CONTEXTUAL INTERFERENCE: INTERACTIONS WITH REFLECTION-IMPULSIVITY¹

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Summary.—In the present study, interactions of contextual interference and the cognitive style reflection-impulsivity were examined for training and retention performance. 64 subjects were randomly assigned to either a random or blocked practice schedule in learning a cursor-movement task. Reflectivity indices were determined by means of our computerized version of the Matching Familiar Figures Test. Analysis showed that the generally positive effect of practicing under a random practice schedule decreased for more reflective subjects. Further, training under a random practice schedule forced impulsive subjects to behave more like reflective ones, which improved their performance at retention. It was concluded that reflection-impulsivity is an important factor to be incorporated into the design of effective training programs.

Recently, an increasing number of studies have contrasted performance under conditions of low and high contextual interference; see for summaries and theoretical perspectives, Lee and Magill (1985), Magill and Lee (1984), and Shea and Zimny (1983, 1988). In this study, we examine interactions between effects of contextual interference on training and retention and the cognitive style reflection-impulsivity (Kagan, Rosman, Day, Albert, & Phillips, 1964).

In typical experiments on contextual interference, a learner is asked to practice a number of (related) tasks or a number of variants of a single task in either a *blocked* or *random* practice schedule, the structure of practice schedule being the determining factor of the degree of contextual interference. Practice schedules in which all trials on one task are completed before a next task is introduced, are considered to produce low contextual interference; practice schedules in which tasks are practiced in an unsystematic order across trials are considered to produce high contextual interference.

In general, random practice conditions result in a decrement in performance during training but produce a consistent facilitation of retention, relative to blocked practice conditions (e.g., Del Rey, Wughalter, & Whitehurst, 1982; Jelsma & Pieters, in press a; Lee & Magill, 1983; Lee, Magill, & Weeks, 1985; Shea & Morgan, 1979). Recently, Shea and Zimny (1988) have associated their theoretical position on the effects of contextual interference with the controlled/automatic processing dichotomy (Schneider

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& Shiffrin, 1977; Shiffrin & Schneider, 1977); see also Shea and Zimny (1983). They suggest that blocked practice enables subjects to attend to fewer aspects of the task on each trial as they would if they were given a different task on each trial. Consequently, subjects perform less well on retention tasks because there is less information available. On the other hand, random practice facilitates controlled processing which results in a memorial representation that is more adequate for retrieval in retention.

Besides particular types of practice schedules also other factors may be related to the extent to which controlled processing is utilized during acquisition. Recently, Ackerman (1986) and Ackerman and Schneider (1985) related individual differences in information processing to concepts of intellectual abilities. In agreement with their theory, also cognitive styles may be conceptualized as peoples' inborn tendencies to utilize controlled processing to a greater or lesser extent. Further justification for this can be found in Baron's (1982) interpretation of cognitive styles. Baron suggests that people differ in their propensities to deviate in setting optimal values of parameters for separate phases of thinking. The optimal setting of each parameter is determined by a rule, for example, that one should stop thinking (stop using controlled processing) when the expected benefit from additional thinking becomes less than the cost of that thinking.

Reflection-impulsivity, which predicts the quality of problem solving when the correct solution of the presented problem is not immediately obvious, may be of particular interest. Reflective persons tend to make few errors but act relatively slowly; impulsive persons respond quickly but do not take the time to select the correct solution carefully. In general, when several possible alternatives are available and there is some uncertainty over which one is the most appropriate, reflective persons gather information more systematically, reflect more on response alternatives, show a more efficient deployment of attention and make a more efficient use of feedback information; see a review by Messer (1976). These characteristics possibly suggest that reflective persons make more intensive use of controlled processing than do impulsive individuals.

