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Validity of the Perceptual Ability Test

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LOMA LINDA UNIVERSITY
School of Behavioral Health
in conjunction with the
Department of Psychology

Validity of the Perceptual Ability Test

by

Brandon Schmid

A Project submitted in partial satisfaction of
the requirements for the degree
Doctor of Psychology

September 2020

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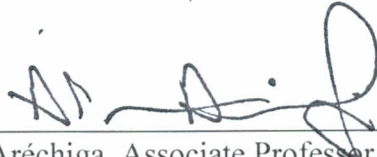
Brandon Schmid
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Each person whose signature appears below certifies that this project in his/her opinion is adequate, in scope and quality, as a project for the degree Doctor of Psychology.



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ABBREVIATIONS

DAT	Dental Admissions Test
DAT AA	Dental Admissions Test Academic Average
PAT	Perceptual Ability Test
PMAT	Perceptual Motor Aptitude Test
CDE	Carving Dexterity Examination
NBDE	National Board Dental Examination
WREB	Western Regional Examining Board
GPA	Grade Point Average
CBSE	Comprehensive Basic Science Examination

ABSTRACT OF THE DOCTORAL PROJECT

Validity of the Perceptual Ability Test

by

Brandon Schmid

Doctor of Psychology, Graduate Program in Psychology
Loma Linda University, September 2020
Dr. Grace J. Lee, Chairperson

The Perceptual Ability Test (PAT), a subtest of the Dental Admissions Test (DAT), has been used for many years by US Dental Schools to evaluate the perceptual ability of incoming applicants of their program. Perceptual ability is broadly defined as the ability to accurately process and interpret visual sensory information. Perceptual Ability skills are important in the field of Dentistry, as they are critical to the applied use of various dental tools and in surgical skills. It is assumed that performance on the PAT is predictive of dental students' surgical skill development. However, multiple studies have found that the PAT subtest scores had little to no role in predicting students' performance by the end of dental school, suggesting that PAT scores may have limited value in predicting clinical achievement. We examined whether the PAT, along with other DAT subtests similarly demonstrate no significant relationships with students' performance scores at Loma Linda University School of Dentistry. We found that the PAT scores significantly predicted performance in most Pre-clinical lab courses and some clinical exams, accounting for approximately 8 to 30 percent of the variance. This suggests the PAT maintains some utility in predicting both preclinical and aspects of clinical performance outcomes among Loma Linda University School of Dentistry students.

CHAPTER ONE

INTRODUCTION

The Perceptual Ability Test (PAT), a subtest of the Dental Admissions Test (DAT), has been used for many years by US Dental Schools to evaluate the spatial visualization ability and visual processing speed of incoming applicants of their program. The PAT is designed to test spatial and perceptual ability determinants and give quantitative data to admissions committees on each individual's ability to learn the kinds of complex skills presented in dental school clinic training. Thus, it is assumed that performance on the PAT is predictive of dental students' surgery skill development. However, in 2002, Sasha A. Gray, DDS, and colleagues found that PAT subtest scores played little to no role with regard to the students' final clinical grades at the completion of their clinical training at Temple University School of Dentistry. Gray concluded that this evidence suggests that DAT scores had little predictive value in clinical achievement (Gray, Deem, & Straja, 2002). We will examine whether or not the students at Loma Linda University School of Dentistry similarly demonstrate no significant relationships between their incoming PAT scores and clinical performance scores.

The Perceptual Ability Test

The DAT is a nationally standardized exam taken by dental school applicants whose scores are used by U.S. dental schools to evaluate applicants to their program. The DAT was first developed and introduced nationally in 1950 and is updated semi-regularly by the Department of Testing Services, a shared service of the American Dental Association. The DAT is designed to provide dental education programs with a means to

assess program applicants' potential for success and is designed to measure general academic ability, comprehension of scientific information, and perceptual ability. It is administered electronically year-round at test centers operated by Prometric Inc. to an estimated 13,000 people per year in the United States, its territories (including Guam, Puerto Rico and the Virgin Islands) and Canada, and consists of 280 multiple-choice items across four main subtests: Survey of the Natural Sciences (100 items), Perceptual Ability (90 items), Reading Comprehension (50 items), and Quantitative Reasoning (40 items). A total of 8 standard scores are calculated. There are 4 subtest scores: Total Science, Perceptual Ability, Reading Comprehension, and Quantitative Reasoning. In addition to the Total Science score, the Survey of the Natural Sciences subtest also yields 3 individual scores for Biology, General Chemistry, and Organic Chemistry. Finally, the Academic Average is the average of Quantitative Reasoning, Reading Comprehension, Biology, General Chemistry, and Organic Chemistry. Dental schools frequently summarize their applicant's scores by listing the Academic Average, Total Science, and Perceptual Ability scores of their matriculating classes. All scores are calculated on a scale of 1 to 30, with the mean score set at 17 for most scores, except for Reading Comprehension which has a mean score of 19.

The Perceptual Ability Test (PAT) of the DAT is meant to test the spatial visualization ability and visual processing speed of an individual through 90 questions completed in 60 minutes. The PAT was first introduced to the DAT in 1968 and in 1973 replaced the Carving Dexterity Examination (CDE), a chalk carving test that was originally intended to measure motor skills but was difficult to administer (Coy, McDougall, & Sneed, 2003). Thus, the PAT was developed as a non-manual substitute

for the CDE. Perceptual ability is broadly defined as the ability to accurately process and interpret visual sensory information. Perceptual Ability skills are important in the field of Dentistry, as they are critical to the applied use of various dental tools and in surgical skills. These applications are thought to include visualization of images of teeth from radiographic images, creation of casts from patient's teeth, and completion of tooth restorations. Perceptual ability skill is also applied to working with complicated 3-dimensional objects in dental surgery and laboratory work, including dental crowns, implants, and dentures. As such, the PAT was designed to predict an individual's level of potential in dental surgery skill development.

