still not expressible or fully expressible in words, enables reasoning about one's body (Montero, 2016, Toner et al., 2016).15

Admittedly, the idea that one can reason outside of language is controversial.16 However, one model of nondeclarative motor planning comes out of theories of cognitive maps that have been developed by psychologists and philosophers (see Rescorla, 2009 for an overview). Some of these have been inspired by studying animals that appear nonlinguistic yet seem to think and reason in navigating their environment. A striking example is that of the Tunisian ant, which may take a tortuous path across a featureless dessert searching for food, and then, upon finding some tasty morsel, beeline back to its nest. This ant, presumably without language mediating its thoughts, appears to find its way home based on stored information about the nest's location. Such behavior, Peter Carruthers argues, is a form of spatial reasoning that seems to involve “genuine forms of decision making” (Carruthers, 2004, p. 808). And it has been argued that humans engage in nondeclarative spatial reasoning in navigating (Camp, 2007), in playing chess (Montero, 2016), and in some forms of mathematical thinking (Montero, 2016). Such examples, we think, indicate that there could be nonverbal spatial reasoning.17 Yet we think that challenging bodily actions, such as those of our three experts, may require something more than spatial reasoning; besides reasoning about the movement of one's body through space, when facing a physically demanding challenge, one might need to reason about how one part of one's body is moving or standing in relation to another part of one's body; in other words, one might need to reason proprioceptively.

What is proprioceptive reasoning? As we see it, the content of proprioceptive reasoning is the experience of the moving body. It can involve reasoning about tempo, force, shape, and quality of movement (smooth, sharp, etc.). And, we would like to suggest (presumably), in contrast to the spatial reasoning of the Tunisian ant, it can be self-conscious. At times it may be expressed in words (tempo, force, etc.), and when it is, retrieval may be facilitated. However, the type of proprioceptive reasoning that we think can result in postperformance amnesia is reasoning about qualities of the moving body that cannot readily or perhaps at all be put into words. When called upon to land in a

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15 We leave open the question here as to whether bodily immersion is best understood as a deliberative act in which the body is conceived of as an object (Montero, 2016) or whether it is a pre-reflective act, in which no such deliberation is necessary (Colombetti, 2011; Le Grand, 2007; Legrand & Ravn, 2009).

16 Buckner (2017) presents an overview of the controversy and a defense of nondeclarative reasoning, in the form of intuition. We would like to go further, suggesting that what bodily immersion encompasses a form of conscious, deliberative, nondeclarative reasoning.

17 Though the focus of this section is bodily-immersion, exclusive engagement in nondeclarative spatial reasoning—or any other type of nondeclarative reasoning—may lead to post-performance amnesia.
perfect fifth after a tour en l’air or move one’s arm in such a way so that it can strike a ball that seems unstrikkable, relying on proprioceptive information during motor planning might enable one to meet to these challenges.18

Perhaps bodily immersion, either on its own or combined with periods of deep engagement, accounted for Bruhn and Verdy’s memory blanks. Ballet is demanding, even for the greatest of greats (or perhaps especially so, since they have higher standards); as the former Royal Ballet Principle dancer Lynn Seymour explains, “in ballet, everything is really technique. And what’s so awful is that the technique is not always within grasp” (Gruen, 1976, p. 134). When it is out of grasp, you are reaching for something that you have never done before, which makes it difficult to see how this could be accomplished entirely automatically. On top of the variability of one’s own technique from day to day, one must contend with the variability of one’s partner’s technique and artistic choices, as well the variability of live music, which means that dancers need to modulate their movements so that they proceeded in an aesthetically pleasing dialog with the music. If Mesh is correct, this challenge could not be done well on autopilot. And the type of planning one engages in—“my partner is further upstage than I was planning, let me adjust this step so that it covers more space,”—may require more than short-term memory, and thus may not be fully explainable by deep engagement. However, bodily immersion (perhaps combined with periods of deep-engagement) may be able to do this.

But how does bodily immersion help us to direct our actions? As Michael Devitt (2006) points out, “we still have very little idea of how thinking could proceed if thoughts were not language-like” (p. 147). Nonetheless, navigational abilities of nonverbal animals provide some reason to maintain that nonverbal thinking does occur.19 And we think that postperformance amnesia following the enactment of skills that call for extended planning provides further support for this conclusion. Performing a ballet well often takes thought and planning over periods of longer than 30 s; when postperformance amnesia occurs despite such thought and planning, these cognitive processes, it seems, would need to take place in a nonverbal realm.20

8 | OUTRO

Expert performers and athletes occasionally report not remembering anything about an exquisite performance they had just completed or a game they had just won. The incidence of this, we argued, is not as high as the experience induced amnesia hypothesis (according to which, the better you are, the less you will remember about what you just did) would lead us to believe. However, our starting point was that such reports call for an explanation. Furthermore, we have left open the possibility that expertise, though it does not induce postperformance amnesia, sometimes facilitates it.

