European Physical Education Review
http://epe.sagepub.com

The contextual interference effect in applied settings

João Barreiros, Teresa Figueiredo and Mário Godinho
European Physical Education Review 2007; 13; 195
DOI: 10.1177/1356336X07076876

The online version of this article can be found at:
http://epe.sagepub.com/cgi/content/abstract/13/2/195

Published by:
SAGE Publications
http://www.sagepublications.com

On behalf of:
North West Counties Physical Education Association

EUROPEAN PHYSICAL EDUCATION REVIEW [DOI: 10.1177/1356336X07076876]
Volume13(2):195–208:076876

The contextual interference effect in applied settings

João Barreiros Technical University of Lisbon, Portugal

Teresa Figueiredo Polytechnic Institute of Setúbal, Portugal

and

Mário Godinho Technical University of Lisbon, Portugal

Abstract

This paper analyses the research literature that approaches the contextual interference effect in applied settings. In contrast to the laboratory settings, in which high interference conditions depress acquisition and promote learning evaluated in retention and transfer tests, in applied settings most of the studies (60%) fail to observe positive effects after manipulation of the contextual interference. Some possible explanations for the fact are hypothesized regarding the characteristics of the task, with serial tasks doing best, short intertrial intervals rare in applied settings, interference produced by the use of different motor programmes and the possible interference of concurrent feedback in slow tasks in contrast to ballistic skills. It seems that there is a more evident contextual interference effect in an applied setting, when subject learns a serial task with high degree of complexity.

Key-words: applied settings • contextual interference • practice schedule

The hypothesis of variability of practice and the contextual interference effect

In 1966, Battig proposed the concept of contextual interference in the realm of verbal learning. Originally, contextual interference was defined as a functional interference in learning responsible for memory improvement. Battig (1979) conceptualized this effect as a consequence of adaptation processes that occur when the learner has to respond to a variable input over an acquisition phase. Motor learning researchers have investigated this variable, as well as many other variables that can be manipulated in practice, in many different motor tasks. This domain of research has experienced tremendous growth since Schmidt's schema theory (1975). As a result, two related research trends have emerged. A first area of interest, called 'variability of practice' (Moxley, 1979), proposes that learning experiences with task variations are vital to

the development of the schemata responsible for response production and enhanced retention and transfer, despite a possible fall in performance during the acquisition phase. The second variability approach was inspired by Battig's writings (1966, 1979) and it was translated into the motor domain, for the first time, by Shea and Morgan (1979).

The general variability of practice hypothesis has been subject to exhaustive experimental questioning. In fact, accumulated evidence has shown that this was quite a peculiar effect. In some open tasks the variability of practice did promote better retention and transfer, but this was not the case for most closed tasks. The most critical limitation to this approach was probably the fact that experimental groups were usually submitted to constant and variable practice conditions, and this was a severe limitation for the constant practice groups as far as transfer designs were concerned. Constant groups were forced to perform a single repetitive version of the task over and over again, which facilitated boredom effects and reduced cognitive engagement. On the other hand, variable groups were closer to transfer tasks. Despite these limitations, the most surprising fact was that variable practice, generally speaking, was not significantly different from constant practice conditions.

Theory predicted more visible effects in children, i.e. in a period of schema formation, than in adults (Schmidt, 1975). This hypothesis was not supported by accumulated empirical evidence (Van Rossum, 1980). The variability of the practice effect depended on a number of variables: amount of practice, distribution of practice, intertrial intervals, task characteristics, sources of variability, similarity between acquisition and transfer tasks, level of expertise, etc. The interaction among these variables was so complex that a huge number of variables would have to be controlled before minimal conclusions could be established. As a result, in some conditions, variability of practice was acknowledged in promoting learning. However, it was not possible to detect exactly when and how this paradoxical effect would be visible.

Yet, a particular manipulation of variability demanded more and more attention. At the beginning of the 1990s, the contextual interference effect was a promising research area, concentrating the attention of motor learning laboratories all over the world. Contextual interference may be produced by structuring practice in such a way that the presentation of the task varies from trial to trial in predictable patterns (serial or blocked practice) or in random order. According to theory, a random structure of practice is supposed to create interference, thus enhancing future retention and transfer to tasks of the same response class (Battig, 1979). The reasoning for this positive adaptation was focused on processing strategies: higher contextual interference would promote deeper processing (Shea and Zimny, 1983) or increased forgetting (Lee and Magill, 1985).

These two theoretical approaches, the *elaboration hypothesis* (Shea and Zimny, 1983) and the *reconstruction hypothesis* (Lee and Magill, 1985), have guided research in the last two decades. The first hypothesis relies on the assumption of the two processing modes: intratask and intertask processing. Constant and blocked structures of

practice do not appeal to intertask processing, nor to the comparison occurring in extended intertask associations. This results in a limited learning approach, with expected limited benefits in transfer and retention. However, a very stable acquisition phase is expected, without the disadvantage of permanent disruption. Under random conditions, the distinctiveness and elaborateness of similar variations of the task to be learned would be emphasized, and that would be the underlying explanation for this paradoxical effect.

