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CLINICAL REASONING

The medical pause: Importance, processes and training

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Abstract

Research has shown that taking 'timeouts' in medical practice improves performance and patient safety. However, the benefits of taking timeouts, or pausing, are not sufficiently acknowledged in workplaces and training programmes. To promote this acknowledgement, we suggest a systematic conceptualisation of the medical pause, focusing on its importance, processes and implementation in training programmes. By employing insights from educational and cognitive psychology, we first identified pausing as an important skill to interrupt negative momentum and bolster learning. Subsequently, we categorised constituent cognitive processes for pausing skills into two phases: the decision-making phase (determining when and how to take pauses) and the executive phase (applying relaxation or reflection during pauses). We present a model that describes how relaxation and reflection during pauses can optimise cognitive load in performance. Several strategies to implement pause training in medical curricula are proposed: intertwining pause training with training of primary skills, providing second-order scaffolding through shared control and employing auxiliary tools such as computer-based simulations with a pause function.

1 | INTRODUCTION

Research has revealed that medical errors are among the leading causes of preventable deaths each year.[1,2] The widespread agreement that health care delivery can harm patients has spurred a movement towards quality improvement and diverse strategy application to improve patient safety.[3] The *timeout*, where the current course of action is paused and the parameters of safe care are reassessed, has been adopted as safety strategy in many settings.[4,5] Although studies have shown that taking timeouts significantly decreases patient morbidity and mortality,[6-8] compliance with timeout protocols appears to be low, diluting its clinical benefit.[5,9,10]

We posit that the basic nature of the timeout is *pausing*, a conscious decision to stop current performance for a physical time that allows for additional cognitive activities. While medical timeouts in general refer to a formal practice with structured protocols in a team setting (eg surgical timeout, diagnostic timeout),[11,12] pausing can occur either individually or collectively, with or without formal protocols. Pausing as a general construct and strategy can potentially advance safety and learning in medicine. Yet, to date, we do not have a theoretical understanding of what constitutes a pause and how pausing might benefit clinical outcomes and spur cultural changes.[13]

In the following, we aim to explicate the importance, processes and training of the medical pause. First, we will focus on the unique advantages of pausing: intercepting negative momentum and promoting learning (Importance). Second, we will describe a new conceptual framework of pausing by analysing its constituent cognitive processes (Processes). Third, moving from a theoretical basis to practical implementation, we will suggest several strategies to train pausing within the medical curriculum (Training). Based on our combined experience in both educational psychology and clinical work, we will integrate existing theories from various fields (eg cognitive psychology and complex learning), resulting in a systematic conceptualisation of the medical pause.

2 | IMPORTANCE: THE STRENGTHS OF PAUSING

Problem solving is one of the major approaches to clinical reasoning.[14] Using an elaborated version of dual-process theories[15,16] and cognitive load theory,[17] we will describe how clinical problem solving is guided by three different levels of cognitive control: skill-based, rule-based and knowledge-based control (Figure 1).

Skill-based control (SC) is activated when dealing with a routine task, using cognitive rules internalised through repetitive practice. When faced with a patient who has ventricular fibrillation, an experienced emergency physician can quickly ensure that the team prioritises chest compressions and defibrillation. With years of training and experience, this process becomes automatic and intuitive (ie autopilot). When problems are not entirely routine but familiar enough to apply internal or external rules, *rule-based control* (RC) is initiated.[16] Using checklists during surgical timeouts or following step-by-step instructions for procedures like central line insertion are examples of this process. For atypical and novel problems, *knowledge-based control* (KC) is stimulated, where 'knowledge' means mental models or schemas of a domain that reflect how concepts in the domain are structured.[18] When diagnosing a patient with a complex presentation (eg adrenal insufficiency as a cause of hypotension), a physician may need to consider alternative diagnoses by reflecting on similar cases and building upon relevant knowledge. Whereas the level of conscious control and its derived cognitive load are highest in the case of KC, they are lowest when practising SC.[19]

In real-life problem solving, these three levels run in parallel, with weighted focus depending on the activity.[16] Figure 1 depicts how this focus shifts across the levels: *slowing down*[20] as the focus moves from SC to KC, and *speeding up* when the opposite is true. During a routine operation, a surgeon who notices atypical anatomy would pause the procedure to reassess a list of alternatives and carefully apply the selected alternative (ie slowing down). Once this step is completed, this surgeon would return to the faster autopilot mode (ie speeding up). Note that this transition is feasible only for experienced performers since novices can neither identify cues that initiate the transition nor effectively change their focus as they lack structured schemas and skills.