The question categories of the PAT include tasks designed to test different elements of spatial visualization ability and visual processing speed, including angle ranking, apertures, view recognition, paper folding, cube counting, and 3-dimensional form development. Visual discrimination is defined as the ability to recognize distinguishing features, like angle size. Visual closure is defined as the ability to identify two objects that are the same when part of one object is missing. Visual closure tasks require an individual to make assumptions in the 3-dimensional form development based on visual fragments and paper folding visualizations. Visual memory and spatial skills are tested in the cube counting questions regarding 3-dimensional cube formation drawings and in the apertures section regarding matching fit of 3-dimensional object drawings.

Assessment of Performance in Dental School

Dental clinical skill training traditionally occurs over a four-year period and is

often designated by two stages: pre-clinical and clinical training. Pre-clinical coursework refers to didactic and lab-based learning that occurs during the first two training years. It is designed to teach dental biology, practical laboratory skills, and beginning surgery techniques in a classroom and laboratory setting. Clinical coursework refers to didactic and lab-based learning that occurs during the final two training years and is designed to teach advanced practical laboratory skills and surgery techniques in a classroom and laboratory setting. These skills can then be applied to dental students' clinical work with patients. The subjects being taught often include dental anatomy, dental occlusion (i.e. 3-dimensional bite patterns and kinetic movements of chewing), and standard restorative dental surgery techniques. Both pre-clinical and clinical skill acquisition is assessed in written examinations and laboratory examinations that contribute to their final class grades. In cases where a student does not pass a class at the acceptable grade level, the student may be required to remediate the course during the following training year. The student's progress in the dental school program can be delayed or discontinued depending on their overall successful completion of this coursework.

Dental skills training is assessed outside of classroom assessment in multiple examinations occurring in laboratory and clinical settings. These examinations can include mock board examinations, state board examinations, and regional board licensure examinations. These exams take place at specified intervals during the four-year training program. Mock boards refer to practice examinations modeled after state, regional, or national board examinations that are sometimes administered and assessed by individual dental schools. These mock exams serve the purpose of preliminary evaluation of student performance and practice for the students during their preparation for the state, regional,

or national board examinations required for licensure. Mock boards are given in both written and clinical forms and precede the corresponding board examinations. Mock board examinations are often subdivided into the corresponding subtest categories in the state, regional, or national board examinations and include Endodontics, Operative, Periodontics, and Prosthodontics dental subjects and skill sets.

The National Board Dental Examination (NBDE) is divided into two parts that are administered at different times in the four-year dental training program. The first part is termed the NBDE Part I and is a written examination evaluating didactic learning gained during the first two years of training. The subject areas assessed include human anatomy, embryology, histology, biochemistry, physiology, microbiology, pathology, dental anatomy, and occlusion. The NBDE Part I is traditionally taken by students during the spring months of the second year in their program. The second part, or the NBDE Part II, is a written examination evaluating both didactic and clinical skills gained through the entire four-year training. Evaluated subject areas include Endodontics, Operative Dentistry, Oral and Maxillofacial Surgery/Pain Control, Oral Diagnosis, Orthodontics, Pediatric Dentistry, Patient Management (including Behavioral Science, Dental Public Education, and Occupational Safety), Periodontics, Pharmacology, and Prosthodontics. The NBDE Part II is traditionally taken by students during the last months of their fourth training year.

State or regional board licensure exams are given after the NBDE Part II examinations and at the end of the fourth training year. Students take the state or regional board based on which test is accepted for licensure in the state where they attended dental school and where they wish to practice dentistry. There are five examinations provided

by agencies responsible for standardizing clinical examinations for licensure in different regions of the United States of America. The five examination agencies are the Western Regional Examining Board (WREB), the Council of Interstate Testing Agencies, the Central Regional Dental Testing Service, the Northeast Regional Board of Dental Examiners, and the Southern Regional Testing Agency. These clinical examinations assess several common dental procedures performed on patients in a supervised clinical environment.

The DAT and Performance in Dental School

Many studies have attempted to look at the predictive validity of the DAT and other admissions criteria used by dental schools' admissions by examining their associations with various markers of dental students' progress through their degree programs. Some studies have evaluated the predictive validity of specific DAT subtests, as well as overall DAT performance and the DAT Academic Average. Other studies have examined the predictive validity of undergraduate grade point averages (GPA), undergraduate science GPA, and entrance interview scores associated with various outcome measures. Several different outcomes measures have been utilized as markers of dental students' success, including pre-clinical and clinical performance, national board dental exam scores, dental school GPA, competency exam scores, licensure examination performance, and specialty program entrance exam performance. Following is a summary of previous research examining the associations between these different admissions criteria and outcomes measures.

A study in 2018 out of Rutgers School of Dental Medicine investigated whether

the PAT was useful in predicting potential targets for remediation and early support in three pre-clinical restorative dentistry courses. Their results showed that for all three courses (Preclinical General Dentistry I, Preclinical General Dentistry II, and Preclinical Fixed Prosthodontics), the remediating students had significantly lower mean PAT scores than did passing students (Schultz-Robins, Markowitz, DeCastro, & Jiang, 2018).

At Indiana University School of Dentistry, investigators examined the relationship between DAT performance and Part I of the NBDE, a nationally administered board examination that assesses cognitive understanding of dental concepts and procedures. Their results showed that the DAT Reading Comprehension subtest was a statistically significant predictor of all four subtests of Part I of the NBDE; DAT Biology and Organic Chemistry subtest scores were statistically significant predictors of the NBDE Biochemistry-Physiology score, and the DAT Quantitative Analysis score was a statistically significant predictor of NBDE Dental Anatomy and Occlusion subtest performance. However, they found that the PAT and DAT General Chemistry subtests were not significant predictors for the NBDE Part I (De Ball, Sullivan, Horine, Duncan, & Replogle, 2002).

In contrast, a similar study conducted at Harvard University Dental School found that PAT scores correlated with the NBDE Part I dental anatomy and occlusion subtest, which tests dental concepts that depend heavily on perceptual ability in achieving an accurate understanding (Bergman, Susarla, Howell, & Karimbux, 2006). Additionally, DAT reading comprehension subtest scores were statistically significantly associated with performance on all four subsections of the NBDE Part I and were the most reliable predictor of performance. DAT general and organic chemistry scores were associated

with performance on the microbiology and pathology subtest of the NBDE Part I.

