2 Contextual interference

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Two old sayings, one mostly correct, the other mostly incorrect, still dominate many opinions regarding the effects of practice. The first saying is that 'practice makes perfect' and has a ring of truth to it, all other factors being equal, the development of skill is generally and positively related to the amount of practice. For example, the *law of practice* (Crossman, 1959; Fitts, 1964; Newell and Rosenbloom, 1981; Snoddy, 1926) characterizes how performance improvements continue to emerge over hours, days, months or years of accumulated time in practice. In general, there are few, if any, exceptions to the law of practice and to the essence of this old adage.

On the surface the other saying, 'perfect practice makes perfect', appears also to have merit. The idea is that the optimization of performance during practice will lead to the best 'memory' for what has been learned. Conversely, making errors in practice leads to learning of these errors and, generally, degrading the overall potential benefit of practice. The adage suggests that conditions of practice that lead to good performance should lead to better learning when compared to conditions of practice that lead to poor performance. In this chapter, we describe the effect of a practice variable called *contextual interference* that contradicts the wisdom of this saying. Moreover, in our discussion of the reasons for this effect, we explain why attempts to optimize performance and learning in practice are generally doomed to failure.

Early studies

Most motor learning researchers attribute the first demonstration of the contextual interference effect to Shea and Morgan (1979). This may be true, but important antecedents to the publication of their research heightened the impact of Shea and Morgan's findings. An early study by Pyle (1919), involving the sorting of cards, illustrated how a difficult practice condition could degrade performance during practice. In the Pyle study, two groups of participants practised a card-sorting task. A trial consisted of placing each card from a deck of 150, one at a time, into compartments (similar to sorting mail). Five cards of each number (1–30) occurred in the deck. The compartments were physically arranged in six rows of five compartments per row. The compartments, each numbered from 1 to 30, were not ordered consecutively, but rather, were arranged unsystematically. Two different compartmental spatial arrangements were used in the experiment. The 'blocked' group used one arrangement for the first 15 days of the study and the second arrangement for the next 15 days. The 'alternating' group switched between arrangements on every other day. The results of the experiment are illustrated in Figure 2.1. With the exception of the first trial on the new spatial arrangement (day 16), the blocked group outperformed the alternating group throughout the practice period. These findings led Pyle (1919, p. 109) to comment that 'The group that alternated from one (arrangement) to the other from day to day was at a great disadvantage in its method .... The inference from this experiment is 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'.

Notice in Pyle's comments that the influence of the practice variable on learning was being assessed *during* the trials in which the variable had been manipulated in these groups. This emphasis on making assessments about learning based on practice performance was common at the time, despite theoretical arguments to the contrary (e.g. Blodgett, 1929; Hull, 1943). A problem similar to this one concerned the role of augmented feedback, often presented as knowledge of results (KR). The manipulation of KR, like the scheduling of reward in animal conditioning experiments, was believed to have an important impact on learning. Reviews of the many human motor learning experiments in which KR was manipulated often focused on the effects that these manipulations had during the time in which these variables were influencing performance. That is, the effects of these KR variables were often attributed to an influence on *learning* (Ammons, 1956).

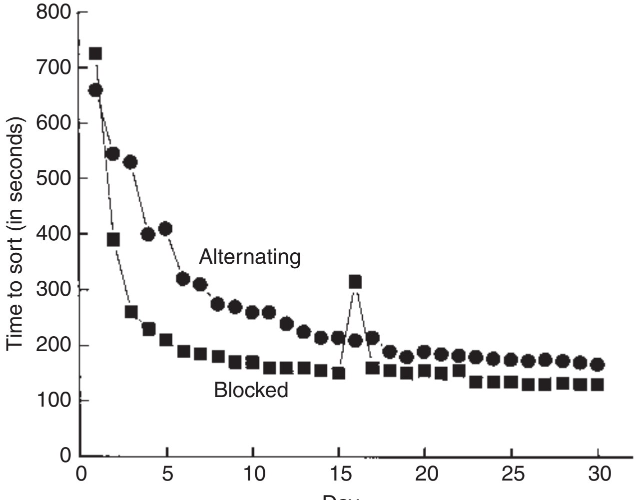

Figure 2.1 Results of the Pyle (1919) experiment.

