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ABSTRACT

An earlier review by the author reported an aptitude-treatment interaction (ATI) relating instructional feedback and prior knowledge. For low prior knowledge learners, single-try feedback (STF) was slightly superior to multiple-try feedback (MTF), while for high prior knowledge learners, MTF was superior to STF. In the current report, raw score data from existing studies that examined STF and MTF, but that had not considered the possibility of an ATI, are combined and reanalyzed by ANOVA (ANalysis Of VAriance). This study addresses the following questions: is there an interaction between learner prior knowledge and number of feedback tries provided by computer-based training (CBT) lessons; and, if so, how large is this effect? The results of this analysis are presented along with a tentative explanation of the observed effect. Prescriptive application of the ATI and suggestions for future study are provided. (Author/MES)

CBT Design: A Feedback Aptitude Treatment Interaction

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Abstract

A review by Clariana (1993) reported an aptitude-treatment interaction (ATI) relating instructional feedback and prior knowledge. For low prior knowledge learners, single-try feedback (STF) was slightly superior to multiple-try feedback (MTF), while for high prior knowledge learners, MTF was superior to STF. In this present report, raw score data from existing studies that examined STF and MTF, but that had not considered the possibility of an ATI were combined and reanalyzed by ANOVA. The results of this analysis are presented along with a tentative explanation of the observed effect. Prescriptive application of the ATI and suggestions for future study are provided.

Relevance

Frequently in corporate settings and occasionally in general education settings, mastery of lower level skills are often critical to safety or performance. For example, consider the multitude of alarm sounds that can occur in a nuclear power plant and the correct employee reactions to these alarms. This message includes verbal information, lower level intellectual skills, and possibly some attitudinal objectives, and it would be hard to dispute that this particular message is not important to the employees safety and also their feelings of well-being. In this case, computer-based training (CBT) can accurately produce the correct sounds and can require the employee to describe the nature of the emergency and the correct responses to each category of emergency (believe it or not, it's not always run away as fast as you can). This type of CBT module would be easy and relatively inexpensive to develop and deliver (especially compared to instructor led training), and allows for new employee training just-in-time and refresher training for existing employees as needed due to the infrequency of such alarms. Decades of educational research support the use of practice with feedback for learning this type of information. This presentation argues that learners' prior knowledge should be considered when deciding which type of feedback to use in the lesson design. This information has immediate practical application for CBT designers.

Note that this is not new data, but is a reanalysis of four previous experimental studies and an expansion of an earlier review by Clariana (1993). Richey (1998) has described these two processes as an accepted form of replicability, though caution must be taken that this present report is not seen as new data. This reanalysis and expansion seem acceptable because of the limited circulation of that earlier review due to the demise of the Journal of Computer-based Instruction at that time and the lack of information regarding this possible ATI when the four experimental studies were originally conducted. Further, the audience for this presentation are the most potent group for utilizing this information.

Introduction

Advances in voice recognition technology will soon allow relatively accurate evaluation of spoken words, and neural network software technology may eventually allow evaluation of sentences and paragraphs. However, currently computers are limited in the types of learner responses that can be evaluated in order to give corrective feedback. Computers can evaluate learner recognition tasks like clicking on an image or a word, and some free recall tasks, such as typing in words and short phrases.

Feedback in these circumstances has consistently been shown to be better than no feedback (for example, see Clariana, Ross, & Morrison, 1991). But is one type of feedback superior to another? A meta-analysis by Bangert-Drowns, Kulik, Kulik, and Morgan (1991) reported effect sizes (ES) that compared no feedback to (a) right/wrong feedback, usually referred to as knowledge of response feedback (KR), (b) knowledge of correct response feedback (KCR), (c) try-again feedback (requires multiple tries), and (d) elaborative feedback. Compared to no feedback, KR was negatively effective (ES = -0.08), followed next by KCR feedback, ES = 0.22. Repeat until correct and elaborative feedback were equally most effective (ES = 0.53). The performance results for feedback may be summarized as: KR < no feedback < KCR < Repeat until correct = Elaborative. Prescriptively, elaborative feedback and multiple-try feedback were equally most effective, however elaborative feedback typically is more difficult and costly to design.

A review of 30 studies by Clariana (1993) took this a step further by comparing forms of multiple-try feedback (MTF) to no feedback, KR feedback, KCR feedback, and delayed feedback. The median effect size for MTF compared to no feedback based on 16 effect size measures from 12 studies was ES = 0.56. This finding is nearly identical to the results of Bangert-Drowns et. al. (1991) above. However, unlike that meta-analysis, the

results for MTF compared to KR, KCR, and delayed feedback were all mixed, with median effect sizes close to no difference.