While the speeding-up process has been highlighted in the professional skill acquisition literature,[21] the slowing-down process has been emphasised in the context of safety culture and expertise maintenance in medicine.[22] Moulton et al identified slowing down as a crucial component of medical expertise, coining the phrase 'slowing down when you should'.[23] They characterised pausing as the most extreme form of slowing down.[24] While slowing down has been described as a cognitive process that may accompany physical manifestation, we further specify pausing as a cognitive and temporal process grounded in the physical world. This physicality grants pausing two unique advantages: pausing allows for (1) explicit interception of negative momentum and (2) dedicated time for necessary processing at the KC level, such as learning.

In experimental psychology, *negative momentum* is a state stimulated to move away from desired goals.[25] Using an analogy from physical laws, the psychological state keeps its current motion, unless extra force is applied to change that state.[26] We identified two examples of negative momentum in medicine: the *hurry-up syndrome*[27] and *drifting*.[24] The term hurry-up syndrome has been used in aviation safety research which reveals that time pressure is significantly correlated with errors and safety risks.[27] In medicine, time pressure and clinical acuity can cause the hurry-up syndrome, resulting in medical

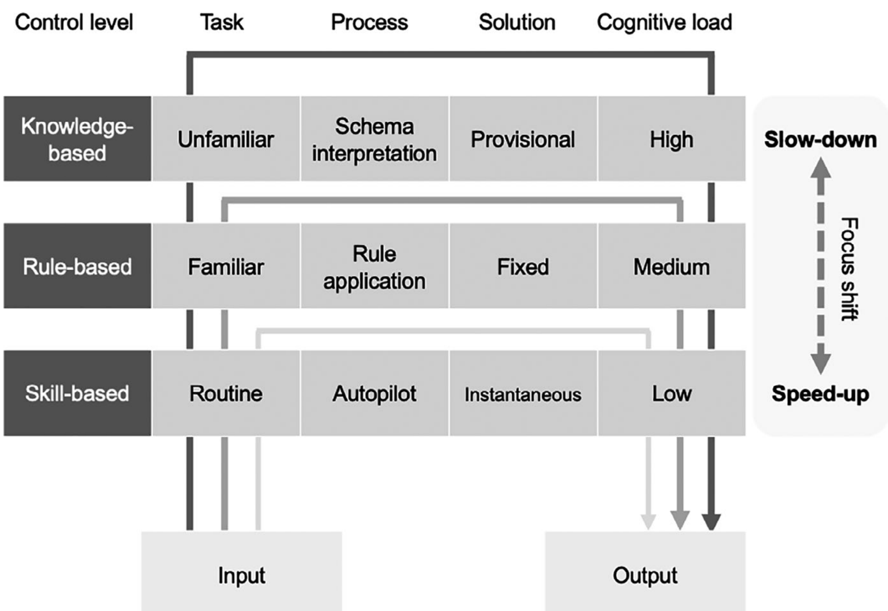


FIGURE 1 Three levels of cognitive control in real-life problem solving (skill-based, rule-based, and knowledge-based). The two-way arrow on the right side represents two different directions in focus changing across these levels (slowing down and speeding up)

errors and safety issues. Facing this negative momentum, novices tend to act quickly but inappropriately. To encourage them to rather stay undetermined and take a pause, experienced surgeons teach their residents the phrase, 'Do not just do something, stand there'.[8]

While this undetermined neutral status can be beneficial sometimes, mind wandering or inattentiveness can be less advantageous, comprising another example of negative momentum.[28] Contrary to the hurry-up syndrome, drifting is the distracted state arising from 'boring' tasks and complacency.[24] During routine tasks in an operation, surgeons could become careless and join extraneous chatting with colleagues, failing to monitor adverse events as they emerge.[24] They inappropriately remain at the SC level, without allocating the cognitive resources that are freed up by automatic processing to essential activities.

