Are Traditional Cognitive Tests Useful in Predicting Clinical Success?

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Abstract: The purpose of this research was to determine the predictive value of the Dental Admission Test (DAT) for clinical success using Ackerman's theory of ability determinants of skilled performance. The Ackerman theory is a valid, reliable schema in the applied psychology literature used to predict complex skill acquisition. Inconsistent stimulus-response skill acquisition depends primarily on determinants of cognitive ability. Consistent information-processing tasks have been described as "automatic," in which stimuli and responses are mapped in a manner that allows for complete certainty once the relationships have been learned. It is theorized that the skills necessary for success in the clinical component of dental schools involve a significant amount of automatic processing demands and, as such, student performance in the clinics should begin to converge as task practice is realized and tasks become more consistent. Subtest scores of the DAT of four classes were correlated with final grades in nine clinical courses. Results showed that the DAT subtest scores played virtually no role with regard to the final clinical grades. Based on this information, the DAT scores were determined to be of no predictive value in clinical achievement.

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For several decades, experimental and applied psychologists have been investigating different ability determinants, or factors influencing aptitude, to predict the capacity for an individual to acquire complex skills.[1-7] Ackerman's theory of ability determinants of skilled performance is a valid and reliable schema in the applied psychology literature to predict complex skill acquisitions.[3,4] This theory suggests that ability-performance relationships are sensitive to the complexity and consistency of a given task. The validity of this model has been supported by a re-analysis of early investigations in psychology, by a series of experiments performed by Ackerman, and more recently by a data analysis of preclinical laboratory performance in dental school.[5,8]

Ackerman's theory integrates a hierarchical model of cognitive intellectual abilities, in the context of predicting individual differences in task performance with several phases of skill acquisition (cognitive phase, associative phase, and autonomous phase).[3,4] The cognitive phase of skill acquisition is characterized by a high cognitive load on a learner in the context of understanding task instruction, general familiarization with task goals, and formulating strategies for task accomplishment. These inconsistent information-processing tasks do not allow for further skill development. Task performance is related to general intellectual abilities in verbal, figural, and numerical content areas. All first-time experiences require inconsistent information processing. Schneider and Shiffrin described such inconsistent processing tasks as "controlled."[1,2]

The associative phase of skill acquisition involves strengthening associations between stimuli and responses, resulting in a performance that is quicker and more accurate. This phase is associated with demands on perceptual speed abilities, or the rate at which tasks are accomplished.

The autonomous phase of skill acquisition, associated with demands on psychomotor abilities, generally proceeds with little attentional effort. Tasks requiring these psychomotor responses resulting from cognitive processing are accomplished quickly and accurately (consistent information processing). Consistent information-processing tasks have been de-

scribed as "automatic," in which stimuli and responses are mapped in a manner that allows for complete certainty once the relationships have been learned.[1,2]

Research using Ackerman's theory has shown that scores obtained on the Perceptual Ability Test (PAT) correlate significantly with grades earned in preclinical laboratory technique courses.[8] Additionally, other investigations have found a strong correlation among the academic subtests scores of the Dental Admission Test (DAT), basic science course grades, and performance on Part I of the National Board Dental Examinations.[8-10] These studies clearly demonstrate the validity of Ackerman's theory and of the DAT as a predictor of success in the preclinical years of dental school. It is the intent of this investigation to validate Ackerman's theory of ability determinants of skilled performance to predict student success in the clinical component of dental school.

Although tasks in the preclinic are designed to simulate those that will be performed in clinic, preclinical tasks are novel and therefore require controlled or inconsistent information processing. Inconsistent information-processing tasks, associated with Ackerman's cognitive phase of skill acquisition, are characterized by a high cognitive load on a learner. Task performance is related to general intellectual abilities in verbal, figural, and numerical content areas. These innate abilities serve as limiting factors for performance. Tests, which quantify these abilities, can be used to predict performance in related areas. For this reason, the PAT subtest of the DAT, which measures spatial and figural cognitive abilities, can be used reliably as a predictor for success in the preclinical technique courses.[8] The Academic Average (AA) of the DAT, composed of subtests in Quantitative Reasoning, Reading Comprehension, Biology, Inorganic Chemistry, and Organic Chemistry, is a very reliable predictor for success in the basic science courses in dental school.[8,9]

For tasks that can be accomplished with automatic processing, individual differences in general cognitive ability have less impact. Performance improves with task practice, ultimately resulting in a near flawless performance regardless of an individual's cognitive abilities. A classic example of automatic processing is assembly-line work. Differences in performance are based upon the anatomic and neurologic considerations of perceptual speed and psychomotor ability.