To explain these mixed findings, Clariana (1993) suggested that low-prior knowledge learners benefited slightly from single-try feedback forms relative to multiple-try feedback forms, while high-prior knowledge learners benefited greatly from multiple-try feedback forms relative to single-try feedback forms. If supported, this provides CBT designers with clear guidelines for selecting number of feedback tries based on audience analysis data and/or ongoing lesson performance.

The current presentation considers this feedback by prior knowledge aptitude treatment interaction (ATI) by combining and reanalyzing data from the existing studies described in Clariana (1993). This study addresses the following questions: (a) Is there an interaction between learner prior knowledge and number of feedback tries provided by CBT lessons? (b) If so, how large is this effect?

Approach

A review of the literature was conducted to identify all available studies that compared MTF and STF while also providing raw score data. It was necessary that besides posttest measures, the data set must also contain some measure of prior knowledge of the content, so that individual subjects could be classified as "low" or "high" in terms of prior knowledge. In all cases, lesson data ultimately was used to form low and high prior knowledge groupings based on median split of lesson scores.

- Three dissertations and one published report were obtained that met these criteria. All four utilized computer-based delivery of the instructional materials. The studies included: Noonan (1984) n = 60, Clariana and Smith (1989) n = 48, Nielson (1990) n = 173, and Clariana (1990) n = 40.
- Posttest raw scores were converted to standard scores within each study, then these standard scores were combined into one data set and analyzed by 2x2x4 analysis of variance (ANOVA) with the factors feedback (MTF and STF), prior knowledge (low and high), and study (the four studies listed above). The final sample contained n = 321 subjects.

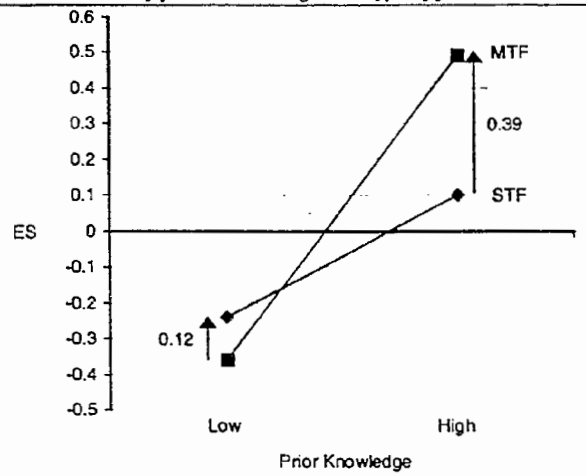
The main effect for number of feedback was not significant (see Table 1). The main effect for prior knowledge was highly significant $F(1, 305) = 24.21$, $p=.0001$. As would be expected, those students that performed well on the CBT lesson also performed better on the posttest. This finding is interesting in that in experimental studies using grouping by lesson performance, there is typically a regression to the mean. The "low" group tends to gain quite a bit since their lesson scores are low, while the "high" group gains less and may even decline. If the experimental treatment is not strong enough, this regression to the mean causes a leveling effect that can wash-out low and high group differences.

Table 1. Posttest scores Analysis of Variance

Source	df	SS	MS	F	p
Feedback tries (T)	1	0.14	0.14	0.16	0.69
Prior knowledge (K)	1	22.02	22.02	24.21	0.00 *
F x T	1	5.05	5.05	5.55	0.02 *
Study (S)	3	0.06	0.02	0.02	0.99
T x S	3	2.15	0.72	0.79	0.50
K x S	3	0.45	0.15	0.16	0.92
T x K x S	3	1.96	0.65	0.72	0.54
Error	305	277.34	0.91		

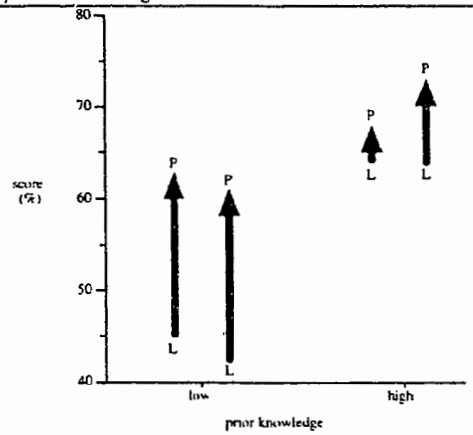
A significant interaction of feedback and prior knowledge was observed $F(1, 305) = 5.55$, $p=.02$. For low prior knowledge students, single-try feedback was more effective than multiple-try feedback, ES = 0.11 (see Figure 1). For high prior knowledge learners, multiple-try feedback was better, ES = 0.39.

Figure 1. Interaction of prior-knowledge and type of feedback.



The low-prior knowledge students made large lesson (L) to posttest (P) gains with both single-try and multiple-try feedback (see Figure 2). The high-prior knowledge students, since they had already scored high on the lesson measure of content knowledge, did not make gains as great as the low-prior knowledge students. In addition, the high prior-knowledge students receiving multiple-try feedback (the right vector of the "high" pair of vectors) made larger gains on the posttest relative to the high-prior students receiving single-try feedback (the left vector of the "high" pair of vectors) even though both groups already had good content knowledge.

