Perfect Practice: The Implications of Contextual Interference for Yongmudo Training

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Psychological research into the processes of learning and performance in sports and physical activities, "sport psychology," has a more recent history than some other psychological fields and less popularity than the recent explosion in neuroscientific pursuits. However, what research exists, when combined with work on motor learning more generally, has been grounded in a desire to successfully answer questions about applied aspects of physical activities, and benefits from a clear focus on the implications and applications of its basic research, as well as an examination of basic theories and literature of applied experiments. Sport psychology and motor learning findings are useful for the martial arts precisely because these questions about learning physical skills and performing them in stressful situations applies directly to the goals and methods of learning a martial art, even if one does not compete in tournaments, or use it in actual physical conflict.

In this paper, I discuss a topic I feel is relevant to martial artists for their training (or the training of others). These observations cannot be taken as absolute prescriptions: the research literature still leaves too many questions unanswered to give direction without any conscious and considered qualification, and my own interpretations and questions are mainly intended as food-for-thought. One substantial resource was Williams and Hodges excellent

compilation, Skill Acquisition in Sport, which is recommended for anyone interested in learning more about the research on these topics, despite the questions still unanswered, (and even for readers with only a mild tolerance for scientific language). Each chapter of the book is a substantial but accessible review of the sport psychology literature on one aspect of skill acquisition in physical activities, and each chapter's author delves into the issues of their topic more thoroughly (and with more references for further exploration) than the few discussed here.

Modern martial arts training is based on and inspired from traditions often as old as the martial art itself (or older than the art, if a training method was passed down through styles that preceded the specific art in question). Yongmudo may not stretch back to the dawn of time but the jujitsu art it is based on adds another substantial piece of history. Martial artists are always evaluating and seeking to improve themselves through their training, and the wealth of precedent makes for a rich set of methods and ideas to evaluate and consider for martial artists who must direct their own training or supervise the training of others. Sport psychology seeks to examine and investigate the mechanisms underlying human training and performance in sports—or really in any activity that involves a complex system of specific movements performed under varying conditions and levels of stress for a specific purpose or goal. One area of recent research into the how of training—contextual interference—raises issues that are directly relevant for training considerations and invokes questions related to the recent re-conceptualizations (within psychological literature) of what expertise is and how improvement might be conceived of and trained for more effectively.

Contextual Interference

The time-honored adage, "practice makes perfect," reflects the observation that, all other things being equal, the amount of practice an individual engages in for an activity is directly correlated with their acquisition of skill and their improvement of performance for that activity. A popular modification to this phrase, "perfect practice makes perfect," reflects the concept that optimal performance during practice (having a "perfect practice") is the most effective way to acquire skill and improve performance. While perfect practice intuitively makes sense (it seems that individuals would have little to gain from practice that ingrained inefficient or incorrect habits or had nothing at all to do with developing the desired skills), research into the phenomena of contextual interference suggests that another—critical—look at the idea of perfect practice is needed. The reason for this is summarized succinctly by Lee and Simon in the introduction to their synthesis of the literature: "attempts to optimize both performance and learning in practice are generally doomed to failure"[1]. Such a conclusion suggests that—contrary to the assumption of "perfect practice makes perfect"—we must choose between achieving perfect practice and making perfect at all.

This might seem puzzling at first (why would anyone training in a physical activity want to avoid making optimal performance a habit?), but past research suggests optimizing performance in practice and learning in practice are two different goals that may interfere with each other. Lee and Simon begin their review of during-practice performance and overall learning with a 1919 experiment by Pyle where

participants engaged in two slightly different card sorting tasks. Their practice opportunities were either a set of blocked trials, where one task was practiced for a number of trials in a row, and then the second task was practiced for a similar number of trials in a row, or a set of alternating trials, where participants alternated between the two tasks (where the specific difference was the spatial arrangement how the cards were to be sorted).