For tasks involving both automatic and controlled processing components, ability-performance relations are more difficult to predict.[4]

To a large extent, clinical tasks are repetitious, they involve cognitive and noncognitive components, and performance generally improves with practice. Using Ackerman's theory, early clinical experiences involve strengthening associations between stimuli and responses, resulting in a performance that is quicker and less error-prone (the associative phase of skill acquisition). This phase is associated with demands on perceptual speed abilities. Theoretically, with regard to some of the technical components of clinical dentistry, a practicing dentist could ultimately reach the autonomous phase of skill acquisition—a level of performance generally proceeding with little attentional effort. Tasks are accomplished quickly and accurately (consistent information processing). Differences in performance are based primarily on noncognitive psychomotor abilities (i.e., manual dexterity). Because of the unpredictable nature of the oral cavity and the diagnostic component of the practice of dentistry, the autonomous phase could never truly be realized.

While the investigators agree that the DAT subtest scores can be used to predict success in the preclinical years of dental school, there is some question as to the role of the DAT as a predictor of success in the clinical years. If one assumes that each treatment procedure in the clinical practice of dentistry is novel and reflects inconsistent information processing requiring specific verbal, spatial, and figural cognitive ability determinants, then the DAT should be a reliable predictor of success. On the other hand, if clinical practice involves a significant amount of repetition and therefore reflects some automatic or consistent learning, the role of the DAT in predicting long-term clinical success may be insignificant.

It is the investigators' hypothesis that the skills necessary for success in the clinical component of dental school involve a significant amount of automatic processing and, as such, student performance in the clinics should begin to converge as task practice is realized and task performance becomes more consistent.

To validate Ackerman's theory of ability determinants of skilled performance and using the investigators' theory that the clinical component of the practice of dentistry involves some degree of automatic processing, the following predictions must be met:

Table 1. Evaluation groups based on DAT subtest scores

Group 1	Group 2	Group 3	Group 4
High AA (⊕20) High PAT (⊕19)	High AA (⊕20) Low PAT (≤16)	Low AA (≤17) High PAT (⊕19)	Low AA (≤17) Low PAT (≤16)

Table 2. Correlation of clinical grades and selected admissions criteria

	R	R^2	LL	UL
AA	0.068	.0046	0.055	0.082
PAT	0.051	.0026	0.037	0.064

R = Correlation coefficients with clinical grades
LL = Lower 95% confidence level
UL = Upper 95% confidence level

1. There will be a weak to insignificant correlation of DAT academic average scores with final grades in the clinical courses.
2. There will be a weak to insignificant correlation of DAT Perceptual Ability Test scores with final grades in the clinical courses.
3. Student clinical grades will start to converge (show less differentiation) as task practice is realized.
4. Variations in consistency of performance will be evident since noncognitive components of psychomotor ability and patient management skills have not been considered.

Methods

Students from the Temple University School of Dentistry (TUSoD) graduating classes of 1998 to 2001 were assigned to one of four groups based on the Dental Admission subtest scores of Academic Average (AA) and Perceptual Ability (PAT) (Table 1). Group 1 included students who had achieved high scores on both the AA (20 or greater) and the PAT (19 or greater) subtests. Group 2 students scored high on the AA subtest, but low on the PAT (16 or less) subtest. Group 3 students' performance on the AA portion was low (17 or less), while the PAT scores were high, and Group 4 students scored low on both subtests. For the purpose of this investigation, high DAT subtest scores for AA and PAT were above the median for students admitted to TUSoD, and low subtest scores were those below the median.

Because of stringent admissions requirements for dental schools, all accepted students could already be considered a select group. Prediction within the midrange is of little practical importance.[11] Therefore, to increase differentiation, students with AA of 18-19 and PAT scores of 17-18 were eliminated, yielding a sample size of 169 students. There was no significant difference in the predental grade point averages of the four groups.

Nine clinical courses in Years 3 and 4 met the criteria of consistent information-processing demands, thereby following automatic processing predictabilities. Each clinical course required completion of a minimum number of defined treatment procedures (repetitive). Each successful clinical procedure was awarded a quality grade by attending faculty. These quality grades were used, in concert with a quantitative assessment, to determine the final course grade. A student completing more than the minimum required treatment procedures could obtain a higher grade as a result.

Final grades were averaged for each student in the following courses: Year 3—Endodontics, Periodontics, Operative Dentistry, and Restorative Dentistry; Year 4—Fixed Prosthodontics, Operative Dentistry, Endodontics, Periodontics, and Removable Prosthodontics. Correlation coefficients were calculated between the averaged clinical grade, the PAT, and the AA to determine significance (Table 2).

Results

Table 2 shows the correlation coefficients of the final clinical course grades with the DAT Academic Average and the DAT Perceptual Ability Test. Results showed that the AA accounted for 0.46 percent of the variance of the final clinical grades, while the PAT accounted for 0.26 percent.