Looking more broadly to overall dental school performance, the predictive validity of the DAT for dental school performance and attrition was explored at the University of Florida (Sandow, Jones, Peek, Courts, & Watson, 2002). Investigators looked at a wide range of admission criteria including undergraduate GPA, DAT Academic Score, Perceptual Motor Aptitude Test score (PMAT; an earlier version of the PAT), and admission interview score. They then looked at outcome measures including the NBDE Part I and Part II scores, yearly and final dental school GPA's. They found that most admission criteria were good bivariate indicators of dental school performance. Students with higher undergraduate GPAs and DAT academic scores were more likely to score higher on the NBDE Parts I and II. The undergraduate science GPA and admission interview score were the most consistent determinants of dental school GPA. Although PMAT scores were not associated with NBDE Part I, Part II scores or with dental school GPA, dental students with lower PMAT scores upon admission were more likely to remediate, repeat an academic year, or to be dismissed.

In 2002, Sarah Gray, Lisa Deem, and Sorin Straja tested the assumption that the DAT and, more specifically, the PAT scores of incoming dental students at Temple University School of Dentistry were predictive of both pre-clinical and clinical performance (S. a Gray, Deem, & Straja, 2002). The DAT Academic Average and PAT subtest scores of four class cohorts were examined in relation to students' final grades in nine courses. They found a significant association between PAT scores and pre-clinical course grades, where PAT scores accounted for about 25 percent of the variance in predicting pre-clinical course grades (S. A. Gray & Deem, 2002). However, they found

that the PAT, as well as other DAT subtest scores, played little to no role in students' final clinical grades. Based on these findings, Gray concluded that although the PAT showed some predictive validity in pre-clinical technique course performance, it did not hold predictive value in overall clinical achievement towards the end of dental school (S. a Gray et al., 2002). Finally, variations in consistency of performance were evident, since they did not evaluate non-cognitive components of psychomotor ability or patient management skills, indicating that other factors besides the perceptual ability evaluated by the PAT could contribute to the success of students during their clinical training (S. a Gray et al., 2002).

A recent study looking broadly at overall dental school performance at the Louisiana State University Health Science Center School of Dentistry in 2015 differed slightly by looking at normal admissions criteria and hand-skill exercises for predictive validity. Specifically, they looked at undergraduate GPA, chalk carving score, undergraduate biology, chemistry, physics (BCP) GPA, DAT Academic Average, PAT, total DAT score, preclinical operative dentistry class grade, morphology and occlusion class grade, and dental school GPA at graduation. Their results showed that undergraduate GPA and BCP GPA were significantly higher for students in the top 10% of their class based on dental school GPA. The DAT Total and Academic Average scores, but not the PAT, were also significantly associated with students' dental school GPA. The only positive correlation involving the chalk carving scores was with the preclinical operative dentistry class grade (Ballard, Hagan, & Cheramie, 2015). They similarly concluded that correlations between their institutional admissions criteria and student performance was limited.

Investigators at the University of California, San Francisco School of Dentistry looked at the correlation of admissions criteria and dental student academic performance in regards to its utility for finding early intervention targets for remediation and academic support in their student populations (Curtis, Lind, Plesh, & Finzen, 2007). They looked at college GPA, undergraduate science GPA, DAT Academic Average, PAT, college rigor evaluations, and academic load while in college as predictor variables for first year and graduating GPAs of their dental students. They concluded that their admissions criteria, including the PAT and the DAT Academic Average were generally weak predictors. Instead, they found the first-year GPA to be a strong predictor of graduating GPA for normally tracking students and a moderate predictor for underachieving students.

Another researcher at Harvard Dental School, Sang E. Park, also attempted to see how the DAT and the NBDE Part I correlated with clinical performance and published his findings in 2006. Clinical performance was assessed by clinical productivity, using the total number of procedures performed, and clinical proficiency, using clinical average grade percentages, across four different competency areas: operative dentistry, major restorative dentistry, fixed prosthodontics, and removable prosthodontics. He found that very few scores from either the DAT or the NBDE Part I were associated with clinical outcomes, and concluded that in the specified study population, there was little to no uniform association between performance on the DAT or NBDE Part I and measurements of clinical productivity and clinical proficiency in in the final 2 years of dental school (Park, Susarla, & Massey, 2006). He suggests that the overlap in skill sets required for success in the pre dental/preclinical and clinical areas is minimal.

Looking more closely at fourth year competency exam performance, a 2015 study

by Dr. Alexander Carroll and Dr. Gregory Schuster at the Midwestern University College of Dental Medicine-Arizona. Carroll and Schuster aimed to look at whether there was a statically significant positive correlation between students' DAT scores, particularly the PAT, and their performance on the dental school's competency exam. Their results showed that the PAT scores were more strongly correlated with the fourth year competency exam scores than other DAT subtest scores and were a positive predictor for all three clinical sections of the exam, including operative dentistry, periodontics, and endodontics. Total DAT score was a positive predictor for the written portion of the exam, specifically for patient assessment and treatment planning and the DAT reading comprehension score for prosthodontics. The total variance explained by the results ranged from 4% to 15% (Carroll & Schuster, 2015). They concluded that while statistically significant relationships were found to exist between the PAT scores and clinical performance, the other DAT subtest scores explained relatively little variance in the competency exam scores and were not useful in predicting their students' clinical performance.

On a slightly different track, looking at a specialty program entrance exam, a study at the Columbia University College of Dental Medicine in 2018 by Dr. Kevin Lee and associates looked at the relationship between students' pre-admission record and performance on the Comprehensive Basic Science Examination (CBSE). The CBSE is the entrance examination for oral and maxillofacial surgery that has recently been implemented among dental students. The study looked at DAT results and showed no significant predictive validity in their full regression analysis. After performing Stepwise regression analysis, only the PAT score remained a significant predictor, explaining 15%

of the variability in CBSE scores (Lee, Lee, Zubiaurre, Grbic, & Eisig, 2018). The study concluded that PAT was the only pre-admission criterion to have an association with CBSE performance, while other DAT scores and undergraduate GPA were poor predictors of CBSE performance.