The reconstruction hypothesis was based on the existence of a working memory. Changing task characteristics from trial to trial, in a non-predictable sequence, demands extra retrieval practice. As a consequence, motor parameters have to be removed from the working memory, as if in a constrained forgetting process. A learning advantage comes from the frequent reconstruction processes that take place in random sequence or in high interference structures of practice. Constant or blocked practice groups do not require these memory operations, as vital information can remain in the working memory for longer periods. Therefore, forgetting is both responsible for acquisition depressing and retention and transfer improving.

The search for contextual interference effects in motor learning shares a common starting point with the testing of the variability of practice hypothesis directly derived from Schmidt's schema theory (see Magill and Hall, 1990, for a review). As a new and counterintuitive effect, the variability issue was given special attention in motor behavior and motor learning journals. From the early 1980s until the mid-1990s, there was an increasing interest in this problem, followed by a slight decline, and a substantial reduction in the new century (Figure 1). The positive slope of this trend clearly reflects accumulated evidence supporting the interference effect. In the mid-1990s, some persistent doubts emerged, while some constant results persisted.

There is considerable laboratory support for the contextual interference effect whenever the tasks are 'closed' or of the 'internally regulated' type. In this category,

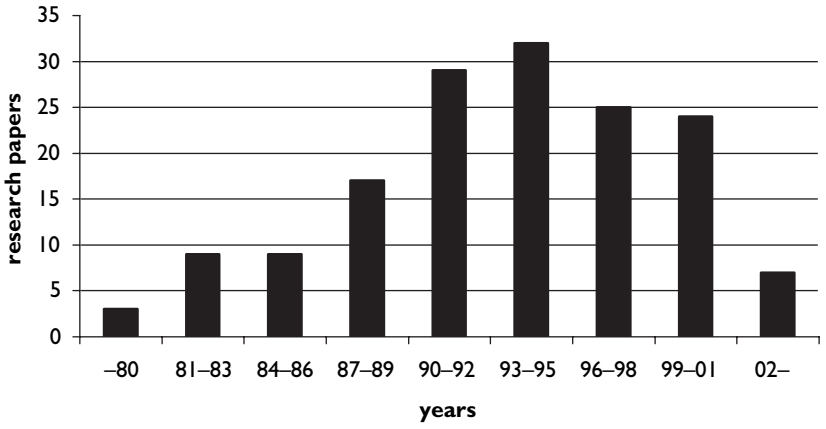

Figure 1 Research publications about contextual interference since 1979

we have included multi-segmental movement tasks (barrier knock-down and sequential button-pressing tasks), some propulsion tasks (e.g. Goode and Magill, 1986; Pollock and Lee, 1997; Wrisberg, 1991; Wrisberg and Liu, 1991), and coincidence-anticipation tasks, where the required response is limited to the action of pressing a button (e.g. Del Rey, 1982, 1989; Del Rey et al., 1982, 1983, 1987; Porretta and O'Brien, 1991).

A previous review of literature (Figueiredo and Barreiros, 1993) has revealed that the contextual interference effect is not evident in the tasks predominantly 'open' or 'externally regulated', and requiring an important interaction of motor and perceptive demands. The tasks on the pursuit rotor (e.g. Dunham et al., 1991; Heitman and Gilley, 1989; Whitehurst and Del Rey, 1983), the coincidence-anticipation timing tasks, which call for the production of a segmental movement (e.g. Edwards et al., 1986; Wrisberg and Mead, 1983) and the tasks of pursuit on computer (e.g. Jarus et al., 1997; Smith, 1997) were included in this group. The characteristics of the task seem to be of extreme importance for this problem.

Contextual interference effects in ecological experiments

Bridging the gap between research conducted in laboratories and in applied settings has been a consistent demand of field practitioners over researchers. This has been the case for many other 'hot topics' in motor learning, such as feedback, demonstration, or knowledge of results. In the contextual interference domain, we have identified and analysed 155 research papers exploring the structure of the practice problem. Most of these papers deal with unusual laboratory tasks, using experimental designs of one single session, under massive practice conditions, and with retention intervals of extremely short duration. The tasks used are usually deliberatively exotic, aiming to show a high degree of novelty. Tasks are also designed to meet specific human motor characteristics, such as temporal structure of movement, anticipation-coincidence or movement precision. These are common features in motor control and motor learning research, and many authors agree that using similar experimental apparatus makes discussion of results and data comparisons easier.

However, the generalization from unusual laboratory conditions to real-life situations always calls for some caution. One solution in order to bypass this gap between labs and reality is to design experiments with as much ecological validity as possible.

The criteria for ecological studies adopted in this review took two conditions into account: (1) the use of common motor tasks, namely sport skills in their natural practice conditions, i.e. in physical education and training environments; (2) the use of real motor skills in ecological practice conditions, with normal amount and distribution of practice.