As hypothesized, there was an insignificant correlation of the AA subtest scores with final grades in the clinical courses. Similarly, the PAT subtest scores showed an insignificant correlation with final grades in the clinical courses. Results indicate that the DAT subtests (AA, PAT) did not play a role in predicting student performance in the clinical courses (Table 3).

To validate Ackerman's theory of ability determinants of skilled performance, and using the investi-

Table 3. Comparison of clinical grades with selected admissions criteria

	Average PAT	PAT Standard Deviation	Average AA	AA Standard Deviation	Average Clinical Grade	Clinic Grade Standard Deviation
Group 1	20.81	1.51	20.59	0.79	3.22	0.61
Group 2	15.00	0.92	20.70	0.98	3.32	0.49
Group 3	20.22	1.45	16.44	0.85	3.16	0.52
Group 4	14.57	1.31	15.96	1.14	3.17	0.61

gators' theory that the clinical component of the practice of dentistry involves some degree of automatic processing, the following results were demonstrated:

1. The DAT subtest scores played virtually no role with regard to the final clinical grades.
2. Student clinical grades started to converge (show less differentiation) as task practice was realized.
3. Variations in consistency of performance were evident, since noncognitive components of psychomotor ability and patient management skills were not considered.

Discussion

The DAT measures specific verbal, spatial, and figural cognitive ability determinants, which have been shown to be reliable predictors for success in the preclinical technique and basic science courses. The PAT subtest score of the DAT has been shown to predict success in the preclinical technique courses, while the AA portion of the DAT is predictive of basic science performance[8,9] (Table 4).

It has been theorized that the clinical component of the dental school curriculum requires both consistent and inconsistent skill acquisition. Clinical practice involves a significant amount of repetition of technical skills and therefore reflects some automatic or consistent performance. In addition to the repetitive technical skills required, each patient presents with a unique set of circumstances that require novel approaches to diagnosis, treatment planning, and patient management. In clinical dentistry, some inconsistent technical skills acquired in the preclinic may become consistent. However, managing and treating patients require another level of inconsistent learning that probably never converts to consistent learning due to the uniqueness inherent in patient care.

As predicted, in theorizing that the clinical component of the practice of dentistry involves some degree of automatic processing, DAT subtest scores played virtually no role with regard to the final clinical grades of students at TUSoD. Students' clinical grades converged as task practice was realized, and variations in consistency of performance were evident since noncognitive components of psychomotor ability and patient management skills were not considered.

Additionally, a variety of other factors may influence clinical grading, causing it to be more subjective. Unlike the preclinical technique courses at TUSoD, where grading is anonymous, clinical grades are awarded by faculty who are aware of the identity of the student being graded. Because of this, clinical grades may be subject to faculty prejudices. Highly competent preclinical students may have acquired a "halo effect," which could result in inflated clinical grading. Conversely, poorer students in the preclinical years could be expected to perform at a lower level in the clinics. Due to the patient involvement and the nature of clinical procedures, time becomes a factor in the quality of the final product. Clinical grades at many schools have a quantitative component that allows a weaker student to achieve a higher grade by doing more repetitions. For example, completion of additional procedures beyond those required for competence can enhance a student's clinical grade if the extra procedures all received high marks. In addition, students with strong patient and time management skills will be able to treat more patients more efficiently and are therefore apt to

Table 4. Comparison of preclinical technique, basic science, and clinical grades for all evaluation groups

	Average Preclinical Technique Grades	Average Basic Science Grades	Average Clinical Grades
Group 1	3.29	3.03	3.22
Group 2	2.87	3.34	3.32
Group 3	3.31	2.47	3.16
Group 4	2.84	2.35	3.17

achieve a higher final clinic grade because they also can complete more graded procedures.

Based on the results reported here, the investigators contend that students possessing the cognitive abilities to successfully complete the basic and preclinical required courses in the first two years of dental school will most likely become equally or more successful in the clinical years of dental school.

Conclusion

Other investigations have shown that the PAT and AA subtest scores can be used as reliable predictors of success in the preclinical technique and basic science courses, essentially the first two years of dental school. The results of our investigation, however, indicate that the DAT subtest scores played virtually no role with regard to the final clinical grades. Based on this information, the DAT scores were determined to be of no predictive value in clinical achievement.

Cognitive tests are useful in providing threshold criteria for admission to dental school. On the other hand, the AA and PAT in this particular study were not useful in predicting the clinical performance of students. The value of using the AA and PAT as predictors for performance in the preclinical years is that admissions committees can selectively exclude those applicants who will most likely be unsuccessful, repeat a year, or spend a disproportionate amount of time in the laboratories.[8] Because traditional cognitive indicators do not predict clinical success, further investigation is needed relative to noncognitive predictors, such as motivation, past experiences, psychomotor ability, and interpersonal communication skills.

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