While there has been extensive scrutiny of the PAT's predictive validity, much is left unanswered. There does seem to be support for the predictive validity of the PAT with regards to preclinical performance in the first two years of dental school, but the utility of the PAT in predicting more long-term outcomes, such as clinical performance and scores on the NBDE, has been inconsistent. Overall, the PAT does seem to hold some value in its predictive validity, but for which outcomes remains unclear. We look to further explore and clarify this ambiguity by examining the relationships between the PAT and various outcome measures at different developmental stages in Loma Linda University School of Dentistry students.

Specific Aim: Investigate the Relationship between the PAT and other DAT Scores and Performance Outcomes of Dental Students at LLUSD.

Hypothesis 1

We hypothesize that PAT and other DAT subtest scores will predict pre-clinical performance outcomes of dental students attending Loma Linda University School of Dentistry.

Null Hypothesis 1

The PAT and other DAT subtest scores will not be associated with pre-clinical performance outcomes of dental students attending Loma Linda University School of Dentistry

Hypothesis 2

We hypothesize that PAT and other DAT scores will not be associated with clinical (4th year) performance outcomes of dental students attending Loma Linda University School of Dentistry.

Null Hypothesis 2

The PAT and other DAT scores will predict clinical (4th year) performance outcomes of dental students attending Loma Linda University School of Dentistry.

Hypothesis 3

We hypothesize that PAT and other DAT scores will not be associated with licensure exam score outcomes of dental students attending Loma Linda University School of Dentistry

Null Hypothesis 3

The PAT and other DAT scores will predict licensure exam score outcomes of dental students attending Loma Linda University School of Dentistry.

CHAPTER TWO

METHODS

Subjects

The current retrospective study utilizes archival data from 1822 students who were enrolled at LLU School of Dentistry between 2009 and 2013 for whom DAT PAT scores were known. All data has been de-identified.

Measures

Dental Admissions Test (DAT)

The Dental Admissions Test is a dental education admission test designed to provide dental education programs with a means to assess program applicants' potential for success. It is administered year-round by Prometric test centers in the United States, its territories (including Guam, Puerto Rico and the Virgin Islands) and Canada, and is normally administered over a 4 hour and fifteen-minute time period. The DAT is comprised of multiple-choice test items presented in the English language.

The DAT consists of four main subtests: Survey of the Natural Sciences, Perceptual Ability, Reading Comprehension, and Quantitative Reasoning. A total of 8 standard scores are calculated. There are 4 subtest scores: Total Science, Perceptual Ability, Reading Comprehension, and Quantitative Reasoning. In addition to the Total Science score, the Survey of the Natural Sciences subtest also yields 3 individual scores for Biology, General Chemistry, and Organic Chemistry. Finally, the Academic Average is

the average of Quantitative Reasoning, Reading Comprehension, Biology, General chemistry, and Organic Chemistry. Dental schools frequently summarize their applicant's scores by listing the Academic Average, Total Science, and Perceptual Ability (PAT) scores of their matriculating classes. All scores are calculated on a scale of 1 to 30, with the mean score set at 17, apart from Reading Comprehension, for which the mean score is 19.

Independent variables will include the PAT, General Chemistry, Organic Chemistry, Biology, Reading Comprehension, Quantitative Reasoning, Academic Average, and Total Science subtest scores.

Dental School Outcomes Measures

Dependent variables will include pre-clinical lab scores from the second and third academic years and clinic test scores from the third and fourth academic years. Pre-clinical laboratory class scores reflect student performance during procedures that are practiced on artificial models in the student lab. Clinic test scores reflect student ability to perform procedures on individual patients in the dental school clinic. These clinical tests evaluate the following clinical procedures: composite dental restorations (class II and III) and class II amalgam dental restorations. The classification refers the G.V. Black classification system that refers to the location and form of the procedure on the patient's tooth, while "Composite" and "Amalgam" refer to the material used for the procedure. The clinical tests also include mock board practice tests evaluating clinical endodontic and prosthodontic procedures, as well as the Western Regional Examining Board (WREB) procedural exam scores achieved near the end of student clinical training in

their fourth year.

Pre-clinical Outcomes

Pre-clinical lab final class grades are scored as a percentage and designated in the following manner. These pre-clinical laboratory courses are designed to evaluate dental restorative surgery skills and are typically performed on typodont (an artificial patient model) with plastic teeth and dental instruments in a laboratory setting. Specific class concepts evaluated include the following:

Restorative Dentistry I (701) Lab. This course includes the study of terminology, morphologic characteristics, and interrelationships of permanent teeth, and is graded on a scale from 0 to 100.

Restorative Dentistry II (702) Lab. This course introduces mandibular movement and the relationship to the anatomy of teeth. It also includes the study of the source, use, and manipulation of dental materials, as well as their physical properties relative to dentistry. Scores are graded on a scale from 0 to 100.

Restorative Dentistry III (708) Lab. This course includes the study of basic principles and techniques of cavity preparation and restoration of teeth with silver amalgam alloy and tooth-colored composite restorative materials. It also continues the study of the source, use, and manipulation of dental materials, and their physical properties relative to dentistry. Scores are graded on a scale from 0 to 100.

Restorative Dentistry IV (709) Lab. This course includes the study of more advanced principles and techniques of cavity preparation and restoration of teeth with silver amalgam alloy and tooth-colored composite restorative materials. It introduces basic

casting principles and techniques of dental crowns. It also continues study of the source, use, and manipulation of dental materials, as well as their physical properties relative to dentistry. Scores are graded on a scale from 0 to 100.