After direct interruption of these types of negative momentum, pausing inserts a certain period of time that not only makes the interruption stronger but also facilitates additional processing at the KC level. We postulate that this processing promotes learning since it allows for a reconstruction of schemas. Ericsson[29] argued that expert performance can be maintained by continuously seeking out learning opportunities, referred to as *deliberate practice*. Deliberate practice includes resisting the tendency towards complacency and deliberately reconstructing schemas by spending additional time analysing everyday performance.[29] Since learning opportunities from pausing arise during performance, they are strongly fostered by fresh memories and embodied experiences that pre- or post-timeouts cannot provide.

The benefits of pausing are evident and long-term compared with the costs. Rall et al[8] have shown that if trained sufficiently, only 10 seconds of timeout can be effective to improve performance in an emergency setting. The time lost taking timeouts is offset by improved team action, while the delay does not significantly jeopardise performance.[8] Moreover, enhanced safety will not only prevent patients from suffering from complications but also protect health care professionals from suffering psychologically from medical errors.[30]

3 | PROCESSES: KEY COMPONENTS OF PAUSING

We identified two phases of pausing: the decision-making phase to determine when and how to take pauses and the executive phase to apply cognitive activities such as relaxation and reflection during the pauses. To make pausing skills effective, multiple cognitive and metacognitive processes must be functioning across these phases.

3.1 | Decision-making phase

While negative momentum should be interrupted, there is also *positive momentum* that should not be interrupted but rather supported during medical workflow; in other words, 'not slowing down when you should not'. In extreme circumstances where expediency must be prioritised (eg emergency caesarean section), the opportunity to slow down does not exist. In team performance, taking an individual timeout could interrupt collective performance. Literature in psychology and brain sciences has confirmed that slowing down may impair performance depending on the situation.[31,32] Therefore, deciding on whether or not to pause becomes a highly advanced clinical judgement, involving time management to assess the time available and the risk of using the time.[8]

3.1.1 | Planning

The deployment of pauses can take two forms: proactive planning or responsive improvisation.[33] Pausing can be proactively planned before a task, by identifying landmines that require special attention.[33] These landmines are determined by assessing the task complexity and the performer's own capability. Through this assessment and mental simulation, one can establish a game plan[33] where measures for the landmines are arranged. For instance, a surgeon who previously experienced difficulties performing lung resection might plan a pause before the challenging portion of the procedure. Expert performers are good game planners who excel in predicting what is going to happen during a procedure, thanks to their superior mental simulation.[33]

3.1.2 | Improvising

Responsively improvised pauses, on the other hand, take place when encountering unexpected events (eg recognising an abnormality in patients' anatomy during surgery) or unsolvable problems (eg initial treatment not working during resuscitation). Realising unexpected landmines along the way, performers must make emergency decisions on taking a pause. This form of decision making is extra demanding because it involves the adjustment of the original game plan, quick problem solving, accurate calculation of the time available and constant vigilance for signals to pause.[33]

3.1.3 | Self-monitoring

Although this vigilance is a prerequisite for pause deployment, the negative momentum is sometimes the result of vigilance decrement.[34] In considering this dilemma, we argue that introducing metacognition,[35] another level of cognitive processes that can oversee cognition itself, might be a solution. Self-monitoring is a metacognitive process to supervise one's own thoughts and mental status.[18] Overseeing one's own monitoring capability could be a measure to help prevent vigilance decrement.