Other researchers have argued differently. In the motor learning literature, the problem of (mis)attributing the influence of practice variables during practice to a learning effect was discussed frequently by Schmidt (1971, 1972) (see also Salmoni *et al.* 1984). He argued that retention or transfer trials were the only reliable means to assess the impact on learning of those various practice conditions, all individuals previously undergoing different practice manipulations should be examined under similar test conditions. The soundness of these theoretical arguments was also supported when considered in the context of learning daily activities. For example, the true test of practice is not how a golfer hits the ball on the driving range, but rather how practice impacts performance during a round of golf on the course.

Shea and Morgan (1979)

In the historical context of discussions regarding the performance/learning distinction and the perceived effect of practice variables in motor learning theory (Adams, 1971; Schmidt, 1975), the timing was perfect for the impact of Shea and Morgan's (1979) findings. In their study, Shea and Morgan compared two groups of individuals who practised three versions of a laboratory task for a total of fifty-four trials (eighteen trials per version). The task required participants to respond to the illumination of one of three coloured lights by picking up a tennis ball, knocking over three (of six) small wooden barriers and replacing the tennis ball, all as quickly as possible. The three different task versions differed in terms of the specific barriers to be struck during the movement. Both groups received the same number of total trials, the same number of trials per version, the same quality and quantity of KR, and took roughly the same amount of time to complete their practice trials. The only difference between the groups was the *order* in which these practice trials were conducted. The *blocked* group practised all eighteen trials of one task version before switching to a second version (then completing those eighteen trials), and then on to the third version. In contrast, the *random* practice group had a much less systematic practice order. The order of practice for this group was randomized with the restrictions that no more than two trials of any one task version could be completed in succession and that three trials of each version were completed in each set of nine trials.

The results from the Shea and Morgan study are presented in Figure 2.2. The total time elapsed in response to an imperative signal was the primary dependent measure (i.e. the sum of reaction time plus movement time). The fifty-four acquisition trials were grouped into six blocks of nine trials each, and represent the progress made by each group during practice. Two retention tests were given for each group: the three task versions were performed both in a random and in a blocked retention order. These retention trials were conducted by one-half of the participants in the blocked and random acquisition groups following a 10-minute rest, and by the remaining participants in each group 10 days after the acquisition trials.

As can be seen in Figure 2.2, the impact of these two orders on performance in practice was predictable: compared to random practice, the blocked practice

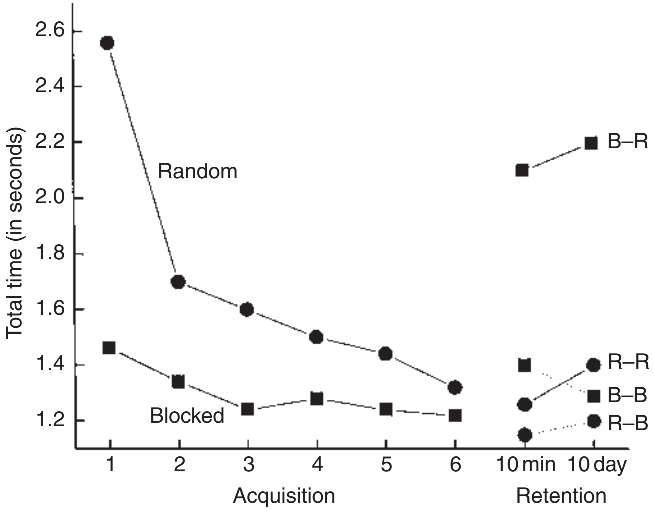

Figure 2.2 Results of the Shea and Morgan (1979) experiment.

order facilitated a rapid reduction in response time during acquisition performance (especially so during the first block of nine trials). Clearly, the blocked group resulted in a much faster *rate* of improvement on the task and a greater overall *amount* of improvement than random practice. The retention results, however, revealed a very different effect. The filled circles represent the randomly ordered acquisition practice and the filled squares represent the blocked-ordered acquisition practice. Dotted lines connect the trials in which the participants performed the retention trials in a blocked sequence and solid lines illustrate the randomly ordered retention trials. Figure 2.2 illustrates the following findings: random practice resulted in better retention performance than blocked practice when compared in both randomly ordered retention trials and in blocked-ordered retention trials, and when compared in retention tests both 10 minutes and 10 days following the practice period. Random practice had facilitated retention (learning) compared to blocked practice.