Within these criteria, a total of 27 research papers were analysed. Many papers fell in the category of propulsive actions, such as basketball throwing tasks (Crumpton et al., 1990; Landin and Hebert, 1994, 1995, 1997), badminton serve (Goode and

Magill, 1986; Wrisberg, 1991; Wrisberg and Liu, 1991), volleyball actions (Bortoli et al., 1992; French et al., 1990; Ugrinowitsch and Manoel, 1999), forehand tennis groundstroke (Farrow and Maschette, 1997; Hebert et al., 1996), baseball hitting (Hall et al., 1994), golf skills, such as driving, middle distance swing, pitching and chipping (Brady, 1997), or soccer pass (Li and Lima, 2002). Prahl and Edwards (1995) have selected three pickle-ball skills, namely the forehand shot, the backhand shot and the serve. Jarus and Goverover (1999) used a beanbag tossing task. Vera and Montilla (2003) analysed a common throwing task with a tennis ball and a feather fly ball, and Wegman (1999) tested the contextual effect in the learning of three skills: ball rolling, racket striking and ball kicking.

Other non-laboratory studies included aerobic step skills (Arnone-Bates et al., 1999), underarm throwing, quintuple jumping and hurdle running (Bortoli et al., 2001), a rifle shooting task (Boyce and Del Rey, 1990), a snowboard turning skill (Smith, 2002), the learning of a kayak roll (Smith and Davies, 1995) and the cart-wheel in gymnastics (Smith et al., 2003). As expected, methodological procedures did not include systematic control of associated variables and, to some extent, the similarity of groups at the beginning of the learning set could not be guaranteed.

All these studies were performed in applied contexts and used common motor skills. They also kept most variables that usually flow in their natural condition in these environments. Nevertheless, we have included studies that constrained some variables but preserved a general ecological design. This was the case for Arnone-Bates et al. (1999), Chamberlin et al. (1990), Crumpton et al. (1990), Goode and Magill (1986), Landin and Hebert (1994, 1995, 1997), Li and Lima (2002), Smith (2002), Smith and Davies (1995) and Smith et al. (2003).

As in many other motor learning topics, young adults were frequently used as samples. Adolescents were sampled in five studies, and children ranging from 5 to 10 years old were studied in four papers. In four other studies, the samples included children, adolescents and adults, allowing for some interesting development comparisons.

Acquisition, retention and transfer effects

Contextual interference effect was clearly observed in 29 percent of the studies analysing the acquisition phase. This means that high interference conditions did not necessarily affect performance adversely during acquisition, as theoretically expected. The studies conducted by Landin and Hebert (1994, 1995: exp. 2), Jarus and Goverover (1999), and as for the 7-year-old group, by Wegman (1999), Boyce and Del Rey (1990) and Smith et al. (2003) observed a deleterious effect. In these studies no relationship could be established between the contextual interference effect and the learning tasks.

Greater support was found for the retention phase. In 42 percent of the studies, better retention performance was a consequence of a high level of interference in the acquisition phase. Positive retention effects were observed in throwing tasks (Farrow

and Maschette, 1997; Goode and Magill, 1986; Wrisberg, 1991; Wrisberg and Liu, 1991), aerobic step tasks (Arnone-Bates et al., 1999), in a snowboard turning task (Smith, 2002) and in the previously mentioned kayak roll (Smith and Davies, 1995). The retention positive effect seems to be independent of the nature of the task and of the uncertainty level. In fact, positive retention effects were found in open as well as in closed tasks. A similar magnitude was observed in the transfer phase (43%), where transfer results were also independent of the task characteristics.

This pattern of results does not provide visible support for the contextual interference effect. In fact, more than 50 percent of all the analysed studies do not support the effect at all. Our results are quite different from those by Shewokis and Snow (1997). In their analysis there was a trend for low to moderate support in the retention phase, and moderate to high in the transfer phase. This difference may probably be justified by the corpus extension of Shewokis and Snow's (1997) analysis, involving only ten studies. In the present review, transfer does not seem to be a more reliable indicator of contextual interference than retention.

Contextual interference in different motor tasks

In the general category of propulsive tasks, i.e. tasks that share the action of throwing or batting an object to a target position as a common goal, little support for the contextual interference effect has been found. Positive effects have been reported by Hall et al. (1994) in baseball batting skills, and by Goode and Magill (1986), Wrisberg (1991) and Wrisberg and Liu (1991) in a badminton serve. However, in basketball throwing tasks (Chamberlin et al., 1990; Crumpton et al., 1990; Landin and Hebert, 1994, 1995: exp. 1 and 2, 1997), contextual variety did not enhance retention and transfer. In volleyball skills (Bortoli et al., 1992; French et al., 1990; Ugrinowitsch and Manoel, 1999), in golf skills (Brady, 1997), and in soccer skills (Li and Lima, 2002) the same trend occurred.

Some studies reported mixed results. That was the case for Hebert et al. (1996) or Farrow and Maschette (1997) in tennis skills. Farrow and Maschette (1997) found different effects for the preferred and non-preferred hand, thus admitting possible effects of prior experience.

In some fundamental motor patterns, such as one-hand throwing (Vera and Montilla, 2003) or racket-striking skill (Wegman, 1999), some positive contextual effects were detected. However, null effects were demonstrated in ball rolling, ball kicking skills (Wegman, 1999) and tossing (Jarus and Goverover, 1999). In the acquisition phase, the expected reduced performance of high interference groups was not detected, with the exception of Jarus and Goverover (1999) in the 7-year-old age group, Landin and Hebert (1994, 1995: exp. 2) and Wegman (1999).