Pyle's conclusion, after observing that changing conditions for the alternating group degraded their performance in the sorting task compared to the blocked trials group, was that "it is not economical to form at the same time two mutually inhibitory sets of habits. The better procedure is to form one, and then the other."[2] What has been hinted at here is that Pyle's observations, while correct, were based on individual performance during practice itself. This during-practice evaluation has remained a common experimental assumption in studies on skill acquisition, despite growing the empirical evidence that advocates for using transfer trials and post-practice retention as better measures of overall skill acquisition. For research purposes, retention is essentially the degree of successful performance of a skill at a specified point after it has been learned or sufficiently practiced in the first place. Transfer is the ability to apply general knowledge from one practiced task to another different and previously unpracticed task.

Despite Pyle's focus on during-practice performance, research by Shea and Morgan published in 1979 stepped outside of this methodological assumption with their study of individuals practicing three different laboratory tasks that involved knocking over a specific

set of three out of six wooden barriers with a tennis ball and replacing the ball at the end of the movement, performed as quickly as possible. The tasks differed in which of the six barriers was to be knocked over, based upon the color of a light that flashed to indicate the start of the trial. The two experimental groups, like Pyle's study, differed only in the order in which they practiced the tasks before performing it in two final retention trials, one trial ten minutes after the end of all the practice sessions, and the other ten days after the practice sessions.

Over a total of fifty-four trials, the blocked experimental group practiced the first task for eighteen trials, then the second for another eighteen, and the third task for the remaining eighteen trials. For the random experimental group, the order of the three tasks was randomized so that no task appeared more than twice in a row, but that all three tasks were practiced three times within one set of nine trials. Ten minutes after these practice sessions (in which the participants rested from their practice), the first retention trial began.

For both retention trials, half of the participants of each group—the blocked or random experimental group—completed a randomized set of the three tests, and the other half completed a blocked set of the three tests (in their original order). While the performance results for Shea and Morgan's practice sessions (the total time it took participants to respond and complete the movement task) are quite similar, between the blocked and random groups with blocked groups showing greater performance on the tasks during the practice sessions (especially when some differences in the presentation of results are corrected[3]), the results for the

retention trials galvanized researchers examining the effect of practice variables in motor learning.

For Shea and Morgan's participants, those who had engaged in randomized practice and took a blocked or randomized retention task after ten minutes performed the best (approximately 1.1 seconds and 1.3 seconds, respectively), compared to those who had engaged in blocked practice and took either a blocked or randomized retention task ten minutes later (approximately 1.5 seconds and 2.1 seconds, respectively). For the retention task ten days later, participants taking a blocked retention trial performed best (approximately 1.2 seconds for those from the random-trials practice group, and 1.3 seconds for those from the blocked-trials practice), participants who had practiced with random trials and were taking a random trial retention task completed their task in approximately 1.4 seconds on average, and those participants who had practiced with blocked trials and took a random trial retention task took the longest at approximately 2.1 seconds.

The phenomenon documented in Shea and Morgan's work was eventually labeled "contextual interference" and sport psychology and motor skill acquisition researchers are still examining its occurrences and pondering its potential mechanisms. That practice order should have differing effects on (differing interference of) performance during skill acquisition and practice, skill retention, and skill transference, which has significant ramifications for learning any task via structured practice opportunities. For later research, interference has been repeatedly encountered in the variation of practice contexts, although with multiple definitions that differ slightly in their details.

Work by Schmidt[4] defines variable practice as "a schedule of practice in which many variations of a class of actions are practiced." In contrast, Magill[5] presents variable practice as a "variety of movement and context characteristics a person experiences while practicing a skill." For Schmidt, random practice is first defined as a "practice sequence in which tasks from several classes of skills are experienced in random order over consecutive trials"[6], but then later as "a practice sequence in which individuals perform a number of different tasks in no particular order, thus avoiding or minimizing repetitions of a single task"[7]. These differences in definition reveal the need for the field to fully flesh out the exact conditions in which these three potential measurements of learning and performance are differentially affected by the structure of practice, but overall, observations of the phenomena remain for anyone interested enough to look for it.