The blocked practice schedule, which had facilitated a rapid performance improvement, appeared to be poor for learning compared to the random schedule, which had resulted in much slower and more modest improvements during practice. The second adage that was discussed at the beginning of this section, that ‘perfect practice makes perfect’, had been violated by these results.

A note on comparing Pyle with Shea and Morgan

The blocked practice group in the Pyle (1919) study shows a very different acquisition practice ‘profile’ than the blocked group in Shea and Morgan (1979). There is a simple, statistical reason for this difference that has gone relatively unnoticed over the years. In Figure 2.1, Pyle's blocked data are plotted chronologically; trials 1–15 are performed with one compartment order, trials 15–30 are performed with a different order. For Shea and Morgan (1979), however, trial block one represents the average performance of the first three trials for each task version; trial block two represents the average of trials 4, 5 and 6 for each task version, and so on. Notice that while this is a true chronological representation of the order by which the random group performed their acquisition trials, this is not so for the blocked group. Rather, trial block one in Figure 2.2 illustrates the average performance of trials 1, 2, 3 (the first three trials of task version one), trials 19, 20 and 21 (the first three trials of task version two), and trials 37, 38 and 39 (the first three trials of task version three). Trial block two is the average of trials 4, 5, 6, 22, 23, 24, 40, 41 and 42. Trial blocks three to six are calculated similarly. *The deterioration in performance seen in the blocked group when switching between compartments in the Pyle study (i.e. between Days 15 and 16) is not replicated in how Shea and Morgan presented their blocked data (Figure 2.2).*

The artefactual nature of the difference between the Pyle and Shea/Morgan results is illustrated in Figure 2.3. These data are taken from Lee (1982), which were subsequently published in Lee and Magill (1983; Experiment Two). In many respects, this experiment replicated the task and procedures used by Shea and Morgan. In Figure 2.3, we have replotted the individual trial performance for each participant in the blocked and random groups as a function of the chronological

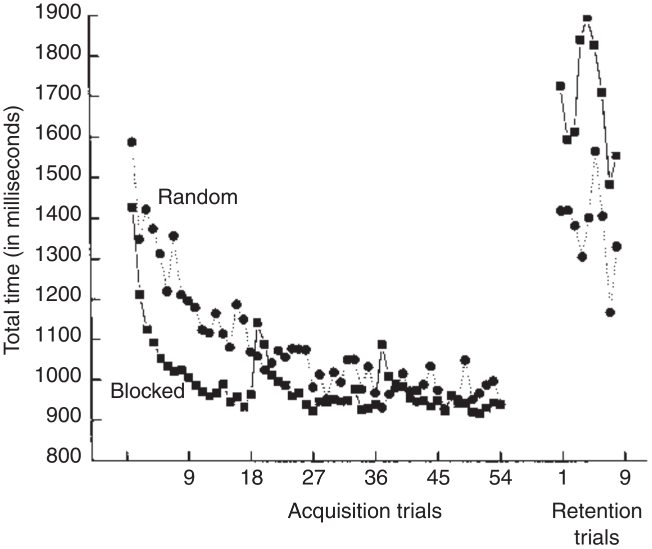

Figure 2.3 Results of Lee (1982). Individual trial data are plotted in chronological order (see text for details). [Originally, these data were presented in a manner similar to Shea and Morgan (1979), replicating their findings (see Lee and Magill, 1983). In the present illustration, the individual trial data have been re-plotted in chronological order. See test for details.]

order in which each trial was performed in practice. Presentation of the results in this way shows an effect similar to that seen in Pyle (1919). There is a marked deterioration in performance of the blocked group in trials 19 and 37, the trials in which there was a change from one pattern to a new pattern.