Although cognitive styles refer to relative stable characteristics in information processing and response generation, research has shown that, under certain conditions, impulsive persons can be forced to behave more reflectively, that is, to increase their use of controlled processing (Jelsma & Pieters, in press a; Messer, 1976; Thompson, Teare, & Elliot, 1983). Assuming that random practice fosters controlled processing and assuming that, as Shea and Zimny (1983) suggest, reflective persons under blocked practice conditions tend to produce their own contextual interference, that is, they tend to make an intensive use of controlled processing of their own, we hypothesize that (a) reflective persons' performance on a retention task is

relatively unaffected by the type of practice schedule and (b) impulsive persons will benefit more from random practice than reflective subjects.

METHOD

Subjects

A group of 64 university students, consisting of 21 men and 43 women, with a mean age of 20.8 yr., participated in the experiment. They were randomly assigned to either a random practice schedule (Random, $n = 32$, high contextual interference) or a blocked practice schedule (Blocked, $n = 32$, low contextual interference).

Task

Subjects had to direct a cursor on a computer screen along four different tracks as quickly as possible and with minimal errors. During training, prior to each trial the structure of the track was displayed for 3 sec. One second thereafter, subjects received an auditory starting signal. Each track required a different procedure. A rectangular framework bordered the area in which the cursor had to be moved (Fig. 1).

FIG. 1. A track

Each track was made up of 16 straight lines and 15 right angles. The fourth, eighth, and twelfth *angular points* were marked by an asterisk. These angular points are referred to as *action points*. During task performance the tracks were not visible. The total length of each track was 60 cm. For each track, the positions of the angular points differed. Also the positions of starting point and finish indicated by the characters 'S' and 'F' respectively, were for each track unique. So, perceptually the four tracks showed little resemblance.

Four levels of task difficulty were created by using different amounts of cues. At level 1, in addition to the three asterisks, all remaining 12 angular points were marked by a dot (Fig. 2A). At level 2, the first two angular points after the 'S' or after an asterisk were marked by a dot (8 dots, Fig. 2B). At level 3, only the first angular point after the 'S' or after an asterisk

FIG. 2. The four difficulty levels of one of the procedures. (A level 1; B level 2; C level 3; D level 4. The dotted lines were not visible for subjects.)

was marked by a dot (4 dots, Fig. 2C). And at level 4, apart from the three asterisks no angular points were marked at all (Fig. 2D).

To set the cursor going, subjects had to perform at each action point (including the starting point 'S') the right procedural step by entering the right response combination of four discrete actions on a special developed

TABLE 1
PROCEDURES TO FOLLOW THE FOUR TRACKS

Procedure	Procedural Steps			
	1	2	3	4
I	R-U-L-U	R-U-R-D	L-D-R-D	R-U-L-U
II	R-U-L-D	L-U-L-U	R-D-R-U	R-D-L-D
III	D-L-U-L	D-R-U-L	U-R-D-R	D-R-U-L
IV	L-U-R-U	L-U-L-D	L-D-R-D	L-D-L-D

Note.—R = right; L = left; U = up; D = down.

control panel. So, a procedural step specified the route for the cursor to go from one action point to the next action point or to the 'F'. As can be seen from Table 1, the procedures through which the tracks could be followed had no procedural steps in common and so there was no overlap between the four procedures.

The cursor moved from one action point to the next action point or to the 'F' only if the right procedural step was executed, that is, only if the right response combination was entered. Its speed was 12 cm/sec. For instance, to direct the cursor in Fig. 1 (see Table 1, procedure I) from the first action point (starting point 'S') to the second (fourth angular point) the response combination Right, Up, Left, Up should be entered on the control panel. To indicate that a next procedural step could be executed, an auditory signal was rendered the moment the cursor arrived at the adjacent action point. Auditory feedback (beep) was provided as soon as the subject pushed in a wrong direction key. In that case, an error was registered. At the same time the part of the procedural step that had been entered correctly was displayed in the bottom left corner of the screen by means of the characters 'R' (right), 'L' (left), 'D' (down), and 'U' (up). The subject just had to complete the procedural step to proceed. For each trial, total number of errors and total decision times were computed. Decision times were measured as the time from the auditory starting signal, or from reaching an asterisk, to the initiation of cursor movement. A trial was completed as soon as the cursor reached the 'F'.