For martial artists, teachers and students alike, the research on contextual interference has several implications for training structure (both in understanding what exists already and thinking about future changes or additions). First is an issue that could arise from uncertain definitions: for martial artists (and Yongmudo practitioners in particular), what and where is the distinction between those activities considered practice and those considered tests of transfer or retention?

For competitive sports in general, the point of practice is to improve performance in a defined setting—the actual competition or game with high levels of emotional and physical engagement, and significance, between competitors of ability that is not

controlled for and who are actively trying to outperform each other by engaging in their own best performance and/or interfering with the performance of the other competitor. For competitive martial arts, the distinction between practice and retention then is performance in class versus performance in a tournament situation. For those people who employ martial arts techniques in a professional capacity (law enforcement, soldiers, etc.), the difference is between training sessions in familiar, controlled settings with opponents who will follow rules to avoid actual injury, and actual altercations in unfamiliar situations with opponents who do not follow any rules and actively seek the individual's injury or death.

Yet there is another category, the martial student who neither competes nor uses martial arts professionally, who attends class for the self-empowerment it brings, or the discipline of character associated with dedication to an art but may never find themselves in what we have previously identified as a real performance situation where retention and transfer are essential. We risk obscuring the reality of martial arts practice to assume that any student should fit neatly into this category, but for students practicing with such a mindset (even if that is not the true situation of things), would the fuzzy, hypothetical definition of "real performance" serve to inappropriately bias them to focus on their practice performance to the detriment of longer-term, overall learning?

Second is the question of emphasis for each of the three possible performance measures mentioned: if one cannot optimize performance during skill acquisition without sacrificing skill retention and transfer, which

option is preferred true goal? For a self-defense oriented art such as Yongmudo, the clear answer is long-term retention and transfer of the motor skills and mental approaches to physical conflict, so that years from now even a former martial arts student can still remember how to remain more in control of the situation if someone hostile grabs their wrist, or how to minimize injury after slipping on ice—even if this retention springs only from their so-called muscle memory.

For many martial artists, this is a tricky goal to pursue without a clear understanding of the relationship between the options, and/or constant reminders about the overall goal of long-term learning. Working with a long-term timeline is tough, when many (if not all) martial artists are almost compulsively driven to fix their technique or improve their performance as soon as possible (a hopeful framework which may sometimes differ substantially from the limits of human ability, let alone the progression of long-term skill acquisition). Vickers, Reeves, Chambers and Martell (2000), after working with coaches in a variety of sports on putting to use sport psychology research like the findings from the contextual interference literature, noted the difficulty in properly translating and applying the basic idea that variable practice could translate into long-term retention, even with an apparent degradation in short-term performance and improvement:

> Our most experienced coaches had difficulty with the notion that skills could be trained in a variable and random manner without a conceptual or tactical reason openly governing the whole endeavor. We also found that some coaches with less experience interpreted a variable random practice environment as one

> where the athletes simply played the game without any overall goals or objectives to the training.[8]

It seemed that there was a very strong urge for coaches with experience to emphasize performance (getting things right) during practice, and so applying research on contextual interference in their practices forced them to personally come to grips with the question, "do we need students to perform well during practice, if they learn even better without doing so?"

However, in Yongmudo training, whether the knowledge of contextual inference and its applicability to class structures is wholly embraced or completely ignored is not a particularly appropriate question, as that would assume that Yongmudo training lies only within one state of the dichotomy (and, like assuming the actual existence of an archetypal student, it would obscure important facts about the reality of things). In fact, while many students (and perhaps a significant proportion of instructors) would assume that optimizing practice performance will lead to better overall learning (including retention and transfer), common structures of practice and the organization of Yongmudo techniques show that variations of technique absolutely litters practice time. The attention Yongmudo gives to a variety of different fighting situations (standing, on the ground, the transition of falling onto or getting up off the ground) and response methods (hard breaking techniques compared with soft flowing techniques) creates a wealth of opportunities for the comparison and contrast that underlies one of the theoretical accounts for why contextual interference occurs.