3.1.4 | Cognitive load

We use cognitive load theory (CLT)[19,36] to further explain *what* and *how* to self-monitor. CLT presumes that diverse mental processes evoke cognitive load on working memory and that task performance deteriorates if the load exceeds working memory capacity. Research has shown that vigilance produces a tangible amount of cognitive load,[34,37] which means performers should always reserve sufficient capacity for this process in working memory.[23] To stress the importance of this reservation, we suggest a new typology of cognitive load: primary load (PL) caused by domain-specific primary tasks (eg a surgical task), secondary load (SL) from domain-general processes that support the primary tasks (eg self-monitoring during surgery) and extraneous load (EL) that does not contribute to the tasks (eg distracting conversations during surgery). Thus, the targets of self-monitoring are narrowed down to two constructs: whether the room for SL is reserved and whether the total load is below the limit.

Conceptualising cognitive load and its typology with explicit terminology guides performers on how to self-monitor. It facilitates the conscious control of behaviour,[38] providing a useful internal cue for self-monitoring that can be measured by introspection.[39] In various medical domains, cognitive load is known as a valid indicator of expertise, performance, and learning.[39-42] The internality of the cue is valuable in many domains of medicine, where access to information on decision support may be limited and professionals often work alone or with less experienced staff who may not be able to provide high-quality feedback.[23]

3.1.5 | Collective decision making

In team performance, more external cues and interventions are necessary. To develop external cues, the team could use real-time clinical decision support[43] and encourage themselves to think aloud during performance. Based on this shared mental profile, the team leader or a separate overseer could make decisions to improvise pauses. When the cues are insufficient, forced pauses initiated by formal timeout protocols can be of benefit.[44] I-PASS[45] and SBAR[46] are good examples of organisational efforts to implement interventions to facilitate medical pauses.

3.2 | Executive phase

Once a decision to pause is made, the processes to optimise internal and external resources ensue to redirect the negative momentum. In the stress literature, this optimisation is essential to titrate the stress level below distress while maintaining the eustress status, thereby maximising performance.[47,48] Similarly in CLT, to promote performance and learning, cognitive load should be kept below working memory capacity, but not too low in order to maintain PL and SL.

We identified two types of processes to find the optimal level: *relaxation* that reduces overload in working memory and *reflection* that interconnects working memory and long-term memory to restructure schemas. In difficult resuscitation cases, a physician may pause the case to calm down (relaxation) and 'recap' the current situation by summarising previous performance, asking for others' ideas, and preparing next priorities, based on experience and knowledge (reflection). Experienced physicians are reportedly better skilled in these coping strategies,[41] likely because of their honed reasoning based on the assessment of internal and external resources in given situations.[49]

3.2.1 | Relaxation

Figure 2 describes the state transition of the cognitive load level triggered by several factors as well as relaxation and reflection. The state of being *overloaded*, sometimes referred to as 'helmet fire', is caused by adverse events such as time pressure, life-threatening complications, and overwhelmingly complex task environments. This results in acute stress and heightened emotions, contributing to either PL or EL depending on the task.[50] Through relaxation processes, the overloaded state can transition to the *freed-up* state, as the source of overload is managed or the depletion of working memory is recovered through cognitive rest.[51]

Among several relaxation techniques,[52] deep breathing has been recommended for clinical settings as the fastest and simplest technique.[53] Deep breathing, or diaphragmatic breathing, works as a brief form of meditation inserted within performance.[54] Empirical studies show that it reduces stress, anxiety, self-doubt and cortisol levels,[55] also benefiting performance and learning, such as working memory enhancement, and motor skill acquisition and retention.[56,57]

3.2.2 | Reflection

The freed-up state is a transient phase where relaxation or the speeding-up processes have created spare capacity for potentially