Research focused on a large diversity of skills has evidenced the contextual interference effect. Arnone-Bates et al. (1999) reported better retention results in random scheduled groups in aerobic stepping tasks; Boyce and Del Rey (1990) confirmed positive effects in acquisition and retention in a shooting task; Smith (2002) found

better retention in a snowboard task; and Smith and Davies (1995) observed better transfer and retention results in the Pawlata roll. Bortoli et al. (2001) detected positive contextual effects in only one of many investigated tasks.

The only study presenting consistent benefits of blocked practice schedules has analysed the cartwheel skill (Smith et al., 2003). The authors reported positive effects of lower interference conditions in acquisition, retention and transfer.

There is no theoretical framework to explain this task-related pattern of results. In fact, it is hard to find a pattern at all. Despite this, some questions must be taken into consideration. First, most tasks show a common feature: they all have components that can be isolated, despite the fact that these skills require whole body coordination. Uncontrolled interference between movement components may occur, probably with higher magnitude than interference between whole body trials. In some studies (Smith, 2002; Smith and Davies, 1995) there was a prior phase of practice directed to some parts of the movement, before subjects could experience the task as a whole. It is possible that tasks integrating a series of components may promote additional interference even in blocked or serial conditions and, consequently, some contextual interference effects. In this type of tasks it is hard to distinguish between high and low interference conditions.

A second reason is the overall duration of movements. Studies supporting the interference effect did frequently use slow movements that allow adjustments during movement execution. On the contrary, the use of concurrent feedback is not possible in ballistic throwing tasks. There is a possible relationship between the use of feedback and the contextual interference effect in motor learning (Boyce and Del Rey, 1990). As a matter of fact, these authors have reported a possible advantage of adjustments during movement, based on the depth of the processing hypothesis.

Another possible explanation to justify positive interference effects derives from the studies by Smith (2002) and Smith and Davies (1995). The authors have argued that, in alternate practice conditions, an important source of information can arise from both sides of the body, promoting bilateral transfer. If they are right, then this is no effect of high interference level at all, but a simple coincidence of the task characteristics and schedule of practice. However, the possibility of enhancing interference by arrangements of left–right variations in the practice session is worth better attention. Darden (1997) showed a positive interference effect in a lacrosse skill, where interference was created by the manipulation of right-hand–left-hand sequence of practice. This hypothesis also agrees with the results reported by Arnone-Bates et al. (1999) and Bortoli et al. (2001).

One last hypothesis refers to the possibility that in complex skills, the induced experimental variations can increase the similarity between tasks during the practice sessions. This hypothesis fits Battig's observations that, in verbal learning, the similarity between items and its inherent 'confusion' created a contextual interference effect that promoted learning (Battig, 1979). Yet, a more precise definition of 'complex skill' is not discussed.

Amount of practice and level of expertise

Magill and Hall (1990) have considered a possible interaction between the level of expertise and the effects of contextual interference. In short, they argued that higher levels of interference are not compatible with the initial learning phases. Some previous experience is necessary to promote maximum benefit. On the other hand, Shea et al. (1990) have demonstrated that contextual interference effects are more effective in more extensive practice sessions. These two observations are clearly worth some attention.

In naturalistic settings, the amount of practice ranged from 30 trials (Jarus and Goverover, 1999) to 1800 trials (Prahl and Edwards, 1995). The mean value for the papers in the present corpus is 336 trials and the correspondent distribution is far from normal.

The analysis of the duration of the acquisition phase does not detect any systematic difference between groups (Table 1). This trend is observable both in children and adults.

The studies conducted by Farrow and Maschette (1997), Hall et al. (1994) and Hebert et al. (1996) have considered the students' ability levels. Their findings seem to indicate that acquisition in novice subjects tends to be higher in low interference conditions. On the other hand, highly skilled subjects show no detrimental effect of high interference conditions during acquisition, and can take advantage of high interference conditions in retention and transfer. These three studies show that the learner's ability level interacts with the practice schedule manipulation. This interaction has been previously identified by Shea et al. (1990) and by Del Rey (1989) and Del Rey et al. (1982) in laboratory experiments.

In general, results do not give clear support to the contextual interference effect. A number of reasons may be presented to help us understand this general trend, as well as some exceptions to it. That will be the purpose of the following general discussion.