Clinical Outcomes

Clinical test scores will include the D4 mock Endodontics exam, the D4 mock Operative exam, the D4 mock Periodontics exam, and the D4 mock Prosthodontics exam taken during their fourth year in the dental program. These exams evaluate endodontic root canal procedures in the D4 mock Endodontics exam, restorative procedures in the D4 mock Operative exam, periodontal procedures in the D4 mock Periodontics exam, and prosthodontic procedures in the D4 mock Prosthodontics exam, all of which are performed on clinical patients in the dental student clinic. The D4 mock Endodontics exam was graded from 0-26 points possible. The D4 mock Operative exam was graded from 0-54 points possible. The D4 mock Periodontics exam was graded from 0-39 points possible. The D4 mock Prosthodontics exam was graded from 0-132 points possible.

Licensure Outcomes

The later clinical test scores will include the WREB Endodontics exam, WREB Operative exam, WREB Periodontics, and WREB Prosthodontics exam performed near completion of clinical training and results in a scaled score of 0 to 5 on each exam. The WREB, or Western Regional Examining Board, tests include clinical competency exams for these same types of dental procedures on patients in the dental student clinic.

Undergraduate Science GPA and Cumulative GPA will be controlled for as a

covariate.

Operational Definitions

- I. Independent Variables
 - a. DAT PAT
 - b. DAT Academic Subtests
 - i. General Biology
 - ii. General Chemistry
 - iii. Organic Chemistry
 - iv. Reading Comprehension
 - v. Quantitative Reasoning
 - c. DAT Academic Average
 - d. DAT Total Science
- II. Dependent Variables
 - a. Pre-clinical Laboratory classes
 - i. Restorative Dentistry I (701) Lab
 - ii. Restorative Dentistry II (702) Lab
 - iii. Restorative Dentistry III (708) Lab
 - iv. Restorative Dentistry IV (709) Lab
 - b. Clinical Test Scores
 - i. D4 mock Endodontics exam
 - ii. D4 mock Operative exam
 - iii. D4 mock Periodontics exam

- iv. D4 mock Prosthodontics exam
- c. Licensure Test Scores
 - i. WREB Endodontics exam
 - ii. WREB Operative exam
 - iii. WREB Periodontics exam
 - iv. WREB Prosthodontics exam

Analysis

We used linear regression analysis to test whether or not there is a statistically significant association between DAT scores, including the PAT, and various measures of pre-clinical and clinical performance in dental students attending Loma Linda University School of Dentistry. SPSS was used to analyze the data and an alpha of 0.05 was used for all statistically significant tests. Independent and Dependent variables are listed above. All analyses were controlled for Undergraduate Science and Cumulative GPA.

CHAPTER THREE

RESULTS

DAT PAT scores were available for 1822 students enrolled between 2009 and 2013. Approximately 35% of the sample was female; no other demographic information was available. Data on various dependent variables were available for a subset of the overall sample. The number of data points, along with sample means and standard deviations, for each variable of interest are described in Table 1.

Table 1. Participant characteristics

	N (%)		
Gender	1184 (64.9%) Male 639 (35.1%) Female		
	N	Mean	Std. Deviation
Entry Science GPA	1818	3.32	0.39
Entry Cumulative GPA	1821	3.42	0.34
DAT PAT	1822	19.57	2.47
DAT Biology	1821	18.84	2.30
DAT General Chemistry	1815	19.41	2.94
DAT Organic Chemistry	1800	19.81	3.13
DAT Quantitative Reasoning	1790	17.73	2.96
DAT Reading Comprehension	1822	19.72	2.69
DAT Academic Average	1822	19.10	1.94
DAT Total Science	1822	19.13	2.08

Table 1. (continued)

701 Lab	666	92.38	3.71
702 Lab	575	93.49	6.16
708 Lab	573	92.65	37.93
709 Lab	483	92.00	4.29
D4 Mock Endodontics	786	16.79	3.34
D4 Mock Operative	786	37.55	6.06
D4 Mock Periodontics	786	26.95	4.20
D4 Mock Prosthodontics	786	97.78	14.41
WREB Operative	410	3.73	0.49
WREB Endodontics	410	3.89	0.58
WREB Periodontics	410	4.57	0.28
WREB Prosthodontics	410	4.30	0.33

Predicting Pre-clinical Outcomes

Results of linear regression analyses revealed a significant relationship between PAT scores and 3 out of 4 pre-clinical scores. Specifically, PAT scores were significantly associated with performance in Restorative Dentistry I (701) Lab ($\beta=0.297$, $p < .001$, Table 2), Restorative Dentistry II (702) Lab ($\beta=0.153$, $p =.001$, Table 3), and Restorative Dentistry IV (709) Lab ($\beta=0.213$, $p < .001$, Table 5). PAT scores did not show a significant association with Restorative Dentistry III (708) Lab (Table 4). No other DAT subtests showed significant associations with the pre-clinical outcomes.

Table 2. Multiple Regression Analysis Predicting Restorative Dentistry I 701 Lab Scores (N = 635)

DAT subtest	Standardized Coefficients		Sig. p	95% Confidence Interval for B	
	Beta	t		Lower Bound	Upper Bound
DAT PAT	0.297	6.990	0.000***	0.341	0.607
DAT Biology	0.019	0.220	0.826	-0.268	0.336
DAT General Chemistry	0.036	0.394	0.694	-0.197	0.296
DAT Organic Chemistry	0.095	1.055	0.292	-0.105	0.349
DAT Quantitative Reasoning	-0.039	-0.534	0.594	-0.240	0.137
DAT Reading Comprehension	-0.007	-0.114	0.909	-0.191	0.170
DAT Academic Average	0.029	0.163	0.870	-0.688	0.813
DAT Total Science	-0.176	-1.315	0.189	-0.911	0.180

Note. *p < 0.05; **p < 0.01; ***p < 0.001

Table 3. Multiple Regression Analysis Predicting Restorative Dentistry II 702 Lab Scores (N = 553)

DAT subtest	Standardized Coefficients		Sig. p	95% Confidence Interval for B	
	Beta	t		Lower Bound	Upper Bound
DAT PAT	0.153	3.301	0.001**	0.160	0.632
DAT Biology	-0.074	-0.740	0.459	-0.759	0.343
DAT General Chemistry	0.000	-0.005	0.996	-0.453	0.451
DAT Organic Chemistry	-0.006	-0.063	0.950	-0.438	0.411
DAT Quantitative Reasoning	-0.033	-0.363	0.717	-0.452	0.311
DAT Reading Comprehension	0.048	0.611	0.541	-0.251	0.479
DAT Academic Average	-0.065	-0.295	0.768	-1.822	1.346
DAT Total Science	0.177	1.159	0.247	-0.417	1.618