In the motor learning literature, the two most common explanations for contextual interference are the elaboration-distinctiveness view, and the forgetting-reconstruction view. As Lee and Simon point out, any explanation must account for the dichotomous effects of practice order on acquisition performance compared to retention and transfer, which these two accounts do, but not in a way that is mutually exclusive, and it is potentially even interactive. The elaboration-distinctiveness view is well summarized by Lee and Simon,

> The basic idea is that random practice, by virtue of the interspersing of the to-be-learned tasks, affords the learner many opportunities to compare and contrast the tasks. As a result of these comparisons and contrasts, the learner develops rich representations of the tasks and thus more elaborate and more distinctive memories are established. The need to keep the patterns unambiguous and to avoid confusion during practice is what causes the disadvantage during acquisition.[9]

This is compared with the forgetting-reconstruction, where each time a switch in the exact task occurs in a set of random practices, the learner must purge the old task's pattern (which in the research literature is often very similar, but not quite correct) from working memory to make space for the new task's pattern. Each time this occurs, the old task pattern is forgotten, and the new task's pattern is reconstructed in working memory. So, for blocked versus random practice trials,

> Uninterrupted repetition of the same pattern in blocked-practice makes for relatively high-quality performance, but the lack of practice at constructing the

> movement patterns anew supports relatively poor learning. In random practice, the opposite is seen: the need to continually reconstruct the to-be-performed action pattern from one trial to the next makes for lower quality performance, but affords an advantage in delayed tests of learning, which make high demands on such reconstruction abilities.[10]

Both ideas involve working memory, and their distinction lies merely in when: elaboration-distinctiveness occurs with the co-presence of the old and new patterns in working memory, and forces the learner to compare and contrast during practice; forgetting-reconstruction's hallmark is the loss of an action plan from working memory and need to regenerate it each time the task is required causes the interference. Because of the differences only in time, Lee and Simon note that both accounts may be occurring: first, more effort is required to load a new task into working memory than to continue using the old one, and second in order to successfully the construct the new task, comparisons and contrasts between the old and new tasks are drawn, taking more effort during practice, but creating a richer representation and increasing reconstructive abilities during later repetitions of the task for insufferably curious motor learning researchers.

While neither of these accounts rules out the other or is conclusively proven (as other explanations exist), both an elaboration-distinctiveness view and a forgetting-reconstruction view seem to have their counterparts in the Yongmudo curriculum. As noted before, one of Yongmudo's strengths for self-defense is the multiple groups of techniques (e.g., those for striking, for

throwing, for locking joints into uncomfortable positions) that students must learn and remember. Depending upon the instructor's direction, a single class can cover all of the major technical areas that Yongmudo uses, effectively forcing students to purge their working memory of what technique is going to be put to use multiple times in one class session in a way that does not happen in other styles that focus only on kicking or punching, or only on throws, or only on joint locks, etc.

At the same time, within each of these major areas of study, the study of multiple techniques from each group (e.g., working on several joint locks in a class session) provides students with an opportunity to compare and contrast the details of several techniques in a practice session, increasing the richness of student representations of each technique. One fun example of varied practice with joint locks seems most specifically to engage the reconstructive aspect of working memory: movement by the grabbed student from an "arm bar" joint lock into the nicknamed "motorcycle" technique and back again. These two techniques have been presented as examples of how easy it can be to "move on" when one's technique is not working for some reason.

If a student begins performing an arm bar on an attack, but the attacker managers to bend his/her elbow to mitigate the stress as the student seeks to finish the lock, instead of expending effort to straighten the attacker's arm and force the arm back into arm bar position, the student can instead simply following the retreating, arm-bending motion of the attack in to the body and slip the attacker's arm into the "Z" position characteristic of the same-side motorcycle wrist.