Table 1 Contextual interference effects in short and long acquisition phases

	'Short' acquisition phase	'Long' acquisition phase
Positive effect	Boyce and Del Rey (1990) Smith (2002) Smith and Davies (1995) Wrisberg and Liu (1991) Arnone-Bates, Hebert and Titzer (1999) Wegman (1999)	Goode and Magill (1986) Hall, Domingues and Cavazos (1994) Wrisberg (1991) Bortoli, Spagolla and Robazza (2001) Vera and Montilla (2003)
No effect	Landin and Hebert (1994) Landin and Hebert (1995; exp.1; exp.2) Landin and Hebert (1997) Li and Lima (2002) Smith, Gregory and Davies (2003)	Brady (1997) Crumpton, Abendroth-Smith and Chamberlin (1990) Hebert, Landin and Solmon (1996) Farrow and Maschette (1997)

General discussion

The research literature on the contextual interference effect in laboratory settings predicted that high interference conditions would depress acquisition but promote learning, i.e. retention and transfer. This hypothesis has received reasonable experimental support for the past 25 years. However, in laboratory research many important variables can be partially or completely controlled. In naturalistic settings, such as physical education classes, a tremendous diversity of variables combine in unpredictable ways, generating peculiar effects. The constraints of naturalistic sets make it very difficult to create the optimal conditions needed to generate and assess learning effects, such as the contextual interference effect. Yet, one of the purposes of research is to influence teachers' choices and to point to better ways to promote learning.

In this paper we have analysed 27 studies on applied practice research. In 60 percent of them, the positive effect of high contextual interference conditions was not observed. Accordingly, there is strong evidence to state that either the experimental organization, in general, was not adequate to illustrate the expected effect or it did not exist at all. These results partially agree with Shewokis and Snow's (1997).

The theoretical prediction for the acquisition phase was that a decrease during practice would occur in high interference practice conditions. This negative effect was observed in less than one-third of all experiments. Therefore, we can admit that the introduced schedules of practice were not sufficient to promote the interference effect. If this was the case, then no expected results in retention and transfer could have been observed. In fact, many constraints are intrinsic to naturalistic settings, such as the class dimension, effective practice control, feedback administration and observational learning.

As in laboratory research, the contextual effect seems to be dependent on the task to be learned. In most propulsive tasks no effects were observed, in acquisition, retention or transfer. However, in other motor skills, significant effects were observed (e.g. Arnone-Bates et al., 1999; Bortoli et al., 2001; Boyce and Del Rey, 1990; Smith, 2002; Smith and Davies, 1995). There is no theoretical basis for this distinction. A possible reason is that serial tasks, with several elements in a prescriptive order, may benefit from changing conditions from trial to trial. As a consequence, deeper elaboration and extra distinction between variations of the task can facilitate adaptation to transfer conditions (Battig, 1979; Shea and Zimny, 1983, 1988). Blocked structures of practice, on the other hand, may not facilitate distinction between variations of the same task. In fact, it is not clear if the contextual interference effect is stronger when the structure of practice includes variations of the same motor programme or distinct motor programmes. From our review, it seems that the combination of skills running under different motor programmes can benefit from high interference conditions, as observed by Magill and Hall (1990). This fact supports both the elaboration hypothesis (Shea and Zimny, 1983, 1988) and the reconstruction or forgetting hypothesis (Lee and Magill, 1983, 1985).

A second aspect is that many tasks have inherent variability, and that variability grows with the complexity of the task, the number of identifiable learning units and with changing environment conditions. Although most studies have reported a good control of the acquisition phase, this control refers mainly to the amount of practice, not to its distribution. In throwing skills, intertrial intervals are usually of short duration, but that is not the case in more complex skills. This particular variable is extremely difficult to control in naturalistic settings, and it is reasonable to assume that longer intertrial intervals may occur in more complex skills. The forgetting hypothesis (Lee and Magill, 1983) has proposed that the duration of the intertrial interval or the interpolated activities between trials tends to cause forgetting of the previous motor solution, and forces a new solution from trial to trial.

A third possible explanation addresses the similarity between variations of the learning task. In the analysed serial tasks, the differences between variations of the task are slight. The idea that small variations are better than big variations was first proposed by Battig (1979). He observed that minimal differences increased confusion in the learner, thus promoting interference. An opposed perspective was shared by Magill and Hall (1990). In their review, it was clear that the contextual interference effect is more evident in practice structures of tasks ruled by different motor programmes.

A final aspect concerns the use of concurrent feedback. In the analysed serial tasks, a moderate effect was observed, but not in the ballistic propulsive tasks. The nature of feedback processes in these two types of tasks is also different. While in ballistic skills there is only access to terminal or postponed feedback, in serial slow tasks, feedback is generally available. As a consequence, concurrent corrections of the ongoing movement are possible in complex but longer movements. In these movements, some small changes and movement adaptations are natural, and the variation between tasks may just be a way to a deeper feedback processing. The interaction between feedback and interference effects is far from being known.

The challenge to confirm ecological validity of laboratory findings is of the highest relevance. Testing theoretical predictions requires carefully designed experiments and well-controlled variables. The generalization of laboratory research has important practical implications for teaching, coaching and for all the professionals concerned with the design of learning environments. The present overview does not discard the contextual interference effect in a definite way. Although a general support was not found, it is important to emphasize that there are some particular conditions where higher interference schedules of practice may be adequate learning proposals. Serial tasks, with a high degree of complexity, tend to be better learned in high interference conditions. Consequently, two challenges for the future may be suggested: corroborating this particular trend and finding out why it happens.

References

Arnone-Bates, M., Hebert, E. and Titzer, R. (1999) 'The Contextual Interference Effect with Children Learning an Applied Task', *Research Quarterly for Exercise and Sport* 70(1) (suppl.): A65–A66.