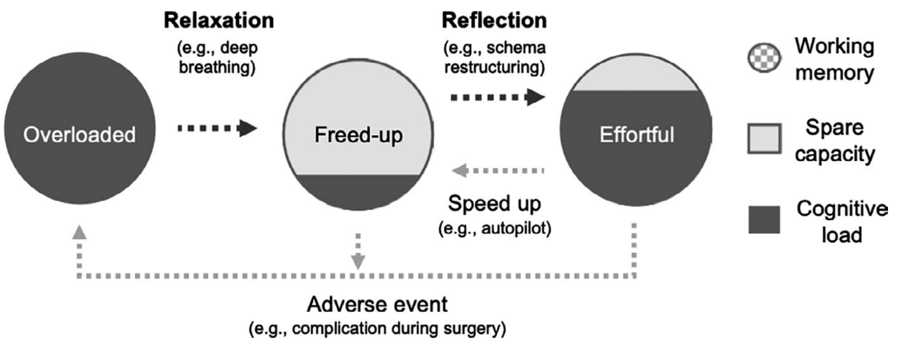


FIGURE 2 The cognitive load state transition triggered by relaxation and reflection during pauses, as well as speeding up and adverse events. Since some tasks do not allow for the opportunity to take a pause, deciding on whether or not to pause becomes a highly advanced clinical judgement

any type of cognitive load to be imposed. This spare capacity can be filled with either positive sources (PL and SL) or rather negative sources (EL). Through reflection, positive load is activated and the freed-up state transitions to the *effortful* state. In this state, cognitive resources are reallocated more efficiently to maintain control over performance.

Reflection is a form of cognitive restructuring vital in every practice of medicine.[58] By interconnecting working memory and long-term memory, it allows for creative solutions or a 'fresh look' by redefining the given problem. Reflection may improve learning as well as performance,[59] since the act of cognitive restructuring promotes the development of mental models. Diverse medical training has included reflective activities to promote learning processes.[12,60]

3.2.3 | Drifting

When spare capacity is devoted to EL (eg listening to the radio during surgery), the freed-up state transitions to rather negative states such as drifting, where cognitive resources are not invested in essential monitoring activities. By removing the source of EL (eg turning off the radio), this state may revert to the freed-up state and move forward to the effortful state by increasing SL.

4 | TRAINING: PRACTICAL IMPLEMENTATION

Now that we understand the importance and processes of pausing, the next issue to be addressed how to train it. We suggest that (1) pausing should be trained within the regular medical curriculum from the start (intertwining), (2) customised support should be provided until the learner can make pauses independently (scaffolding) and (3) auxiliary tools (eg checklists) and learning environments (eg computer-based simulation) can be used.

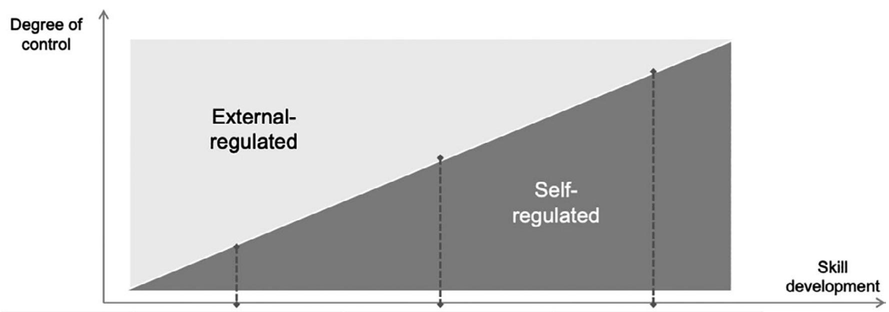
4.1 | Intertwining and scaffolding

Pausing skills cannot be taught by a separate course alone since it is a domain-general secondary skill that is interlaced with domain-specific primary tasks.[18] Research in education has shown that teaching secondary skills outside of primary skills training consistently fails.[61] Moreover, transitioning between different cognitive control levels is not feasible without domain-specific schemas in long-term memory. Thus, it is necessary to *intertwine* pausing skills training with a primary skills training curriculum from a very early stage.

Given this necessity, the question that arises next is how to guide novices throughout the curricula. Making a pause meaningful is a highly advanced skill that requires clinical expertise and workplace experience. According to instructional design models,[18] training programmes for complex skills should be presented in a simple-to-complex manner, through scaffolding where support and guidance gradually decrease as learners become more experienced. While scaffolding is generally referred to as a technique for domain-specific skills, *second-order scaffolding* is the technique designated for domain-general skills.[18]

Figure 3 demonstrates a second-order scaffolding model for pausing skills. Since practical skills such as pausing can only be taught by hands-on experience,[62] some degree of direct control to initiate pauses should be granted to learners throughout a program. During this program, supervisors have a dual responsibility: they must transfer short-term and direct control to learners while maintaining global control of the training.[63] To find a balance, supervisors should first assess the learner's level of competence, after which both supervisor and resident can negotiate the distribution of control. The degree of supervisor control should be maximised for beginners (ie external-regulated) and gradually reduces in favour of learner control as the learner becomes experienced (ie self-regulated).