Additionally, across some groups of practice and in the normal method of switching training partners, Yongmudo students experience even more variation in the execution of techniques. As mentioned, one of Yongmudo's strengths is its study of self-defense techniques in a variety of situations that other styles may par down to one of two main focuses. However, in Yongmudo, the joint locks that in Aikido may primarily be studied while the students are standing or in otherwise pre-defined positions are in Yongmudo investigated for how they can be performed in many other situations, such as from the ground (or elsewhere) when two students are grappling and one wishes to apply a lock even though the student's training partner has control of the student's hips, which he/she would normally use in a specific, gravity-dependent way to achieve the lock.

Furthermore, the simple act of switching partners and repeating a technique on people of different sizes and body compositions is one of the most basic and yet most valuable ways of training with subtle variations to form a richer representation in the student's mind of one or a set of martial techniques. These structures of practicing a variety of techniques within one training session are very helpful in expanding a student's overall knowledge of the techniques, because such variation explains (implicitly or explicitly, depending upon the teacher's methods) the relationships and distinctions between the wide variety of techniques available and used by the Yongmudo practitioner, and prompts the student to repeatedly re-evaluate and reconstruct the tasks appropriately for the situation set before them, the knowledge and experience of which is extremely

useful for self-defense in real conditions of uncertainty and danger that often mandate efficient and effective adaptation, and benefit the most from successful technique retention and its transfer to new contexts.

What this literature might also recommend is even more conscious experimentation with variation in practice. Anecdotes about the teaching methods of accomplished and well-respected martial arts instructors seem to abound with initially terrifying or confusing—yet overall useful—variations to standard practice methods (an impromptu decision to switch from barrier rolls on soft mats to ones of hard floor, or to perform strike passes while stepping up and over obstacles, or simply perform some technique with one's eyes closed, just to "see what happens" when performance conditions are tweaked). Less-experienced instructors can follow such examples knowingly and use suggestions from the literature to add helpful variation to practices for their students.

For example, practicing proper hip motion while moving in formal stance work across the floor, students might perform one pass of solely reverse punch and one of solely front punch, but then another pass might involve alternating between the two hip motions required to reinforce the differences between them, and prepare the student to launch either type of punch with hip power from whatever kind of footwork they might find themselves in a conflict.

For higher ranking belts who should be very interested in performing the details of this motion correctly, such variations might play havoc at first with in-practice performance of the stance work. However, in the long run, this could very well result in better

application of strong hip motion in other contexts, such as power while sparring or successful coordination of force for board breaking, or better use of the hips in joint lock techniques or on-the-ground sweeping techniques. Additionally, the variation can increase concentration and motivation to continue working on the details of the technique for students who may be developing unwarranted comfort with their performance (like the variations of performing rolls on hard surfaces to test what detailed problems are obscured by landing on soft mats).

Indeed, research by Wulf, Lee, and Schmidt (unpublished), hypothesized that the contextual interference phenomenon occurs from the fact that random practice is more interesting, leading students to have higher levels of attention and motivation to achieve better performance and thus end up with an enhanced level of retention. The idea has not yet been tested rigorously as an explanation for contextual interference, however from a practical standpoint, motivation is still very useful to consider because although it may not yet be shown to be responsible for contextual interference, as Lee and Simon note in their summary and further directions section, motivation is an essential component of an individual's approach to training. If an individual does not have the motivation to train they do not, and whichever training structure (blocked or varied) they were planning to use is rendered completely irrelevant.

Problems with the motivation to train brings up one of the keys issues for the application of variable practice and its association with poorer performance during acquisition. The motivation that comes from

basic acquisition and good acquisition performance can be invaluable for anyone learning a new skill. Many people have had at least anecdotal familiarity with an activity that they "just couldn't get", and their decision to continue an activity (whether a sport, musical instrument, or career field) was based on their initial skill acquisition performance.