Battig, W.F. (1966) 'Facilitation and Interference', in E.A. Bilodeau (ed.) *Acquisition of skill*, pp. 215–44. New York: Academic Press.

Battig, W.F. (1979) 'The Flexibility of Human Memory', in L.S. Cermak and F.I.M. Craik (eds) *Levels of Processing in Human Memory*, pp. 23–44. Hillsdale, NJ: Erlbaum.

Bortoli, L., Robazza, C., Durigon, V. and Carra, C. (1992) 'Effects of Contextual Interference on Learning Technical Sports Skills', *Perceptual and Motor Skills* 75: 555–62.

Bortoli, L., Spagolla, G. and Robazza, C. (2001) 'Variability Effects on Retention of a Motor Skill in Elementary School Children', *Perceptual and Motor Skills* 93(1): 51–63.

Boyce, B.A. and Del Rey, P. (1990) 'Designing Applied Research in a Naturalistic Setting Using a Contextual Interference Paradigm', *Journal of Human Movement Studies* 18: 189–200.

Brady, F. (1997) 'Contextual Interference and Teaching Golf Skills', *Perceptual and Motor Skills* 84: 347–50.

Chamberlin, C.J., Rimer, T.N. and Skaggs, D.J. (1990) 'The Ecological Validity of the Contextual Interference Effect: A Practical Application to Learning the Jump Shot in Basketball', paper presented at the annual meeting of the North American Society for the Psychology of Sport and Physical Activity. Houston, TX, May.

Crumpton, R.L., Abendroth-Smith, J. and Chamberlin, C.J. (1990) 'Contextual Interference and the Acquisition of Motor Skills in a Field Setting', paper presented at the annual meeting of the North American Society for the Psychology of Sport and Physical Activity, Houston, TX, May.

Darden, G.F. (1997) 'The Effect of Practice Sequence on the Transfer of Learning for a Novel Bilateral Lacrosse Skill', *Research Quarterly for Exercise and Sport* 68(1) (suppl.): A-58 (abstract of completed research).

Del Rey, P. (1982) 'Effects of Contextual Interference on the Memory of Older Females Differing in Levels of Physical Activity', *Perceptual and Motor Skills* 55: 171–80.

Del Rey, P. (1989) 'Training and Contextual Interference Effects on Memory and Transfer', *Research Quarterly for Exercise and Sport* 60: 342–7.

Del Rey, P., Whitehurst, M., Wughalter, E. and Barnwell, J. (1983) 'Contextual Interference and Experience in Acquisition and Transfer', *Perceptual and Motor Skills* 57: 241–2.

Del Rey, P., Wughalter, E. and Carnes, M. (1987) 'Level of Expertise, Interpolated Activity and Contextual Interference Effects on Memory and Transfer', *Perceptual and Motor Skills* 64: 275–84.

Del Rey, P., Wughalter, E. and Whitehurst, M. (1982) 'The Effects of Contextual Interference on Females with Varied Experience in Open Sport Skills', *Research Quarterly for Exercise and Sport* 53(2): 108–15.

Dunham, P., Jr, Lemke, M. and Moran, P. (1991) 'Effect of Equal and Random Amounts of Varied Practice On Transfer Task Performance', *Perceptual and Motor Skills* 73: 673–4.

Edwards, J.M., Elliott, D. and Lee, T.D. (1986) 'Contextual Interference Effects during Skill Acquisition and Transfer in Down's Syndrome Adolescents', *Adapted Physical Activity Quarterly* 3: 250–8.

Farrow, D. and Maschette, W. (1997) 'The Effects of Contextual Interference on Children Learning Forehand Tennis Groundstrokes', *Journal of Human Movement Studies* 33: 47–67.

Figueiredo, T.P. and Barreiros, J.M. (1993) 'Contextual Interference Research: An Overview', *Motricidade Humana* 9(2): 61–71.

French, K.E., Rink, J.E. and Werner, P.H. (1990) 'Effects of Contextual Interference on Retention of Three Volleyball Skills', *Perceptual and Motor Skills* 71: 179–86.

Goode, S.L. and Magill, R.A. (1986) 'Contextual Interference Effects in Learning Three Badminton Serves', *Research Quarterly for Exercise and Sport* 57(4): 308–14.

Hall, K.G., Domingues, D.A. and Cavazos, R. (1994) 'Contextual Interference Effects with Skilled Baseball Players', *Perceptual and Motor Skills* 78: 835–41.

Hebert, E.P., Landin, D. and Solmon, M.A. (1996) 'Practice Schedule Effects on the Performance and Learning of Low and High-Skilled Students: An Applied Study', *Research Quarterly for Exercise and Sport* 67(1): 52–8.

Heitman, R.J. and Gilley, W.F. (1989) 'Effects of Blocked Versus Random Practice by Mentally Retarded Subjects on Learning a Novel Skill', *Perceptual and Motor Skills* 69: 443–7.

Jarus, T. and Goverover, Y. (1999) 'Effects of Contextual Interference and Age on Acquisition, Retention, and Transfer of Motor Skill', *Perceptual and Motor Skills* 88: 437–47.