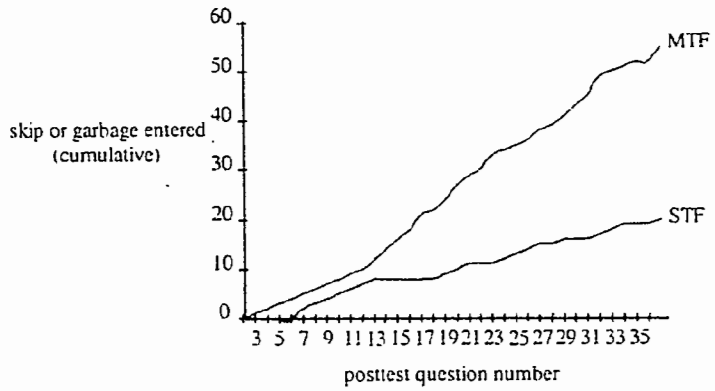
Figure 2. Lesson score (L) to Posttest (P) gains as vectors for single-try (left) and multiple-try (right) at low and high prior-knowledge levels.



Discussion

To summarize, this reanalysis supports an ATI for prior knowledge and number of feedback tries. Our *tentative explanation* of this effect involves an attitudinal impact on learning. Note that for these four studies, and for most if not all MTF studies so far, there is no difference in presentation form between STF and MTF when the learner's response is correct. The difference in presentation form between STF and MTF occurs only with lesson errors, in that the learner must respond again with MTF but is usually provided the correct answer without additional responses with STF. Dick and Latta (1970) reported that low ability students became frustrated with repeat until correct (MTF) recall lessons relative to high able students and also the STF treatment. To examine possible frustration with MTF, we recently collected item-by-item posttest responses for twenty of our students who were taking a computer-based module as an assignment in an instructional design class. In that module, it was possible to intentionally skip posttest questions (recall level) by entering either nothing or else entering nonsense letters ("garbage") and pressing Enter. Figure 3 below shows the total number of intentionally skipped posttest items for the STF group (n=10) and MTF group (n=10). Note that the posttest was identical for each treatment, thus the pattern observed relates to attitude carried over from the preceding lesson activity.

Figure 3. Cumulative posttest "skip" or "garbage" responses.



This data leads us to feel that, as in the Dick and Latta (1970) study, students may experience some frustration with MTF, and this will likely negatively impact learning.

At the same time, in a survey of the same class, 71% of the students said that they would prefer to try-again (MTF) if given the choice. Some specific comments included: "I learn more when I get it on my own" and "Trying a second time makes me think more about the question and what it is really asking". This suggests that these learners and maybe learners in general have a bias towards "getting it right on their own", and so if they don't miss so many items that it becomes punishing, then they actively engage the items and learn more (relative), thus accounting for the higher performance for MTF with high prior knowledge learners. But if the learner misses a number of items, they begin to become frustrated and may eventually stop trying to learn, thus the lower performance for MTF (relative) for the low prior knowledge learners. Providing the correct answer after one try (STF) tends to reduce frustration for the students who miss a lot of items, but it seems to come at the cost of reduced engagement for the students who are doing well. Thus, the type of feedback given can influence the learners approach to the lesson, and on-going lesson performance serves as advisement allowing the student to decide to engage in or disengage from the lesson.

Requiring high-prior knowledge learners to try again in CBT has intuitive appeal, and can be implemented by tracking lesson performance and basing feedback prescription of STF or MTF on that performance. A lesson may start out with MTF, if a students on-going lesson performance drops below some designated value, say 80%, then the lesson changes to STF.

Does this finding generalize to other, and non-CBT settings? For example, in a constructivist-based classroom, what are the ramifications of asking questions to high-prior knowledge students versus the low-prior knowledge students. Asking a difficult question and requiring a student to develop the answer parallels the MTF condition with low prior knowledge students. This approach may be frustrating to the student, and could result in disengagement and reduced learning. Of course, teachers in class have additional options to mitigate frustration, but the question remains about what is the best approach in terms of questioning level and which students should be asked to respond. If this ATI holds for classroom instruction, in-class questions should be carefully crafted and targeted to the individual student, along the lines of Vygotsky's zone of proximal development (Vygotsky, 1986), and maybe asking some "easy" questions is a good idea.

Though this ATI is only supported by four experimental studies, there is enough evidence to warrant future studies to confirm or deny it, and possibly to expand on these findings to other settings. Though it is not currently fashionable to investigate "lower level" domains such as verbal learning using simple (or not so simple) recognition tasks like answering multiple-choice tests, nevertheless, these domains are an important and foundational to learning; and multiple-choice items, especially with feedback, are one tool among many that any instruction designer may use.

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