Returning to formal stance work as an example, for students with little to no prior martial arts experience, the variety of techniques practiced by passes of stance work can initially be a bit overwhelming. Working solely on the basic movements across the floor into front stances (any kind of blocking or striking left aside at the start) results in a number of initial passes of uncertain, slow and often jerky movement across the floor as students try to end up in the correct front stance, remember that their instructor seemed to be sliding more than stepping to maintain steady balance (a reason they cannot now remember when they try the movement themselves), while bending their knees appropriately and pondering what exactly the instructors mean by pushing power from the hips—let alone consistently distinguishing between the hip motions and foot work for executing a reverse punch versus a front punch.

It is in such a case that blocked trials of a previously unfamiliar technique would be worlds more helpful for motivation than launching right into variations between tasks—to allow for a basic level of acquisition performance in practice to aid in keeping the motivation of students high enough for them to continue practicing. For this reason, Wulf, Lee and Smith's suggestion has been considered most pertinent

for athletes who have already learned a technique sufficiently well, and for whom the blocked practice approach has become too easy (not necessarily boring, but less engaging than learning a new technique).

Issues with the motivation of students have been noted by researchers considering how the students feel about their own practice—their metacognitive attributions. Lee and Simon note that although such research had not been performed at that time,

> Metacognitive misattributions concerning performance and learning might be expected to have dire consequences if random practice schedules were to be strictly enforced in an applied setting, such as a rehabilitation clinic.[11]

Indeed, they continue to emphasize:

> Practice is a key law of learning, and that motivation plays a very important role in the continuation of practice on a task. Therefore, it might be expected that random practice could be doomed to failure if the learner does not feel that improvement (learning) is progressing as well as might otherwise be expected (e.g., in a blocked order).[12]

For these reasons, a "hybrid practice schedule," has been proposed in the research literature (even if hybrid schedules, whether implicitly or explicitly categories as such, are already de facto in common training use across sports). The few attempts to study this, such as described by Al-Ameer and Toole in 1993, or Simon et. al. in 2002, have yet to reveal as robust phenomena as the original experiments and replications, but the design of these experiments holds "significant promise" for further research.

In addition to the working memory-focused accounts of contextual interference and discussion about metacognitive attributions as an explanation, Lee and Simon also discuss several other alternatives, though not as commonly cited, which include views that add greater variety to interpretations of the contextual interference phenomenon. While much of the research is not satisfactorily examined for explaining contextual interference, most all of it touches on observations and ideas that could be relevant for a martial artist looking for different ways to approach training, and thoughts on how and/or why these approaches can help or hinder skill acquisition.

The first mentioned is retroactive interference, the concept that "later experiences affect memory for earlier learned associations" (for example, retroactive interference helpfully interferes with your memory for an old cell phone number when you receive a new one; or overwrites the memory of yesterday's parking space with where the car is parked today). In her 1988 Ph.D. thesis, Carol Poto applies this to motor learning and suggests that "later learned patterns in blocked practice tend to act backwards to attenuate the memory strength of earlier learned patterns."[13] The theoretical implications of such an explanation include the occurrence of an observable recency affect to distinguish the tasks when performed in blocked practices: the task last practiced in the blocked trials should show the greatest retention, at the expense of the other tasks, because of this overwriting. However, Magill and Hall dispute this view, on the grounds that research by David Wright about retroactive interference reduction as a way of showing its effects

on contextual interference (less interference should mean less overwriting of the non-recent tasks) did not result in better retention between the groups with normal retroactive interference and reduced retroactive interference. Comparing the blocked versus random trial groups regardless of their retroactive interference reduction showed the same differences in improvement.

Another useful, and more detailed piece of this picture is the work by Del Ray, Liu, and Simpson who found contributions of retroactive interference to contextual interference effects—but for reaction times (the delay between receiving a signal to start and beginning the actual movement, in which the participant is assumed to have noticed the signal and mentally planned the movement) and not for movement times (the actual movement execution itself). So, while the recency effect could be put to use for martial artists training specific skills and retroactive interference for prepping reaction for specific instances (such as right before a tournament), for the long-term retention of self-defense motor skills, this is not an avenue to strongly pursue.