Jarus, T., Wughalter, E.H. and Gianutsos, J.G. (1997) 'Effects of Contextual Interference and Conditions of Movement Task on Acquisition, Retention and Transfer of Motor Skills by Women', *Perceptual and Motor Skills* 84: 179–93.

Landin, D. and Hebert, E. (1994) 'Comparing Practice Schedules along the Contextual Interference Continuum: An Applied Study', *Journal of Sport and Exercise Psychology* 16: S-74.

Landin, D. and Hebert, E.P. (1995) 'Practicing Basketball Shooting under High, Moderate and Low Levels of Contextual Interference', *Research Quarterly for Exercise and Sport* 66 (suppl.): A64–A65.

Landin, D. and Hebert, E.P. (1997) 'A Comparison of Three Practice Schedules along the Contextual Interference Continuum', *Research Quarterly for Exercise and Sport* 68: 357–61.

Lee, T.D. and Magill, R.A. (1983) 'The Locus of Contextual Interference in Motor Skill Acquisition', *Journal of Experimental Psychology: Learning, Memory and Cognition* 9: 730–46.

Lee, T.D. and Magill, R.A. (1985) 'Can Forgetting Facilitate Skill Acquisition?', in D. Goodman, R.B. Wilberg and I.M. Franks (eds) *Differing Perspectives in Motor Learning, Memory and Control*, pp. 3–22. Amsterdam: North Holland.

Li, Y. and Lima, R.P. (2002) 'Rehearsal of Task Variations and Contextual Interference Effect in a Field Setting', *Perceptual and Motor Skills* 94(3): 750–2.

Magill, R.A. and Hall, K.G. (1990) 'A Review of the Contextual Interference Effect in Motor Skill Acquisition', *Human Movement Science* 9: 241–89.

Moxley, S.E. (1979) 'Schema: The Variability of Practice Hypothesis', *Journal of Motor Behavior* 11: 65–70.

Pollock, B.J. and Lee, T.D. (1997) 'Dissociated Contextual Interference Effects in Children and Adults', *Perceptual and Motor Skills* 84: 851–8.

Porretta, D.L. and O'Brien, K. (1991) 'The Use of Contextual Interference Trials by Mildly Mentally Handicapped Children', *Research Quarterly for Exercise and Sport* 62(2): 244–8.

Prahl, B.K. and Edwards, W.H. (1995) 'A Field Test of the Contextual Interference Effects on Skill Acquisition in Pickle-Ball with Seventh Grade Boys and Girls', *Research Quarterly for Exercise and Sport* 66 (suppl.): A-55.

Schmidt, R.A. (1975) 'A Schema Theory of Discrete Motor Skill Learning', *Psychological Review* 82: 225–60.

Shea, C.H., Kohl, R. and Indermill, C. (1990) 'Contextual Interference: Contributions of Practice', *Acta Psychologica* 73: 145–57.

Shea, J.B. and Morgan, R.L. (1979) 'Contextual Interference Effects on the Acquisition, Retention and Transfer of a Motor Skill', *Journal of Experimental Psychology: Human Learning and Memory* 5: 178–87.

Shea, J.B. and Zimny, S.T. (1983) 'Context Effects in Memory and Learning Movement Information', in R.A. Magill (ed.) *Memory and Control of Action*, pp. 345–66. Amsterdam: North Holland.

Shea, J.B. and Zimny, S.T. (1988) 'Knowledge Incorporation in Motor Representation', in O.G. Meijer and K. Roth (eds) *Complex Movement Behaviour: The Motor-Action Controversy*, pp. 289–314. Amsterdam: North-Holland.

Shewokis, P.A. and Snow, J. (1997) 'Is the Contextual Interference Effect Generalizable to Non-Laboratory Tasks?', *Research Quarterly for Exercise and Sport* 68: A-64.
Smith, P.J. (1997) 'Attention and the Contextual Interference Effect for a Continuous Task', *Perceptual and Motor Skills* 84: 83–92.
Smith, P.J. (2002) 'Applying Contextual Interference to Snowboarding Skills', *Perceptual and Motor Skills* 95(3): 99–105.
Smith, P.J. and Davies, M. (1995) 'Applying Contextual Interference to the Pawlata Roll', *Journal of Sports Science* 13(6): 455–62.
Smith, P.J.K., Gregory, S.K. and Davies, M. (2003) 'Alternating Versus Blocked Practice in Learning a Cartwheel', *Perceptual and Motor Skills* 96(3): 1255–64.
Ugrinowitsch, H. and Manoel, E.J. (1999) 'Interferência contextual: Variação de programa e parâmetro na aquisição da habilidade motora saque de voleibol', *Rev. Paulista de Educação Fisica* 13(2): 197–216.
Van Rossum, J.H.A. (1980) 'The Schema Notion in Motor Learning Theory: Some Persistent Problems in Research', *Journal of Human Movement Studies* 6: 269–79.
Vera, J.G. and Montilla, M.M. (2003) 'Practice Schedule and Acquisition, Retention, and Transfer of a Throwing Task in 6-Yr.-Old Children', *Perceptual and Motor Skills* 96(3): 1015–24.
Wegman, E. (1999) 'Contextual Interference Effects on the Acquisition and Retention of Fundamental Motor Skills', *Perceptual and Motor Skills* 88: 182–7.
Whitehurst, M. and Del Rey, P. (1983) 'Effects of Contextual Interference, Task Difficulty and Levels of Processing on Pursuit Tracking', *Perceptual and Motor Skills* 57: 619–28.
Wrisberg, C.A. (1991) 'A Field Test of the Effect of Contextual Variety during Skill Acquisition', *Journal of Teaching in Physical Education* 11: 21–30.
Wrisberg, C.A. and Liu, Z. (1991) 'The Effect of Contextual Variety on the Practice, Retention and Transfer of an Applied Motor Skill', *Research Quarterly for Exercise and Sport* 62(4): 406–12.
Wrisberg, C.A. and Mead, B.J. (1983) 'Developing Coincidence Timing Skill in Children: A Comparison of Training Methods', *Research Quarterly for Exercise and Sport* 54(1): 67–74.