Replications and extensions of Shea and Morgan (1979)

The implications of Shea and Morgan's findings for theory and practice were staggering. Why should a practice order be good for performance, but poor for learning? Conversely, why should a practice order retard performance, but boost learning? What processes underlying performance and learning were being affected by these practice orders? And, if the findings were reliable and externally valid, what were the practical implications? Before these important questions could be addressed, the Shea and Morgan findings needed to be replicated elsewhere.

Extensive reviews of the contextual interference literature have been published by Brady (1998) and Magill and Hall (1990), and document numerous task, participant and methodological considerations that moderate the magnitude of the contextual interference effect. In some cases, blocked practice produces much better acquisition performance than random practice (replicating Shea and Morgan), and in some cases, the difference is minimal or non-existent. We feel, it is, therefore, safe to conclude that *in the acquisition of a motor skill, a blocked practice schedule is very likely to facilitate performance when compared to the performance of individuals in a random practice schedule*.

Reviews of the contextual interference literature regarding the influence of practice schedules in retention and transfer also have reported mixed results (see Brady, 1998; Magill and Hall, 1990). In some cases, the benefit of random practice is as large, or larger, than was found by Shea and Morgan. In other cases, there have only been small or null differences between blocked and random schedules. However, rarely, if ever, have there been reliable learning advantages that favour blocked practice. Thus we feel confident in making the following conclusion: that *in the learning of a motor skill, when differences due to practice schedules are found, these differences will favour retention or transfer following a random acquisition schedule*.

A matter of clarification

The effects of random, blocked and other types of practice schedules in which the effects of trial practice order are the main concern, are often confused with a related, but different issue regarding the effects of *variability of practice*. This latter theoretical concern was motivated by schema theory (Schmidt, 1975), which predicted that transfer to a novel parameterization of a generalized motor program (GMP) would be facilitated following practice involving many parameter variations of the GMP compared to practice following only one or a limited number of parameter variations. Schema theory offered no provision regarding how the order of these practice trials might be conducted, only that 'variable' practice should be better for transfer than 'non-variable' practice. In studies of contextual interference, however, the typical experimental protocol is to compare groups that experience the same amount of practice on the same number of task variations, the only difference being the order of practice trials.

Thus, it seems as though these two practice variables are distinct and separate lines of investigation. However, some have argued that there is more overlap than appears at first. In their review of the variability of practice literature, Lee *et al.* (1985) discovered that tests of the schema theory prediction (better transfer following many task variations in practice versus a few or only one task variation) was supported only when those task variations had been conducted in a random practice sequence. Studies in which task variations had been conducted in a blocked order most often resulted in transfer that was no better than constant (single variation) practice. The conclusion of Lee *et al.* (1985), based on the literature review and their own empirical evidence, suggested that random practice was necessary in order to maximize the benefits of variable practice when comparisons are made to transfer following non-variable practice conditions.

Theoretical concerns

A variety of theoretical accounts have been advanced to explain the contextual interference effect. Of course, any satisfactory account needs to explain the relative performances observed for blocked and random practice not only in retention, but in acquisition also. It is relatively easy to postulate mechanisms that predict an ordering of performance of two practice conditions. Less easy is to explain the interaction effects observed in contextual interference: blocked practice with superior performance in acquisition, but random practice with superior performance in tests of delayed retention or transfer. In the following, we outline theories that have been advanced, though we feel that it is important to recognize the possibility that many of the accounts are not mutually exclusive, and that contextual interference may represent the confluence of a set of concurrently acting mechanisms. The two most commonly cited explanations of contextual interference are the elaboration-and-distinctiveness view and the forgetting-and-reconstruction view.

The Elaboration–distinctiveness view

Borrowing heavily from the work of William Battig (1972, 1979), the elaboration–distinctiveness view was put forward by Shea and Morgan to account for their original findings. 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, in blocked practice, the continued repetition of long series of the same task makes it less important to keep track of which task is which, except perhaps for the first few trials of a new block. Although more demanding during acquisition, the need to compare and contrast, leading as it does to more elaborate and distinctive memorial representations of the practiced tasks yields superior performance in retention tests. In transfer tests, the argument is essentially that random practice has made learners more adept at identifying the relevant features of the to-be-performed transfer task, providing an advantage on these tasks, even though they are novel.

