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ABSTRACT

Some of the problems in research on aptitude treatment interactions (ATIs), are discussed. Among these problems are the inconsistency and lack of generality to many ATI findings, especially in classroom-based ATI investigations. It is suggested that such investigations may be of limited generality due to the nature of the phenomena. The importance of careful classification of aptitude and treatment variables is also discussed. Investigation of the interaction between individual differences in prior achievement and instructional method is proposed as one way to avoid some of the problems of other approaches, including examining interactions between cognitive processes and instructional method. Finally, it is suggested that ATI researchers precede formal investigations by an observational phase: instead of beginning research by generating a prediction as to what students are likely to do in instructional situations offering a variety of alternatives, primary observation of the students' selection of options is preferable. (Author/RL)

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Abstract

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This paper discusses some of the problems in research on aptitude treatment interactions (ATIs). Among these is the inconsistency and lack of generality to many ATI findings, especially in classroom based ATI investigations. It is suggested that such investigations may well be of limited generality due to the nature of the phenomena. The importance of careful calssification of aptitude and treatment variables is also discussed. It is suggested that investigating the interaction between individual differences in prior achievement and instructional method avoids some of the problems of other approaches, including examining interactions between cognitive processes and instructional method. Finally, some suggestions are made that ATI researchers might precede more formal investigations by an observational phase.

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Adapting Instruction to Individual Differences Among Students[1]

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Adapting instruction to individual differences among students is an old challenge to education. As has been suggested elsewhere (Tobias, [illegible]) perhaps the first record of instruction being adapted to individual differences among students was Plato's recording of Socrates' attempt to instruct the slave boy Meno in the mysteries of rectangles. I might note parenthetically that old Socrates knew his beans since his instruction was adapted purely to the kid's prior achievement in this particular area, a theme that will returned to.

Since then there have been many exhortations to teachers to individualize instruction. One can go back to Thorndike in 1911 for the first of these calls (Thorndike, 1911) and more recently there have been numerous others. It is only fair to note that such exhortations have been as effective as inveighing against the weather. There is a good deal of individualization of the rate of instruction rampant in the land. Keller's (1968) people are personalizing instruction, Block's (1971) and Bloom's (1974) followers have been getting their students to master instruction, and various computer managed instructional sequences are looping students to and fro. It should be noted, however, that in these instructional schemes students proceed through essentially the same instructional material in essentially the same way. The fast ones can skip out of a lesson pretty easily, the slower ones chug along at a more leisurely rate by virtue of being looped back until the elusive mastery has been attained.

There are some large scale attempts to adapt the method of instruction to individual differences among students. Perhaps the largest of these is the advanced instructional system of the U.S. Air Force which has been documented by the McDonald group (Notes 1,2). Nevertheless, these are in the minority and, in general, what adaptations of the method of instruction exist are based on the teacher's, or the instructional designer's art rather than on persuasive theory or research findings.

This discussion has, so far, been limited to the applied consequences of adapting instruction to individual differences. I believe that such adaptation also poses a formidable challenge to basic researchers and to our understanding of the phenomena which have traditionally been of central concern to educational psychologists: the nature of individual difference and determining what practices in various instructional methods can actually lead to differences in student achievement. The clarification of this ose problem could well stand as one of the major definitions of what the discipline of educational psychology is, or should be all about. Frank Farley's whimsical subtitle for this symposium: "The State of the Union" is perfectly appropriate. Adapting instruction to student differences is at the center of this union and the solution of this problem, would be a major accomplishment for educational researchers and educational psychologists.

Failure to solve this problem is caused principally by the reluctance of ATI's to be consistant, replicable, or robust. As everyone knows ATI stands for aptitude treatment interaction, and is generally defined as the interaction

between student aptitude and different instructional methods. As fewer researchers seem to know, ATI also stands for attribute treatment interactions (Tobias, 1973a), or achievement treatment interactions (Tobias, 1976; Note 3). But, more about that later.