To teach proactive planning of pausing, learners should have the opportunity to plan for a scenario, rather than merely having a brief



	Beginner	Intermediate	Advanced
Planned pausing	Supervisor-plan	Shared planning	Learner-plan
Improvised pausing	Supervisor-control	Shared control	Learner-control

FIGURE 3 Second-order scaffolding to improve pausing skills. While first-order scaffolding applies to domain-specific skills, second-order scaffolding pertains to domain-general skills. As a learner becomes more experienced, the supervisor's support in planning

look at the patient chart. During this activity, supervisors should provide a framework to predict the landmines that require special measures. By explicitly locating the required focus, learners can deploy either informal or formal timeouts. To maximise learning opportunities, this plan should be thorough and specific to a particular case (eg 'for this scenario, I will pause to be extra reflective at this point').[63]

Learners can train improvisation of pausing by modelling the initiation of in-action pauses. In the case of novices, the supervisor should take full control of such initiation, while the learner acts as observer. By attending various unexpected real-life events (eg manpower shortage, malfunctioning equipment), the learner can develop his or her own measures (eg 'if this happens to me, I will quickly assess how much time I have and initiate a timeout'). As the learner becomes more experienced, the supervisor's support in planning and improvising would gradually disappear, eventually resulting in full control by the learner.

In many training programmes, prompting learners to construct such If-Then cognitive rules[18] as an anticipatory strategy is already a common teaching method. Thus, integrating these cognitive rules for pausing might be easily embedded in existing programmes. Additionally, using auxiliary tools such as checklists or debriefings can be a beneficial approach to scaffolding. For instance, diagnostic checklists can help learners to train what to reflect on during pauses. Debriefing about how the executed pauses contributed to performance could also afford additional learning opportunities.

4.2 | Simulations with a pause function

Simulated task environments offer favourable learning opportunities for medical training.[18] They present diverse scenarios without risking patient safety or loss of materials, provide better control over the format of learning content (eg sequence of tasks, support and guidance) and make it possible to pace the task progress. This flexibility in format and pace facilitates second-order scaffolding for pausing skills: Instructors can tailor their level of intervention to teach pausing by modulating the task progress, as learners' competency grows.

A promising way of training pausing skills is to use computer-based simulation (CBS) which allows for easy instalment and practice of pause functions. Diverse CBS formats, such as web-based multimedia, serious games and virtual or augmented reality, have been used to replicate clinical settings.[40,64] In any given format, learners can practice the planning and improvisation of pauses merely by pressing a pause button. Empirical studies have shown that novices experience more cognitive load during CBS training than experts do, and that pausing may significantly help them to manage this load, especially during moments of panic (eg when virtual patients have a seizure).[40,65] However, since students reportedly tend not to understand the importance of pausing,[65] CBS training with a pause function should include specific instructions for students to acknowledge the importance to initiate effective pauses by referring to relevant cues.

Another advantage of using CBS is that it produces objective real-time data (eg log data of serious games) about performance that can be used as these cues. By integrating it with other types of data such as eye movements, the data can become even richer. Eye-tracking is a novel technique that provides specific information about users' cognitive processes during human-computer interaction.[66] For instance, the level of self-monitoring or vigilance can be measured by recording how gazes are allocated across different objects.[40] The level of cognitive load can be also measured in real time via pupillometry.[41,67]

5 | DISCUSSION

In this article, we identified pausing as a professional skill used to interrupt negative momentum and facilitate reflective performance and learning. The constituents of pausing skills were categorised into two phases: the decision-making phase (planning, improvising and self-monitoring) and the executive phase (relaxation and reflection). We argued that training programmes should be systematically designed to cultivate pausing skills.