Note. *p < 0.05; **p < 0.01; ***p < 0.001

Table 4. Multiple Regression Analysis Predicting Restorative Dentistry 708 Lab Scores (N = 552)

DAT Subtests	Standardized Coefficients	Sig.		95% Confidence Interval for B	
	Beta	t	p	Lower Bound	Upper Bound
DAT PAT	0.053	1.142	0.254	-0.628	2.372
DAT Biology	-0.054	-0.533	0.594	-4.460	2.556
DAT General Chemistry	-0.021	-0.198	0.843	-3.169	2.588
DAT Organic Chemistry	-0.025	-0.237	0.813	-3.028	2.376
DAT Quantitative Reasoning	0.102	1.108	0.268	-1.058	3.799
DAT Reading Comprehension	0.096	1.210	0.227	-0.892	3.754
DAT Academic Average	-0.159	-0.714	0.476	-13.761	6.426
DAT Total Science	0.187	1.214	0.225	-2.473	10.479

Note. *p < 0.05; **p < 0.01; ***p < 0.001

Table 5. Multiple Regression Analysis Predicting Restorative Dentistry 709 Lab Scores (N = 468)

DAT Subtest	Standardized Coefficients	Sig.		95% Confidence Interval for B	
	Beta	t	p	Lower Bound	Upper Bound
DAT PAT	0.214	4.376	0.000***	0.212	0.558
DAT Biology	0.091	0.865	0.387	-0.224	0.577
DAT General Chemistry	0.095	0.873	0.383	-0.184	0.479
DAT Organic Chemistry	-0.008	-0.070	0.944	-0.322	0.300
DAT Quantitative Reasoning	-0.078	-0.815	0.416	-0.400	0.165
DAT Reading Comprehension	0.032	0.382	0.702	-0.219	0.325
DAT Academic Average	-0.108	-0.468	0.640	-1.449	0.891
DAT Total Science	-0.026	-0.162	0.871	-0.815	0.691

Note. *p < 0.05; **p < 0.01; ***p < 0.001

Predicting Clinical Outcomes

In terms of clinical outcomes, PAT scores were not significantly associated with D4 Mock Endodontics (Table 6), D4 Mock Operative (Table 7), or D4 Mock Periodontics (Table 8) scores. However, there was a significant relationship between PAT scores and D4 mock Prosthodontics exam scores ($\beta=0.079$, $p = .028$, Table 9). Apart from the PAT, the DAT General Chemistry subtest showed significant relationship with the D4 mock Endodontics exam (of $\beta=-0.251$, $p = .02$), and the DAT Reading Comprehension subtest showed significant associations with all fourth-year mock board exam clinical scores, including the D4 mock Endodontics exam ($\beta=0.17$, $p = .025$), D4 mock Operative exam ($\beta=0.299$, $p < .001$), D4 mock Periodontics exam ($\beta=0.293$, $p<.001$), and D4 mock Prosthodontics exam ($\beta=0.269$, $p<.001$).

Table 6. Multiple Regression Analysis Predicting D4 Mock Endodontics Scores (N=762)

DAT Subtest	Standardized Coefficients		Sig.	95% Confidence Interval for B	
	Beta	t	p	Lower Bound	Upper Bound
DAT PAT	-0.016	-0.435	0.664	-0.142	0.090
DAT Biology	-0.101	-1.040	0.299	-0.458	0.141
DAT General Chemistry	-0.251	-2.331	0.020*	-0.558	-0.048
DAT Organic chemistry	0.005	0.043	0.965	-0.226	0.236
DAT Quantitative Reasoning	-0.060	-0.721	0.471	-0.252	0.117
DAT Reading Comprehension	0.170	2.244	0.025*	0.026	0.391
DAT Academic Average	0.129	0.581	0.561	-0.566	1.042
DAT Total Science	0.210	1.292	0.197	-0.188	0.913

Note. * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

Table 7. Multiple Regression Analysis Predicting D4 Mock Operative Scores (N=762)

DAT Subtest	Standardized Coefficients		Sig. p	95% Confidence Interval for B	
	Beta	t		Lower Bound	Upper Bound
DAT PAT	-0.002	-0.048	0.962	-0.200	0.190
DAT Biology	0.043	0.472	0.637	-0.383	0.625
DAT General Chemistry	-0.121	-1.198	0.231	-0.691	0.167
DAT Organic Chemistry	-0.016	-0.159	0.874	-0.420	0.357
DAT Quantitative Reasoning	-0.023	-0.297	0.766	-0.357	0.263
DAT Reading Comprehension	0.299	4.184	0.000***	0.347	0.961
DAT Academic Average	-0.031	-0.146	0.884	-1.454	1.252
DAT Total Science	0.191	1.253	0.211	-0.335	1.518

Note. *p < 0.05; **p < 0.01; ***p < 0.001

Table 8. Multiple Regression Analysis Predicting D4 Mock Periodontics Scores (N=762)

DAT Subtest	Standardized Coefficients		Sig. p	95% Confidence Interval for B	
	Beta	t		Lower Bound	Upper Bound
DAT PAT	-0.029	-0.814	0.416	-0.194	0.080
DAT Biology	0.075	0.820	0.413	-0.206	0.501
DAT General Chemistry	-0.155	-1.527	0.127	-0.535	0.067
DAT Organic Chemistry	0.008	0.080	0.936	-0.262	0.284
DAT Quantitative Reasoning	-0.044	-0.554	0.580	-0.279	0.156
DAT Reading Comprehension	0.293	4.102	0.000***	0.235	0.665
DAT Academic Average	0.217	1.035	0.301	-0.449	1.450
DAT Total Science	-0.097	-0.633	0.527	-0.860	0.440