Reviews of ATI research are about as plentiful as replicated ATIs are rare. Their plentitude is probably caused by the fact that ATI studies are hard to run, difficult to analyze, and often impossible to understand. Reviewers, then, bravely shoulder the burden of informing the ignorant masses about the state of our arcane pursuit with prose that has all the lightness of a Mack truck, the grace of a football lineman trying out for the ballet, and the comprehensibility of any nine out of ten statistical textbooks. To be serious for a moment, this is a difficult area to study, demanding complex methodology and statistical analyses which are just not easy to understand. Couple that with the eagerness of some investigators to confuse the issue even further so that journal reviewers will be impressed by the difficulties of the research and, hence, not judge its failures too severely and you will understand why some ATI research reports are not too understandable.

If any one wants to have some light bed-time reading they might try Cronbach and Snow's (1977) tome summarizing the problems in ATI land. This milestone in the field gives a detailed chronicling of the difficulties in the design, analysis, and interpretation of this body of research.

Space does not permit a comprehensive recounting of the genuinely difficult problems of AT research. Lee Cronbach and Dick Snow made a major contribution to the field by chronicling most of the available ATI literature and attempting to make some order out of it. Other reviews of this research are also available (Snow, 1976, 1977, Tobias 1976, 1977a). Let me try to summarize some of the major difficulties in this field as detailed in these various sources.

Inconsistency of findings

In many of the studies reviewed the number of significant ATIs tend to be balanced by an almost equal number of non-significant results. Even more troubling is the difficulty in determining specifically what attributes of the students, or exactly what characteristics of the instructional method accounted for the significant or nonsignificant findings. Failure to specify such characteristics makes it difficult to follow up leads or to develop more consistent findings. Another aspect of the inconsistencies noted in previous research is the fact that of those studies reporting significant ATIs few have been succesfully repeated. This lack of replication can be attributed to many variables. Many investigations are "one shot" affairs such as dissertations, or studies in which evaluators compared two

instructional methods, and happened to have some individual difference data kicking around by which they hope to elevate a cursory evaluation to a scientific contribution. Such haphazard research is unlikely to generate a consistent body of findings. More disturbing is the fact that when replications of research attempted to use slightly different student samples, the results were frequently different from those of the initial investigation. I will return to this theme below, but you can see the kinds of difficulties this poses for ATI research.

Lack of generality

Let me give you some examples that are hair raising to ATI researchers. I developed an instructional program dealing with the diagnosis of heart disease (Tobias, 1968) which was subsequently used at a number of research centers. The program was developed in a linear programmed instruction format, and was subsequently modified for presentation via computer assisted instruction. The history and variations to this program are discussed elsewhere (Tobias, Note 4). In the programmed instruction version a number of significant interactions between instructional strategies and student differences in prior achievement were reported. When the program was converted verbatim for presentation via computer assisted instruction the findings obtained with the programmed material could not be replicated. Following a task analysis of the CAI version of the materials, they were revised. In the revised version the previous findings were both replicated and extended (Tobias, 1973, a, b, Tobias and Duchastel, 1974).

There are examples of other troubling inconsistencies in ATI research. In her dissertation study Peterson (1977) studied the interaction between instructional method and a number of personality variables using a night grade student sample. In a succeeding study, Peterson (1979) repeated essentially the same study using a different subject matter and a different student population. Some of the interactions in the second study were opposite from those of the first, some were similar, and some were unreplicated. Even more unsettling were interactions which appeared when a multiple choice test was the dependent variable and disappeared when the criterion was switched to an essay. You will grant that this is limited generality with a vengeance.

The problem of lack of generality may not be as discouraging a phenomenon as it first appears. Brophy (1979) comments on the same lack of generality in recent research relating teacher behavior to student learning. The renascence in that area, reflected in the work of such writers as Rosenshine (1979), Berliner (1979), McDonald (1976), and Brophy (1979) among others has documented a number of highly context specific relationships. For example, in the primary grades there appears to be no significant correlation, or significant negative correlations between learning gains and amount of student talk (Stalling and Kaskowitz, Note 5; Brophy and Evertson, Note 6). At the junior high school level, however, Evertson and her colleagues (Note 7) did find correlations between student talk, some related variables, and learning gains in seventh and eighth grade math classes. In the latter study it should be noted, only some kinds of student talk correlated with these gains, not amount of student talk in general.