The Forgetting–reconstruction view

The forgetting–reconstruction view of contextual interference (Lee and Magill, 1983, 1985) draws more heavily on the preparatory processing involved in practice. The idea here is that random practice forces the learner to 'dump' a given pattern from working memory in order to plan and execute successive practice trials. Because a given pattern is dumped and superceded by planning and execution of trials of one of the other patterns, it is not immediately available and must either be drawn out of long-term memory, or constructed from scratch (or more likely some hybrid of the two). In blocked practice, a given movement pattern can be planned and maintained in working memory across an entire series of trials. Although modifications may be made to the movement in that period, this practice schedule generally affords the learner only one opportunity to bring up, or construct, each movement pattern, once for each pattern. This need (or lack of need) for forgetting–reconstruction in the two practice schedules is seen as the basis for both the acquisition and retention effects seen in contextual interference: uninterrupted repetitions 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.

On the surface, the distinction between the elaboration–distinctiveness view and the forgetting–reconstruction view comes down to working memory. In elaboration–distinctiveness, the argument is that concurrent presence of the to-be-learned patterns in short-term memory (STM) allows opportunities for comparison and contrast. In the forgetting–reconstruction view, it is the loss of an action plan from working memory and the consequent need to generate it anew that is the hallmark of random practice. These distinctions suggest that working memory should be the basis for distinguishing the theories. It seems plausible, however, that both accounts are tenable. Upon constructing one action pattern, it seems likely that one could make comparisons and contrasts with the previous action, whilst essentially replacing it as the 'loaded' response. In other words, the two accounts need not be at odds with one another, but could simply reflect different aspects of the same cognitive process.

Alternative views

Drawing on ideas from the verbal learning literature, some investigators have proposed that contextual interference effects may be due to retroactive interference effects. Retroactive interference is a phenomenon where later experiences affect memory for earlier learned associations. As an example, learning someone's new phone number would hopefully have a retroactively interfering effect on one's tendency to call the old number. The parking spot chosen this morning will, hopefully, retroactively interfere with your recollection of yesterday's parking spot. The suggestion by Poto (1988) is that later learned patterns in blocked practice tend to act backwards to attenuate the memory strength of earlier learned patterns. In random practice, there is less scope for the patterns to 'undo' earlier learning because the practised patterns are all carried on throughout practice. The prediction arising from the retroactive interference view is thus, not that blocked practice is bad for learning per se. The later practised patterns should fare well, while earlier practised patterns should be less well learned, so that the blocked practised patterns would, on average, not be so well learned. Detailed, pattern-by-pattern analyses in retention are obviously needed to test these predictions. In a relevant modelling simulation by Horak (1992), a neural network was trained on different patterns in blocked or random fashion and it was observed that after random training, the network was optimized for the three trained associations, whereas at the end of blocked training, the network was essentially better for the later practised patterns and weaker for the earlier trained patterns. Data from studies by Meeuwsen and Magill (1991) and Poto (1988) are consistent with an influence of proactive and retroactive interference for blocked practice.

Magill and Hall (1990) cite the doctoral work of Wright as providing evidence against a retroactive interference interpretation for contextual interference. Wright had people engage in different types of information processing between blocked learning trials: viewing another to-be-learned pattern and stating the commonalities between it and the task being practised, viewing the current practice task and verbalizing the movement sequence involved, viewing another to-be-learned task and verbalizing the movement sequence involved in it, or no intervening task. Magill and Hall (1990, p. 273) state, '. . . retention performance showed that only the group that made comparisons between the new and present patterns was better than the other groups. Thus, reducing retroactive interference during practice did not necessarily improve retention performance, which is counter to what a retroactive interference explanation would predict.' However, it is debatable as to whether or not the intervening cognitive activity truly reduced retroactive interference in these practice schedules. Indeed, in what is presumably the publication of those same data, Wright (1991) makes no reference to retroactive interference issues.