The main contribution of this work lies in that it connects key concepts in safety culture that have been discussed in different contexts and brings them back to the fundamental principles of the medical pause. We have linked the practical observations and strategies from studies on slowing-down phenomena identified by Moulton et al[20,23,33] and checklists by Pronovost et al[68,69] We then recognised the cognitive mechanisms shared between the basic concepts in these studies and integrated them within a broad range of clinical activity. This will move the literature one step further as it supports the arguments of the previous studies on formal or informal timeouts and allows future researchers to build upon the literature through our newly developed understanding. Moreover, since the idea of the medical pause can be easily applied to various health professions, more practitioners may consider how to adopt a simple habit of pausing, allowing the existing discussions on slowing down and checklists to develop.

Another contribution of this work is that it provides practical techniques to implement pausing in training programmes as well as examples of application, which serves as a translational education effort. This provision may be of value to educators seeking to design better training programmes that foster the habit of reflective practice. They can start by introducing simple applications such as checklists that prompt learners to plan and improvise pauses on their own. Moreover, we discussed cognitive constructs using the new terms of primary and secondary cognitive load, which may facilitate explicit communication for supervisors and learners to jointly develop second-order scaffolding.

We identify two limitations to this work. First, we did not consider other factors that might influence the practice of pausing (eg personality, emotions and social pressure). For instance, social pressure to make enjoyable conversation during an operation would likely affect the decision making of pausing. This social aspect of pausing can be further studied in the field of social capital in medicine. Second, since we mainly focused on theoretical conceptualisation, empirical evidence is lacking. We, therefore, welcome future studies that empirically verify the effects of medical pausing on performance and cognitive load, and the pragmatic consequences of pause training.

Medical practitioners, being either overloaded or underloaded, can lose control over their performance leading to undesirable consequences. To improve patient safety by effecting cultural and fundamental changes, the acknowledgement of the medical pause should be nurtured through communication, education and skill-building opportunities. As a result, mastering the medical pause may become an integral part of clinical expertise, in such a way that medical professionals strategically deploy pauses in the heat of the moment by knowing when and how to pause.

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CONFLICT OF INTEREST

No competing interests exist with regard to this article.

AUTHOR CONTRIBUTIONS

Joy Yeonjoo Lee is the main author of this work. She contributed to (1) the conception or design of the work, (2) drafting and revising the manuscript critically, (3) final approval of the manuscript and (4) agreement to be accountable for all aspects of the work. Adam Szulewski is a coauthor of this work. As an expert in emergency medicine, he contributed to (1) the conception or design of the work, (2) drafting and revising the manuscript critically by giving concrete examples from his work experience, (3) final approval of the manuscript and (4) agreement to be accountable for all aspects of the work. John Q. Young is a coauthor of this work. As an expert in medical education and psychiatry, he contributed to (1) the conception or design of the work especially making sharp ideas about safety culture in medicine, (2) drafting and revising the manuscript critically by giving concrete examples from his work experience, (3) final approval of the manuscript and (4) agreement to be accountable for all aspects of the work. Jeroen Donkers is a coauthor of this work and a supervisor of Joy Yeonjoo Lee. As an expert in medical education, he contributed to (1) the conception or design of the work, (2) drafting and revising the manuscript critically by giving concrete examples from his work experience, (3) final approval of the manuscript and (4) agreement to be accountable for all aspects of the work. Halszke Jarodzka is a coauthor of this work, and a supervisor of Joy Yeonjoo Lee. As an expert in education sciences, she contributed to (1) the conception or design of the work, (2) drafting and revising the manuscript critically, (3) final approval of the manuscript and (4) agreement to be accountable for all aspects of the work. Jeroen van Merrienboer is a coauthor of this work and a supervisor of Joy Yeonjoo Lee. As an expert in theories in medical education, such as complex learning and cognitive load theory, he contributed to (1) the conception or design of the work, (2) drafting and revising the manuscript critically, (3) final approval of the manuscript and (4) agreement to be accountable for all aspects of the work.

ETHICAL APPROVAL

Not applicable for ethical approval. This is a theoretical paper.

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