In view of the specificity of effects seen in research relating teacher behavior to student learning, the lack of generality of ATI studies in classroom contexts is not surprising. The specific interaction of studies such as Peterson's and similar investigations (Corno, 1979; Porteus, Note 8) are beginning to document similarly specific interactions of

individual difference variables in classroom contexts. It appears possible that in such classroom based investigations interactions should be sought not only among student individual difference variables and instructional methods, but also interactions with the instructional context. Specifically, interactions may well exist between classroom context variables and instructional methods, as suggested by Brophy's (1979) review of this research but higher order interactions among context variables, instructional methods and student individual differences may well be the expected outcome of such classroom based ATI investigations.

The results of ATI classroom based studies may, then, be developing sets of findings which are also replicable only within a specific context but do not generalize to other settings. This may make research in this area much less fun, as well as making incredible cognitive demands upon readers of such research. The tables of results of these ATI studies (Peterson, 1977, 1979; Corno, 1979) are difficult to master at one sitting, two sittings, or for that matter, master in any other manner. I suspect that the results of these studies are easily retrievable from the long term memories of only the investigators themselves, and perhaps their dissertation advisors who, probably labored long and hard analyzing and re-analyzing the data, and then longer and harder trying to interpret the output of such electronic largesse. This may account for the curious phenomenon that researchers in this particular ATI specialty have an interesting preference for citing one another's work again, and again, and yet again while it remains essentially uncited by strangers to this particular milieau. Perhaps they are the only ones who can comprehend, and more importantly, easily recall the results of these studies. I have come to envy computer programmers who write flexible multiple linear regression programs capable of disgorging voluminous double, triple, quadruple, and quintuple interactions without having the inconvenience of having to understand them.

Consideration similar to these probably promted Cronbach (1975) to suggest that interactions in this domain may well not have the generality we initially assumed. Cronbach speculated that generalizations made from such research may well be limited to the particular locale in which they were studied, and also to the particular period in which they were found. He suggests that in the social sciences in general, and in ATI research in particular, findings may well shift from decade to decade rather than holding from time immemorial, or at least from one AERA meeting to another.

Needs for Classification and Theory

The inconsistency of results and the lack of generality of many ATI findings points to an important problem: the need for a classification scheme of instructional methods on the one hand and student characteristics on the other.

Our descriptive schemes for instructional methods are vague, excessively general, and highly descriptive. For example, homogeneous-heterogeneous grouping is one of the most studied problems in education, note that I did not say best understood. In a review of grouping research, Findley and Bryan (1971) concluded that "taking all studies (of ability grouping) into account, the balance of findings is chiefly of no strong effect either favorable or unfavorable" (p. 54).

There are numerous problems with the grouping research. The range of abilities in one study may be different from that used in another one. Furthermore, while any two studies may both examine grouping they often use very different instructional methods. Clearly, given such differences it is impossible for this research to cumulate and lead to powerful generalizations.

What we need is a precise taxonomic scheme which allows a thorough description of the instructional method so that investigators can be reasonably sure of having two groups working on instructional methods which are highly similar except for the variable being investigated. A starting point for such a scheme may be the useful classification of content and method proposed by the San Diego Navy Personnel Research and Development Center Group (Note 9, 10), or the work of Merrill (Note 11) and Reigeluth (Note 12).

Another problem for ATI researchers is in the classification of student aptitudes. Let's use the area of anxiety as an example. Most tests of anxiety tend to correlate with one another at approximately .45, meaning that 80% of the variation of scores in one of these tests is unaccounted for by variation in the other. Hence, different anxiety ATI studies, an area in which research is plentiful (Cronbach and Snow, 1977, Chapter 10; Tobias, 1977a, 1979), can hardly be considered to have studied the same problem if different indexes of anxiety were utilized. These problems are obviously multiplied if the instructional methods or other aspects of the study have also been changed.

These examples of chaos in ATI land suggest that better description of both the instructional method and individual difference parameters is required. In addition, it is important for ATI research to be driven by a consistent instructional theory, rather than speculations generalized from research in other fields.