Note. *p < 0.05; **p < 0.01; ***p < 0.001

Table 9. Multiple Regression Analysis Predicting D4 Mock Prosthodontics Scores (N=762)

DAT Subtest	Standardized Coefficients	t	Sig.	95% Confidence Interval for B	
	Beta		p	Lower Bound	Upper Bound
DAT PAT	0.079	2.201	0.028*	0.058	1.018
DAT Biology	0.032	0.339	0.735	-1.026	1.453
DAT General Chemistry	-0.083	-0.797	0.425	-1.485	0.627
DAT Organic Chemistry	0.082	0.807	0.420	-0.564	1.351
DAT Quantitative Reasoning	0.053	0.660	0.510	-0.507	1.021
DAT Reading Comprehension	0.269	3.666	0.000***	0.656	2.167
DAT Academic Average	0.043	0.198	0.843	-2.995	3.667
DAT Total Science	-0.065	-0.418	0.676	-2.767	1.795

Note. *p < 0.05; **p < 0.01; ***p < 0.001

Predicting Licensure Outcomes

PAT scores were significantly associated with 2 of the 4 WREB subtest scores. Specifically, PAT scores demonstrated a significant association with WREB Operative exam scores ($\beta=0.137$, $p = .009$, Table 10) and the WREB Endodontics exam scores ($\beta=0.21$, $p < .001$, Table 11). The PAT did not show significant associations with the WREB Periodontics (Table 12) or WREB Prosthodontics exams (Table 13). The DAT Reading Comprehension subtest did show a significant relationship with the WREB Prosthodontics exam ($\beta=0.212$, $p = .022$), but no significant associations with any other WREB subtests. No other DAT subtest showed significant associations with any of the WREB subtest scores.

Table 10. Multiple Regression Analysis Predicting WREB Operative Scores (N=398)

DAT Subtest	Standardized Coefficients		Sig.	95% Confidence Interval for B	
	Beta	t	p	Lower Bound	Upper Bound
DAT PAT	0.137	2.622	0.009**	0.007	0.047
DAT Biology	-0.108	-0.838	0.403	-0.082	0.033
DAT General Chemistry	-0.058	-0.413	0.680	-0.054	0.035
DAT Organic Chemistry	0.047	0.330	0.742	-0.033	0.047
DAT Quantitative Reasoning	-0.080	-0.662	0.509	-0.046	0.023
DAT Reading Comprehension	0.002	0.016	0.987	-0.034	0.034
DAT Academic Average	0.195	0.656	0.512	-0.102	0.204
DAT Total Science	0.032	0.156	0.876	-0.092	0.107

Note. *p < 0.05; **p < 0.01; ***p < 0.001

Table 11. Multiple Regression Analysis Predicting WREB Endodontics scores (N=398)

DAT Subtest	Standardized Coefficients		Sig.	95% Confidence Interval for B	
	Beta	t	p	Lower Bound	Upper Bound
DAT PAT	0.210	4.067	0.000***	0.027	0.077
DAT Biology	-0.124	-0.970	0.333	-0.108	0.037
DAT General Chemistry	-0.006	-0.045	0.964	-0.058	0.055
DAT Organic Chemistry	-0.017	-0.122	0.903	-0.054	0.048
DAT Quantitative Reasoning	-0.025	-0.208	0.836	-0.048	0.039
DAT Reading Comprehension	0.031	0.325	0.745	-0.036	0.050
DAT Academic Average	-0.133	-0.452	0.652	-0.238	0.149
DAT Total Science	0.220	1.088	0.277	-0.056	0.195

Note. *p < 0.05; **p < 0.01; ***p < 0.001

Table 12. Multiple Regression Analysis Predicting WREB Periodontics scores (N=398)

DAT Subtest	Standardized Coefficients	Sig.		95% Confidence Interval for B	
	Beta	t	p	Lower Bound	Upper Bound
DAT PAT	-0.028	-0.528	0.598	-0.016	0.009
DAT Biology	0.154	1.183	0.237	-0.014	0.057
DAT General Chemistry	0.066	0.463	0.644	-0.021	0.034
DAT Organic Chemistry	0.125	0.872	0.384	-0.014	0.036
DAT Quantitative Reasoning	0.051	0.418	0.676	-0.017	0.026
DAT Reading Comprehension	0.126	1.313	0.190	-0.007	0.036
DAT Academic Average	0.003	0.009	0.993	-0.095	0.096
DAT Total Science	-0.260	-1.264	0.207	-0.102	0.022

Note. *p < 0.05; **p < 0.01; ***p < 0.001

Table 13. Multiple Regression Analysis Predicting WREB Prosthodontics scores (N=398)

DAT Subtest	Standardized Coefficients	Sig.		95% Confidence Interval for B	
	Beta	t	p	Lower Bound	Upper Bound
DAT PAT	0.085	1.687	0.092	-0.002	0.026
DAT Biology	0.076	0.607	0.544	-0.027	0.052
DAT General Chemistry	-0.067	-0.491	0.623	-0.038	0.023
DAT Organic Chemistry	0.118	0.862	0.389	-0.016	0.040
DAT Quantitative Reasoning	0.086	0.734	0.463	-0.015	0.032
DAT Reading Comprehension	0.212	2.305	0.022*	0.004	0.051
DAT Academic Average	0.048	0.167	0.867	-0.096	0.114
DAT Total Science	-0.181	-0.917	0.360	-0.101	0.037

Note. *p < 0.05; **p < 0.01; ***p < 0.001

Discussion

We found that PAT scores had a significant association with most (3 out of 4) pre-clinical lab scores, while no other DAT subtest showed significant associations with the pre-clinical outcomes. With the PAT explaining between approximately 15 to 30 percent of the variance, it appears to be a valuable predictor of performance in these preclinical laboratory courses. This indicates that the PAT likely does represent factors that predict students' ability to excel in these early dental skills learning and application courses, and, moreover, that the PAT provides predictive utility that is not provided by any of the other DAT subtests. The other DAT subtests may reflect factors relevant in predicting other aspects of dental school performance, such as didactic learning, but do not appear to predict performance in surgery skill acquisition. Although the PAT did not predict performance in one of the preclinical performance measures, its association with the other 3 measures does indicate merit in continuing the use of the PAT with regards to predicting early development of preclinical skills that may rely more on perceptual ability and manual dexterity.