Résumé

L'effet d'interférence contextuelle dans un cadre appliqué

Cette étude analyse les publications scientifiques qui traitent de l'effet d'interférence contextuelle dans un cadre appliqué. Contrairement à un cadre de laboratoire, où les conditions d'interférence élevées réduisent l'acquisition et favorisent l'apprentissage évalué grâce à des tests de mémorisation et de réinvestissement, dans un cadre appliqué, une majorité d'études (60%) n'observent pas d'effets positifs après la analyse de l'interférence contextuelle. Quelques explications de ce phénomène sont avancées en ce qui concerne les caractéristiques de la tâche, comme la prédominance d'exercices séquentiels, peu d'intervalles courts entre les essais dans un cadre appliqué, l'interférence produite par l'utilisation de programmes moteurs différents et la possible interférence entre l'influence concurrente des exercices lents comparativement aux compétences balistiques. Il semble qu'il y ait un effet d'interférence contextuelle plus évident dans un cadre appliqué, où le sujet apprend une tâche séquentielle présentant un degré de complexité élevé.

Resumen

La interferencia instrumental y la influencia de los contextos de aplicación

Este trabajo analiza la literatura científica que trata de la relación entre los contextos de aprendizaje y los planteamientos e instrumentos de enseñanza. En contraste con las preparaciones de laboratorio en las cuales unas altas condiciones de interferencia hacen disminuir la adquisición y promueven el aprendizaje, evaluable en la retención y la transferencia mediante tests, en el caso de la aplicación contextualizada de un instrumento de trabajo, la mayor parte de los estudios (60%) no observan efectos positivos tras la manipulación de interferencias o modificaciones del contexto. Algunas posibles explicaciones se centran en la hipótesis de las características de los objetivos planteados y las formas de trabajarlos; así, parece ser que el trabajo en series de objetivos o de metas son más ventajosos que otros que establecen intervalos de aprendizaje. Parece evidente que es mayor la influencia del contexto, cuando los aprendizajes plantean series de tareas de un alto grado de complejidad.

Zusammenfassung

Kontextuelle Interferenz-Effekte im empirischen Feld

Der Artikel gibt den Forschungsstand zu kontextuellen Interferenz-Effekten im empirischen Feld wider. Im Unterschied zu künstlichen Labor-Versuchen, in denen durch Retention- und Transfer-Tests nachgewiesen wurde, dass hohe Interferenzbedingungen Lernerfolge herabsetzen und das Lernen fördern, konnten im empirischen Feld in 60% der Studien nach Überprüfung der kontextuellen Interferenzen keine positiven Effekte nachgewiesen werden. Als mögliche Erklärungen für diesen Tatbestand werden Hypothesen aufgestellt mit Blick auf die Charakteristika der Aufgabe: demnach sind serielle Aufgabenstellungen vorteilhaft, kurze Untersuchungs-Intervalle im empirischen Feld selten zu finden, Interferenzen durch die Nutzung verschiedener motorischer Tests produziert und dass die mögliche Interferenz durch gleichzeitiges Feed-Back bei langsamen Aufgabenstellungen im Kontrast zu den ballistischen Fertigkeiten steht. Es scheint so, als ob der kontextbezgoene Interferenz-Effekt im empirischen Feld eindeutiger nachgewiesen werden kann, wenn das Subjekt eine serielle Aufgaben mit einem hohen Komplexitätsgrad bewältigen muss.

João Barreiros and **Mário Godinho** are associate professors in the Faculty of Human Movement Sciences, at the Technical University of Lisbon.

Address: Faculdade de Motricidade Humana, Estrada da Costa, Cruz Quebrada, 1495–688 Cruz Quebrada-Dafundo, Portugal. [email: jbarreiros@fmh.utl.pt; mgodinho@fmh.utl.pt]

Teresa Figueiredo is an assistant professor at the Polytechnic Institute of Setúbal.

Address: Instituto Politécnico de Setúbal, Escola Superior de Educação, Estefania, 2914–504 Setúbal, Portugal. [email: teresa.figueiredo@sapo.pt]