Much early ATI research in anxiety was borrowed from Spence-Taylor's drive theory (Spence & Spence, 1960), which predicted that individuals high in anxiety could be expected to do better than their low-anxious counterparts on easy material, and the opposite state of affairs would exist on difficult material. ATI researchers, including this one (Tobias & Williamson, Note 13),

ignored Spence's (1958) warning that this formulation held only in tightly circumscribed experimental contexts consisting largely of classical conditioning procedures, and should not be blithely applied to more complex instructional settings. Reviews of this research (Cronbach & Snow, 1977; Tobias, 1977a) have verified this caution, and what we hope are more appropriate models for research on anxiety and instructional methods (Tobias, 1977b, 1979) have been proposed. Let me turn to another attempt to approach ATIs from a consistent instructional paradigm rather than from loose generalizations borrowed from other areas.

Prior Achievement and Instructional Support

In an attempt to integrate a number of ATI studies (Tobias, 1973a) concerned with such variables as anxiety, creativity and a variety of instructional alternatives using programmed materials, it was noted that none of the instructional variables made any difference when material with which students were familiar was used. On novel content, on the other hand, it was generally found that eliciting student responses, providing feedback concerning them, and tight organization of the instructional material made substantial differences in student achievement. These findings led to the statement of a general hypothesis (Tobias, 1976, Note 3) predicting an inverse relationship between prior knowledge and amount of instructional support required in order to master educational objectives. Prior achievement is, of course, easily defined by a student's pretest score. Instructional support may be defined as the assistance given to the learner in organizing content, making provisions to maintain attention, providing feedback regarding the student's performance and monitoring achievement at a micro level from one

unit to another. The hypothesis implies that the lower the level of prior achievement the more assistance needs to be provided to the learner in order to master objectives. Conversely, the higher the level of prior achievement, the less such assistance is needed by students.

Some of the most recent results dealing with this hypothesis may illustrate the general approach. In a study (Deutsch & Tobias, Note 14) using four video modules dealing with individualized instruction, the instructional support variable consisted of giving students the option of rewinding video tapes by viewing them individually, or being unable to do so when viewing them in group form. As expected, we obtained the significant interaction shown in Figure 1 between having the option to rewind the tape and achievement.

Insert Figure 1 about here

Students who were able to rewind the tape outperformed those denied that option and, as expected by the achievement treatment formulation, the differences among these groups were greater at the lower end of the achievement continuum than at the higher end.

This is precisely the type of ordinal interaction expected from the prior achievement-instructional support hypothesis; other evidence supporting this formulation is summarized elsewhere (Tobias, 1976, Note 3). In order to show you that all is not rosy in achievement-treatment-interaction land either, there is also some recent evidence failing to support this hypothesis (Tobias & Redfield, Note 15).

The achievement-instructional support hypothesis avoids some of the problems confronting other ATI research. Specifically, since a pretest is necessarily specific to the content taught, its similarities and differ-

ences to other measures pose less of a problem. That is, a pretest is not assumed to have any generality beyond serving as an index of the degree to which a particular content has been mastered. It may well be that pretest scores contain components other than knowledge of a specific subject matter, such as test-taking skills, intelligence, and the like. While such more general abilities may contribute to pretest scores, the present hypothesis is that it is the unique variance attributable to a particular content that will be most useful in predicting optimal instructional method.

A number of studies dealing with concept formation (Alvord, Note 16), intelligence test data (Tobias, Note 3), and instructional material (Tennyson & Rothen, 1977) used both data from the more general, traditional individual difference measures and data highly specific to the task to predict the results of prior trials. It was shown that the latter data were most useful in predicting the results of future trials. Thus, while specific pretest scores may well be correlated with more general aptitude measures, I would predict that the pretest is nonetheless most useful in adaptive instructional decisions.

The hypothesized interaction between prior achievement and instructional support is somewhat similar to one of the conclusions reached by Cronbach & Snow (1977) following their review of ATI research. They suggest that any procedures which reduce the intellectual demands made on the student by the instructional method would reduce achievement differences between students of high and low intelligence. The concept of instructional support is, obviously, not dissimilar to procedures reducing the intellectual demands of a task.