Materials

Subjects' scores on the reflection-impulsivity dimension were measured by a computerized version of the Matching Familiar Figures Test (Van Merriënboer & Jelsma, 1988). On this test, standard pictures are presented with eight alternatives; only one of those alternatives is identical to the standard. For each of the 12 items of the test, a visual match of the alternatives to the standard is required. Time in seconds to first response and number of errors are registered for each item; total time and total error scores are computed over the 12 items. For each subject, the 'reflectivity index' is computed as the standardized total time score minus the standardized total error score (Kagan, Lapidus, & Moore, 1978).

The cursor-movement task was conducted in a sound-proof cubicle, and the whole experiment was controlled by a PDP-11/03 minicomputer. The tracks were presented on a monochrome screen; subjects directed the cursor with four soft-touch direction keys of a control panel that was mounted on a table in front of them.

Procedure

At the beginning of each training session, the Matching Familiar Figures Test was administered, and subjects were given written instructions that explained the purpose of the task. During training, each subject performed 10 trials for each track, that is, a total of 40 trials. In the Random group, subjects practiced the four tracks, with a different difficulty level for each track, in a random order; moreover, the same track was never practiced

twice in succession. In the Blocked group, subjects practiced the four tracks, again with a different difficulty level for each track, in a blocked order; that is, they completed all 10 trials for one particular track before a new track was introduced. The design was completely counterbalanced for both difficulty levels and order of presentation of tracks.

Three weeks after the training, both groups performed three retention trials for each track, that is, a total of 12 trials. Now, they had to infer the complete track from the positions of the 'S,' 'F,' and asterisks that were all specific for each track. Prior to the retention trials, the structure of the track was not displayed on the screen; furthermore, during the retention trials, no dots were displayed so that all tracks were assigned the highest difficulty level. The retention trials were always performed in a blocked order. For each trial, total number of errors and total decision times were computed as during training.

RESULTS

All effects were established by multiple-regression analyses on errors and decision times; for a discussion on using this statistic in the analysis of reflection-impulsivity data, see Messer (1976).

Acquisition

Analyses of training data yielded significant effects for difficulty level on both errors and decision times; more errors were made at higher difficulty levels ($F_{3,2556} = 16.35$, $p < .001$) and also more time was needed ($F_{2,2557} = 17.81$, $p < .001$). For decision times, the group effect was significant as well; the Random group took longer times than the Blocked group ($F_{2,2557} = 49.09$, $p < .001$).

The analyses also yielded a significant interaction of group $\times$ cognitive style on errors. In the Blocked group, the more reflective subjects made less errors; in the Random group, the degree of reflectivity seemed to be unrelated to the number of errors ($F_{3,2556} = 3.91$, $p < .05$). A similar tendency was observed in decision times. In the Blocked group the more reflective persons took longer times; in the Random group decision times were relatively unaffected by reflectivity. Differences between an impulsive and reflective way of responding were for the greater part neutralized if tasks were practiced under conditions of high contextual interference. Fig. 3 presents errors and decision times plotted as a function of reflectivity for both training and retention; Table 2 presents corresponding slopes and intercepts of the regression lines.

Retention

Analyses of retention data indicated significant effects of difficulty level on both errors and decision times; increasing difficulty level during training resulted in fewer errors ($F_{3,764} = 6.54$, $p < .01$) and shorter decision

ERRORS

DECISION TIMES (sec.)

FIG. 3. The influence of reflection-impulsivity under a random and blocked practice schedule for training and retention data

times on retention ($F_{2,765} = 13.08, p < .001$). For errors, an effect for cognitive style was found as well; the more reflective persons made fewer errors than the more impulsive ones ($F_{3,764} = 8.50, p < .01$).