Several other interpretations of the contextual interference phenomenon discuss spacing effects— deciding that contextual interference occurs because individual trials in a random schedule are spaced out compared to those in a blocked practice schedule. There is considerable empirical evidence to suggest that spacing of learning opportunities can facilitate learning, as compared to massing of such opportunities. It is unlikely, however, that "the standard spacing effect is attributable to time per se, but rather due to the cognitive activity that is afforded by spacing delays"[14].

This clarification is important to consider, regardless of what is behind the contextual interference effect. An area in which the reason for such a clarification comes to light is from research that found sleep to be beneficial for learning. This has been examined in studies where participants worked to memorize a list of words or complete a specific task, after which the control group waited 8 hours during the day without sleep and then repeated their same experimental task, compared to the experimental group who sleep 8 hours at night and then repeated the task. The second group, who had slept performed better.

Researchers have suggested this is because the mind uses the time during sleep to reorganize information in more efficient and/or effective matter (similar to how cooking for a large family reunion is a little bit easier if one has recently cleaned out and organized the pantry several days before). Researchers of contextual interference posited that even without the full disconnect of falling asleep, a little bit of cognitive breathing room (the spacing provided by the random-structure trials, where the participant is not scrutinizing the task and allows their mind to quietly organize it as they actively practice the other task using working memory) is important for successfully acquiring skill in movements, directed by the mind as they are.

Conclusion

In their discussion of the future directions for contextual interference Lee and Simon note that researchers still need to account for the variations in effect sizes (how often, proportionately, is the

contextual interference phenomenon observed) that occur across experiments. "Blocked practice does not always facilitate acquisition performance [for every individual], and random practice does not always facilitate learning [for every individual]"[15] although after evaluations for statistical significance, this is the case for the average group of individuals. The difference in effect sizes for various studies suggests that researchers could begin to identify the specific conditions in which contextual interference effects occur more strongly, or more weakly, and with such an understanding the use of variable versus blocked practice could be more specifically tailored for practice application in training structures. Why the effect differs for individuals is clearly an important aspect of the research to investigate, and martial artists who find success with a method contrary to what contextual interference would suggest are well-advised to continue with what has been found to work for them, in part because of this uncertainty about why effect sizes vary among studies of the phenomenon.

Despite these concerns, contextual interference is a significant and recurring effect, observed across multiple, varying physical activities, and even in mental practice, as investigated by Gabriele, Hall, & Lee, in 1989. Its theoretical implications—that optimizing practice during performance can come at a cost to skill retention and transfer—raises significant concerns about how practice of a motor skill or physical technique can be best structured to optimize overall learning. In conclusion, the overarching and persistent questions raised by the research into contextual interference is how much do teachers:

- teach to the ideal execution of technique in mind
- tolerate or manage less-than-ideal performance during practice (less-than-perfect practice), and
- actively teach or train technique execution in differing/non-ideal contexts or situations?

The applied research in this area is still un-comprehensive, and so the greatest source of information at this point would be an experienced instructor's knowledge of past successes and the clear desire to learn and improve training through any information deemed appropriate.

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Endnotes

[1]   Lee & Simon, p.29

[2]   Pyle, p. 109

[3]   Lee, 1982

[4]   Schmidt, 1991, p. 287

[5]   Magill, 2001, p. 285

[6]   Schmidt, 1991, p. 287

[7]   Schmidt and Wrisberg, p. 233

[8]   Vickers, pp. 106–107

[9]   Lee & Simon, p. 35

[10]   Ibidem, p. 36

[11]   Ibidem, p. 40

[12]   Ibidem, p. 41

[13]   Poto, p. 37

[14]   Lee & Simon, p.38

[15]   Ibidem, p.40