Del Rey *et al.* (1994) also searched for possible contributions of retroactive interference to contextual interference effects. Their data supported such a contribution, but for reaction times and not for movement times. Again then, it seems to be debatable as to whether the contributions to actual performance effects (movement execution) as opposed to pre-performance delays (movement planning) in contextual interference are related to retroactive interference. Overall, this theoretical explanation is worthy of further consideration, along with the others we mention. Contextual interference may well be the result of multiple concurrent processes. Perhaps it should also be pointed out that, in principle at least, proactive interference effects could be argued for as well, and thus should be considered when evaluating the effects of contextual information.

Wulf and Schmidt (1994) have suggested that feedback dynamics may play a role in the contextual interference effect. Their idea is that random practice may be beneficial because feedback for a given trial cannot be used on the very next trial, thus making it less immediately useful. In contrast, for blocked practice, the inferential benefits of feedback can be applied on the very next trial. At first blush, this reasoning may appear somewhat backwards: *less* useful feedback supports better learning? However, as mentioned above, contrary to early ideas of the mechanistic benefits of feedback in motor learning, there are a number of findings primarily attributable to Schmidt and colleagues (e.g. Salmoni *et al.*, 1984; Schmidt *et al.*, 1989; Winstein and Schmidt, 1989) in which conditions of practice that make feedback less immediately available/useful to learners, may have a detrimental impact on performance, but a beneficial impact on learning.

Although not a theory per se, the contextual interference effect may also be seen as an instance of spacing effects. The individual trials in a random schedule are spaced compared to those in a blocked practice schedule. There is considerable evidence to suggest that spacing of learning opportunities can facilitate learning as compared to massing of such opportunities (see, e.g. Crowder, 1976). Some investigators have considered spacing as the basis for contextual interference effects (Meeuswen and Magill, 1991) though based on their data, these authors suggest that the phenomena may be independent of one another. 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. Attempts to somehow equate the amount of interference due to a given amount of temporal spacing with that due to practice of other to-be-learned movements may prove useful in answering this interesting question.

Gabriele *et al.* (1989) have investigated the influence of a random schedule in mental practice. Their data suggest that physical practice is not necessary for beneficial interference to occur. Similarly, data from Simon and Bjork (2003) also show potential benefits of watching models performance different rather than the same response within a block of trials. Findings such as these lend weight to the role of cognitive processes in the contextual interference effect, but in and of themselves do not support any one information processing-based account.

In a study by Wright (1991) inter-trial processing during blocked practice made acquisition poorer but helped retention. Thus, blocked practisers were made to look more like random practisers by this intervention (see also Simon and Bjork, 2003). However, no direct comparison between the impact of these intervening cognitive activities and the interposition of actual physical practice of other movement patterns is afforded by Wright's data (and the Simon and Bjork data yielded an additive effect of the blocked/random manipulation and the form of between-trial processing, rather than an interaction effect). As such, it seems possible that the inter-trial cognitive activities in these studies may be tapping different learning processes than are invoked by random practice. Further exploration of these issues is clearly warranted. A final explanation of the differential benefits in blocked and random practice is that random practice is simply more interesting than blocked practice and that consequent differences in learning are attributable to differential motivation levels in the two practice regimens (e.g. Wulf *et al.*, unpublished). As yet, however, this idea has not been rigorously tested.

Although each of these theories makes sense to some degree, it is not clear that any one of them can explain the phenomenon of contextual interference completely. It may well be that contextual interference represents the confluence of two or more of these contributing factors at any time. Experiments to address this issue need to be set up so that they not only provide evidence in favour of a particular theory, but that they also allow for the elimination of other explanations. If only one of these conditions is met, as usually seems to be the case, the evidence may support the pet explanation of the investigator, but will fail to rule out the other accounts. Such an approach represents something of a challenge for those interested in understanding the phenomenon of contextual interference.