Psychological Processess and ATI Research

There are other approaches to bringing order to the discrepant research findings in this area. The desirability of relating achievement from different instructional methods to individual differences in the psychological processes underlying aptitudes has been advocated by a number of writers (Glaser, 1971, 1976; DiVesta 1972) and stimulated a good deal of contemporary research. Some of the difficulties in this approach have been alluded to elsewhere (Tobias, Note 3). In summary, it has been suggested that such research offers the exciting prospect of being able to specify the psychological processes on which differences in cognitive processes such as intelligence, problem solving ability and the like are based. Such research may clarify some traditional problems of educational psychology such as the nature-nurture controversy and the structure of human abilities. In addition such research opens up the possibility of investigating the degree to which instruction in the psychological processes can modify students' standing on such cognitive aptitude variables as intelligence, certainly an exciting possibility of enormous practical and theoretical consequence. Recent research in this area is summarized in an issue of the Journal Intelligence (Note 17).

It has been suggested (Tobias, Note 3) that adapting instruction to differences in psychological processes may not be as promising a line of research as it appears. The principal problem of such research would appear to be the high probability that processes underlying instruction in any moderately complex topic are likely to shift very rapidly. An instructional strategy, then, which is designed to capitalize on processes at the outset of some content may be less then functional once the student has made some progress into the course.

Adapting instruction to differences in psychological processes may be useful in two areas: 1) Actually teaching the psychological processes (as indicated above), and 2) instructing students in content appropriate for the first few months of formal schooling, such as decoding in reading and acquiring some of the basic quantitative concepts. Such prospects are, of course, extremely important. It should be noted, however, that such instruction is likely to be extremely brief, probably lasting no more than several weeks. While this is an important field, it is nonetheless of limited importance when one considers the 12 years of compulsory schooling at the elementary and secondary levels, not to speak of instruction at the college undergraduate and graduate levels, and learning in a variety of training contexts.

Observation and ATI Research

Research relating teacher behavior to student achievement may well have an important lesson for ATI researchers. The essential method used in that research (Brophy, 1979) was to conduct careful observations of classroom behavior free from high inference schemes, or heavy theoretical preoccupations. Conceivably, ATI researchers could adopt that method. Instead of beginning research by generating a prediction as to what students are likely to do in an instructional situation where a variety of alternatives are available, it might well be better first to watch what students of varying individual difference characteristics actually do, and what instructional options they select. One wonders whether all of the research relating mode of responding to instructional materials to anxiety (Tobias, 1973a, 1977a) might not have most profitably begun by matching students of known anxiety characteristics select available options, and ask students to provide rea-

sons for their selection, rather than begin by hypothesizing outcomes in an area in which few instructionally relevant prior studies had been conducted. Conceivably a lot of findings of non-significant differences could have been avoided this way in the past, and hopefully in the future.

ATI researchers in all areas, not only those working in the vineyards of response modes, might well learn this lesson from our colleagues who have been observing teachers for some years and save ourselves expensive research resulting in non-significant differences.

Conclusion

This selective and somewhat biased review of the problems in ATI research must conclude with a note near and dear to the hearts of educational researchers: further research is obviously needed. One of the early milestones in this field was the publication of the book edited by Gagne in 1967, or thirteen years ago. In the faith in which I was reared 13 marks the advent of adulthood and responsibility for one's actions. I am not sure that ATI research has achieve adulthood; nor am I all together sure that adulthood is such a desirable state. I have tried to suggest that in these 13 years, I think we have not discovered any blinding revelations which have answered the most vexing questions in this complicated field. I do feel, however, that our questions are clearer and more precise. In the years to come, I would imagine that our answers to these questions will be equally specific and precise. Enlightenment in this area, then, will be similar to that in most other fields of scientific inquiry. That is, we will learn more and more about less and less.

Footnotes

1. This paper was presented at a symposium entitled "Psychology and Education--State of the Union," held at the annual convention of the American Educational Research Association, Boston, April 1980. It is based, in part, on a chapter entitled, "Adaptation to Individual Differences," in F.H. Farley and N.J. Gordon (Eds.), New perspectives in educational psychology, National Society for the Study of Education. In press.