The analyses also gave a significant interaction on errors for group $\times$ cognitive style; see Fig. 3 and Table 1. In the Blocked group, the more reflective subjects made fewer errors; in the Random group, this tendency was far less pronounced ($F_{3,764} = 4.21$, $p < .05$). This finding was supported by a similar tendency in decision times. The higher the degree of reflectivity, the less difference was observed between practicing under low and high conditions of contextual interference. As reflectivity increased, the advantages of a random practice schedule over a blocked practice schedule decreased.

TABLE 2
SLOPES AND INTERCEPTS OF REGRESSION LINES UNDER RANDOM AND
BLOCKED PRACTICE SCHEDULES FOR TRAINING AND RETENTION

Measure	Slope	Intercept
Errors		
Training		
Blocked	-.079	1.14
Random	.026	1.55
Retention		
Blocked	-.295	2.44
Random	-.052	2.22
Decision Times (sec.)		
Training		
Blocked	.384	17.04
Random	.078	21.63
Retention		
Blocked	-.352	20.82
Random	.114	17.79

DISCUSSION

Main effects and interactions of group $\times$ difficulty level are extensively discussed by Jelsma and Pieters (in press b). Here, we focus on interactions of practicing under low and high levels of contextual interference and the cognitive-style reflection-impulsivity. In general, our findings give more insight into interactions between practicing under low and high contextual interference and individual differences related to the cognitive style reflection-impulsivity. In addition, the results of our study provide some support for results of earlier studies of contextual interference effects. As expected, random practice results in lower performance during training, and there is a clear tendency that random practice enhances retention performance.

Our results indicate that the effects of contextual interference are related to reflectivity. As retention data show, the benefits of practicing under conditions of high contextual interference disappear as reflectivity increases.

Reflective subjects are able to acquire skills and achieve high performance independently of the structure of practice schedules. This finding may be related to the typical characteristics of a reflective way of responding, which can be interpreted in terms of utilization of controlled processing during the course of learning. It can be argued that unlike impulsive persons, reflective persons make a more intensive use of controlled processing of their own, which makes them relatively indifferent to effects of blocked or random practice. This is in agreement with Shea and Zimny's (1983) observation that reflective persons under blocked practice conditions tend to create their own contextual interference.

In the other direction, as impulsivity increases, there is a growing advantage of a random practice schedule over a blocked practice schedule. On inspection of training data, it appears the usually found differences between reflective and impulsive subjects in terms of errors and times, that reflective persons make few errors but act slowly and impulsive persons make many errors but act quickly, are indeed present in the Blocked group, but absent in the Random group. Practicing under conditions of high contextual interference suppresses the typical behavioral characteristics of the cognitive style reflection-impulsivity. It appears that random practice makes impulsive persons behave more like reflective ones, that is, random practice forces impulsive subjects to make a more extensive use of controlled processing. This finding supports the results of an earlier study of Jelsma and Pieters (in press a) in which a similar tendency was observed. Because impulsive persons behave more like reflective subjects under conditions of high contextual interference, random practice turns out to be of particular interest for impulsive subjects in terms of achievement on a retention test, as indicated by the results of our study.

In summary, we found that effects of contextual interference on retention are related to the degree of reflectivity, which may be of particular interest to research on aptitude treatment interaction (Cronbach & Snow, 1977). However, it should be noted that we focused on a special kind of retention. Whereas the four tracks of the cursor-movement task were practiced at four levels of difficulty, which were created by displaying a different number of cues, on retention all tracks were assigned the highest difficulty. In this respect, our retention task may be considered as a near-transfer task to indicate that it is similar but not identical to the training setting. Thus, our results cannot be directly generalized to either pure retention or further transfer tasks. For those kinds of tasks more research is needed to examine interactions between contextual interference and reflection-impulsivity. Nevertheless, based on the results of our study, it is concluded that reflection-impulsivity is an important factor to be incorporated into the instructional design of effective training programs,

particularly with the potential of the increasing use of individualized instruction offered by computer-based instruction.