18 Again, the word “amnesia” is being used in this context more broadly than it would normally be used. There is a sense in which you might still remember the nondeclarative qualities of your movements yet not be able to explain them.

19 Another attempt at conceptualizing “thinking in movement” can be found in Maxine Sheets-Johnstone’s (1999) The Primacy of Movement.

20 Wayne Christiansen has suggested (pers. communication) that the incidence of bodily-immersion (or other attentional states that are relatively unlexicalized) may be higher in groups, such as self-taught rock musicians, that have not been given theory-based training (compared to groups, such as today’s Julliard trained jazz musicians who have been exposed to a large amount of theory) and thus are less likely to think verbally; such musicians, however, may have developed a large set of unlexicalized concepts that ground their thought in action. It may be true that self-taught rock musicians are more likely to experience postperformance amnesia than jazz musicians who have been steeped in theory (and one can imagine testing this empirically), however, as our three experts, as well as the members of the DSQ all have theoretical backing to their training, it seems that a lack of theory-based training, though it may be conducive to it, is not necessary for entering into an unlexicalized mode of thinking.
According to the Mesh theory of skill, challenging conditions demand conscious attention since such conditions generally require one to store information about what one is doing for ongoing conscious control of one's action. Because of this, proponents of Mesh have maintained that "in general, Mesh would not expect reduced memory in challenging conditions" (Christensen, Sutton, & McIlwain, 2016, p. 17). However, our three experts experienced memory blanks yet faced challenging conditions. Bruhn's case is especially clear: He was a young dancer performing the extremely difficult role of Albrecht for the first time with someone he had never partnered after a mere two rehearsals neither of which were with the orchestra (Martin, 1955). As Bruhn explains, during the rehearsal sessions, Markova was in charge, “we did it her way” (quoted in T. Sutton, 2013). Under such conditions, it is difficult to imagine how Bruhn's performance could have been fully proceduralized, and we hope that the considerations we have presented here have alleviated the need to do so.

Meshonites comment that their expectation that reduced memory will not follow demanding performances is "modulated by future relevance" (Christensen et al., 2016, p. 51). And one can understand our first proposed explanation of postperformance amnesia, what we referred to as deep engagement, as illustrating one modulation of the Mesh account: Reduced memory may occur in challenging conditions when information is relevant to future control, but the period of time for which it is relevant is so brief that it need not be stored in long-term memory. Furthermore, we hypothesized that such information not only need not be stored but will not be stored when attention to ongoing action retroactively interferes with the long-term encoding of that information. However, on our second proposal, what we referred to as bodily immersion, information may be stored and reflected on for more distant future control. On this proposal, performers may at times focus exclusively or nearly exclusively on aspects of skill, such as the proprioceptive qualities of movement, that are not readily put into words. Because the content of such focus is not declarative, one has little to say about what occurred during periods of bodily immersion, and, thus, one will not be able to report what one recollects about such periods. Yet, if bodily immersion provides an expert with non-declarative proprioceptive information, such information might be stored for future control of movement in challenging situations.

Both deep engagement and bodily immersion, we have argued, may be able to account for the experience of feeling as if one was not present during performance. It is often said that we are the stories we tell about ourselves (see Schechtman, 2011, for an overview). If so, it makes sense that without any long-term memories of an episode in our lives, we would feel that during that period we were not there; the self disappears during those episodes because we have a narrative gap in our lives. Yet, although both deep engagement and bodily immersion can lead one to feel as if one had missed one's own performance, this judgement is merely retrospective. During neither deep engagement nor bodily immersion, as we have explained these attentional states, does the self disappear: in the former, one never disappears, as one is always there, exclusively occupied with the momentary task at hand; while in the latter, one is there focusing on aspects of one's bodily movements that cannot be put into words.

We conclude that if either of our proposals is correct, reduced memory in challenging conditions is not problematic for theories of skill, such as Mesh, that maintain that when a task is formidable, the enactment of expertise requires conscious thought.

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