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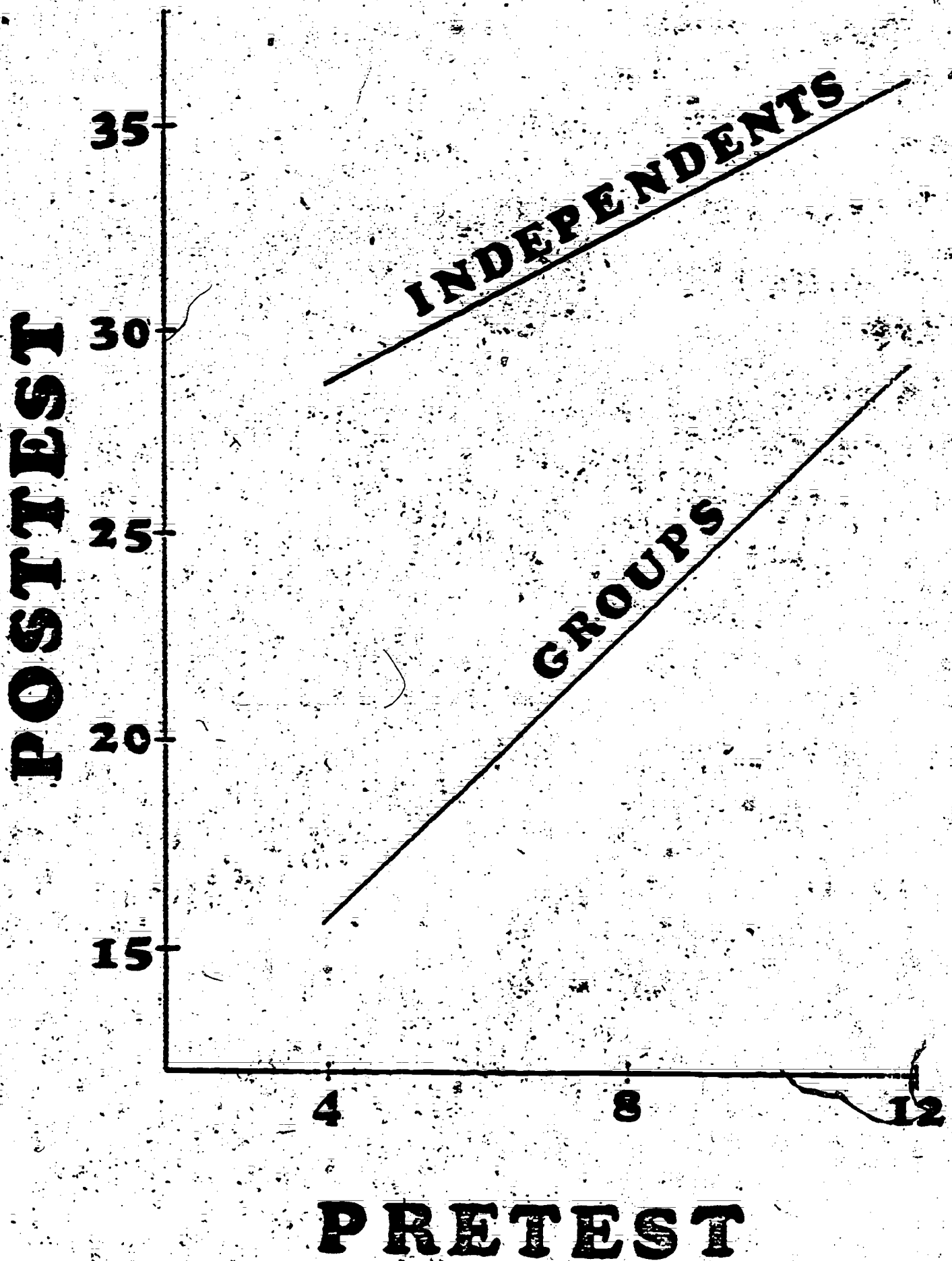

Figure 1. Interaction between individualized or group instruction and instructional method. From Deutsch and Tobias (1980).