REFERENCES

- ACKERMAN, P. L. (1986) Individual differences in information processing: an investigation of intellectual abilities and task performance during practice. *Intelligence*, 10, 101-139.
- ACKERMAN, P. L., & SCHNEIDER, W. (1985) Individual differences in automatic and controlled information processing. In R. F. Dillon (Ed.), *Individual differences in cognition*. Vol. 2. New York: Academic Press. Pp. 35-66.
- BARON, J. (1982) Personality and intelligence. In R. J. Sternberg (Ed.), *Handbook of human intelligence*. Cambridge, MA: Cambridge Univer. Press. Pp. 308-351.
- CRONBACH, L. J., & SNOW, R. E. (1977) *Aptitudes and instructional methods: a handbook for research on interactions*. New York: Irvington.
- DEL REY, P., WUGHALTER, E. H., & WHITEHURST, M. (1982) The effects of contextual interference of females with experience in open sport skills. *Research Quarterly for Exercise and Sport*, 53, 108-115.
- JELSMA, O., & PIETERS, J. M. (in press a) Instructional strategy effects on the retention and transfer of procedures of different difficulty level. *Acta Psychologica*.
- JELSMA, O., & PIETERS, J. M. (in press b) Practice schedule and cognitive style interaction in learning variants of a maze task. *Journal of Applied Cognitive Psychology*.
- KAGAN, J., LAPIDUS, D. R., & MOORE, M. (1978) Infant antecedents of cognitive functioning: a longitudinal study. *Child Development*, 49, 1005-1023.
- KAGAN, J., ROSMAN, B., DAY, D., ALBERT, J., & PHILLIPS, W. (1964) Information processing in the child: significance of analytic and reflective attitudes. *Psychological Monographs*, 78, No. 1 (Whole No. 578).
- LEE, T. D., & MAGILL, R. A. (1983) The locus of contextual interference in motor skill acquisition. *Journal of Experimental Psychology: Learning, Memory and Cognition*, 9, 730-746.
- LEE, T. D., & MAGILL, R. A. (1985) Can forgetting facilitate skill acquisition? In D. Goodman, R. B. Wilberg, & I. M. Franks (Eds.), *Differing perspectives in motor learning, memory, and control*. Amsterdam: North-Holland. Pp. 3-23.
- LEE, T. D., MAGILL, R. A., & WEEKS, D. J. (1985) Influence of practice schedule on testing schema theory predictions in adults. *Journal of Motor Behavior*, 17, 283-299.
- MAGILL, R. A., & LEE, T. D. (1984) Contextual interference effects in motor skill acquisition: interference or elaboration benefit. Paper presented at the Olympic Scientific Congress, Eugene, OR.
- MESSER, S. B. (1976) Reflection-impulsivity: a review. *Psychological Bulletin*, 83, 1026-1052.
- SCHNEIDER, W., & SHIFFRIN, R. M. (1977) Controlled and automatic human information processing: I. Detection, search and attention. *Psychological Review*, 84, 1-66.
- SHEA, J. B., & 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, 9-187.
- SHEA, J. B., & ZIMNY, S. T. (1983) Context effects in memory and learning movement information. In R. A. Magill (Ed.), *Memory and control of action*. Amsterdam: North-Holland. Pp. 345-366.
- SHEA, J. B., & ZIMNY, S. T. (1988) Knowledge incorporation in motor representation. In O. G. Meijer & K. Roth (Eds.), *Complex movement behaviour*. Amsterdam: North-Holland. Pp. 289-314.
- SHIFFRIN, R. M., & SCHNEIDER, W. (1977) Controlled and automatic human information processing: II. Perceptual learning, automatic attending, and a general theory. *Psychological Review*, 84, 127-190.
- THOMPSON, R. W., TEARE, J. F., & ELLIOTT, S. N. (1983) Impulsivity: from theoretical constructs to applied interventions. *Journal of Special Education*, 17, 157-169.
- VAN MERRIËNBOER, J. J. G., & JELSMA, O. (1988) The Matching Familiar Figures Test: computer or experimenter-controlled administration? *Educational and Psychological Measurement*, 48, 161-164.

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