Applications

Although research on the contextual interference effect has generated significant interest for reasons related to learning theory, perhaps of greater importance have been the studies conducted using tasks of everyday living and the potential application of these results in other life events. For example, effects of random versus blocked practice have been found using a number of sport-related skills specific to badminton (e.g. Goode and Magill, 1986), baseball (Hall *et al.*, 1994), rifle-shooting (Boyce and Del Rey, 1990), kayaking (Smith and Davies, 1995) and volleyball (Bortoli *et al.*, 1992). As well, contextual interference effects have been found in non-sport-related tasks such as automatic bank machine transactions (Jamieson and Rogers, 2000), foreign vocabulary learning (Schneider *et al.*, 1998), and in physical rehabilitation following stroke (Hanlon, 1996). It seems to be the case that, for tasks in which learning differences due to practice order are found, the advantage will favour a random practice schedule.

The study of the contextual interference effect as an empirical laboratory finding, as an important issue for learning theory, and as an empirical, applied finding, has been met with considerable interest in a wide number of applied disciplines in which ordering of 'task repetitions' are a daily practical consideration. Discussions of contextual interference effects in this context have been engaged in areas diverse as coaching (e.g. Vickers, 1999), the military (Druckman and Bjork, 1994; Schmidt and Bjork, 1992), speech rehabilitation

(Knock *et al.*, 2000; Verdolini and Lee, 2003), physical therapy (Winstein, 1991; Lee *et al.*, 1991; Marley *et al.*, 2000), and occupational therapy (Jarus, 1994).

Summary and future directions

By now, it should go without need for comment that the publication of Shea and Morgan's (1979) classic experiment has had a major impact on research and application in fields that include, and far exceed, the motor learning area. Is there continued need for research and theory development regarding contextual interference? We think so and briefly conclude this chapter with two promising areas for continued investigation.

- *Accounting for variations in effect sizes*. As highlighted in the reviews of Magill and Hall (1990) and Brady (1998), blocked practice does not *always* facilitate acquisition performance, and random practice does not *always* facilitate learning. Obvious goals for the future then must include a better understanding of the conditions (e.g. task, environment, individual differences) under which contextual interference effects might be expected to be large, small or non-existent and a better understanding of *why* these expectations are so. Regarding individual differences, some have suggested that since contextual interference effects are largely cognitively based, then effect sizes should be small or opposite to the norm in populations in which cognitive functioning has been compromised (e.g. Dick *et al.*, 2000). Regarding tasks differences, theoretical explanations of contextual interference suggest that larger effect sizes would be anticipated for discrete tasks (compared to continuous tasks) because of the greater reliance on planning processes prior to movement execution required in discrete tasks. However, despite the intuitive appeal of such proposals, there exists evidence to the contrary. For example, contextual interference effects remain strong in individuals with Down's syndrome (Edwards *et al.*, 1986) and for continuous tasks (e.g. Tsutsui *et al.*, 1998). Clearly, the influence of moderating variables remains an important area for investigation.
- *Optimizing performance and learning*. Perhaps one of the most important, and overlooked, issues regarding contextual interference relates to *metacognitive* differences in judgements of performance versus learning. Quite simply, individuals are often poor judges of the state of their own learning, and misattribute feelings about how *learning* is proceeding instead to feelings about how changes in *performance* are proceeding (e.g. Koriat, 2000). For instance, participants undergoing blocked practice are likely to feel overconfident in their ability to perform a retention test compared to participants undergoing random practice (Simon and Bjork, 2001).

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 (although, to our knowledge, such applied metacognitive research has not been done). It is known that amount of 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). Although random practice would be expected to facilitate learning, the metacognitive judgements about learning that might be anticipated to arise during a random practice schedule might lead to discouragement and perhaps, cessation of practice.

The question arises then, as to the possibility that there exists some *hybrid* practice schedule that combines the performance virtues of blocked practice with the learning advantages of random practice. There have been a few attempts to organize such a hybrid schedule, such as scheduling several blocked task variations before randomly switching to another task for a few blocked trials (Al-Ameer and Toole, 1993), or in which task to task changes are contingent on the individual's performance (Simon *et al.*, 2002). Such hybrid schedules show promise in terms of facilitating performance and learning, and possibly, too, the metacognitive attributions that might further engage the individual in practice. The design of different types of hybrid schedules, their influences on performance and learning, and the metacognitive attributions that arise from them reflect a significant promise for future theoretical and applied contextual interference research.

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