With regards to later performance on clinical outcome measures during the last two years of dental school, the PAT showed a significant relationship with only 1 of the 4 D4 Mock Exam scores. With the PAT accounting for approximately 8 percent of the variance in only the D4 Mock Prosthodontics exam, the predictive validity of the PAT appears to be more limited for clinical performance measures. However, the significant association with the D4 mock Prosthodontics indicates some usefulness of the PAT that may indicate a higher sensitivity to assessing factors related to a specific set of skills used in Prosthodontic procedures. This further supports the idea that the PAT is sensitive to

specific factors related to perceptual ability and manual dexterity. The DAT Reading Comprehension subtest showed the most consistent relationship with clinical performance, with significant associations to all 4 subtests of the fourth-year Mock Board exam clinical scores, predicting between 17 to 30 percent of the variance. This may point to the DAT Reading Comprehension subtest's ability to assess factors that are essential to overall mastery of dental subjects during their dental school training process.

Although the PAT was not significantly associated with most of the D4 Mock Board exam scores, the PAT was found to have a significant relationship with 2 of the 4 WREB licensing exam scores. Specifically, PAT scores predicted WREB Operative and Endodontics exam scores, but not WREB Periodontics or Prosthetics exam scores. This stands in contrast to the clinical D4 Mock Board exam results in which the PAT was only significant in predicting the D4 Mock Prosthodontics exam. This continues to demonstrate the inconsistency with which the PAT predicts later clinical skill development. The DAT Reading Comprehension subtest did show a significant relationship with the WREB Prosthodontics exam, but no significant associations with any other licensure outcome measure. No other DAT subtest showed significant associations with any of the licensure outcomes measures as well. Therefore, the PAT seems to be at least as good, if not a better predictor of licensure exam performance, than the other DAT subtests.

These findings show the limitations of the PAT for accurately predicting clinical performance of dental school applicants. Results confirmed that the DAT PAT scores are useful in predicting performance early on in dental school, particularly in the pre-clinical lab courses. However, the predictive validity of the PAT with regards to clinical

performance during the second half of dental school was less consistent. Although the DAT Reading Comprehension scores were also predictive of performance in performance on clinical exams, the other DAT scores, including DAT total science score did not appear to have any significant associations with clinical performance in dental school. This demonstrates the need to further investigate the predictive value of the PAT and other DAT subtests, as well as how individual subtests relate to performance in various aspects of dental school.

Limitations and Future Directions

One of the limitations of this study is that the sample population is based only on students who scored high enough on the overall DAT and PAT to gain admission to Loma Linda Dental School. Thus, we have a somewhat biased sample and are not able to confirm whether applicants who scored lower than Loma Linda University's School of Dentistry's acceptance criteria, including criteria specific to their overall DAT and PAT performance, would have performed more poorly than their counterparts who entered with higher DAT and PAT scores.

Another limitation of this study is the lack of alternative measures available to improve the predictive capacity for surgery skill development in the clinical stage of learning in dental programs. Further study could be directed into factor analysis of dental student surgery skill development. This analysis could then be applied to development of superior assessment measures to be added to the PAT or fully replace the PAT portion of the DAT. This could then lead to providing admissions committees better information for use in selecting applicants who show the greatest potential for successful Surgery Skill

development for their professional training programs.

REFERENCES

- Ballard, R. W., Hagan, J. L., & Cheramie, T. (2015). Relationship between hand-skill exercises and other admissions criteria and students' performance in dental school. *Journal of Dental Education*, 79(5), 557–62. Retrieved from <http://www.ncbi.nlm.nih.gov/pubmed/25941149>
- Bergman, A. V, Susarla, S. M., Howell, T. H., & Karimbux, N. Y. (2006). Dental Admission Test scores and performance on NBDE Part I, revisited. *Journal of Dental Education*, 70(3), 258–62. Retrieved from <http://www.ncbi.nlm.nih.gov/pubmed/16522754>
- Carroll, A. M., & Schuster, G. M. (2015). Correlation Between Students' Dental Admission Test Scores and Performance on a Dental School's Competency Exam. *Journal of Dental Education*, 79(11), 1325–9. Retrieved from <http://www.ncbi.nlm.nih.gov/pubmed/26522638>
- Coy, K., McDougall, H., & Sneed, M. (2003). Issues regarding practical validity and gender bias of the Perceptual Abilities Test (PAT). *Journal of Dental Education*, 67(1), 31–7. Retrieved from <http://www.ncbi.nlm.nih.gov/pubmed/12540103>
- Curtis, D. A., Lind, S. L., Plesh, O., & Finzen, F. C. (2007). Correlation of admissions criteria with academic performance in dental students. *Journal of Dental Education*, 71(10), 1314–21. [http://doi.org/10.1016/0014-2999\(86\)90271-2](http://doi.org/10.1016/0014-2999(86)90271-2)
- De Ball, S., Sullivan, K., Horine, J., Duncan, W. K., & Replogle, W. (2002). The relationship of performance on the dental admission test and performance on Part I of the National Board Dental Examinations. *Journal of Dental Education*, 66(4), 478–84. Retrieved from <http://www.ncbi.nlm.nih.gov/pubmed/12014563>
- Gray, S. A., & Deem, L. P. (2002). Predicting student performance in preclinical technique courses using the theory of ability determinants of skilled performance. *Journal of Dental Education*, 66(6), 721–7. <http://doi.org/10.1016/j.biocontrol.2013.10.006>
- Gray, S. a, Deem, L. P., & Straja, S. R. (2002). Are traditional cognitive tests useful in predicting clinical success? *Journal of Dental Education*, 66(11), 1241–5. Retrieved from <http://www.ncbi.nlm.nih.gov/pubmed/12484675>
- Lee, K. C., Lee, V. Y., Zubiaurre, L. A., Grbic, J. T., & Eisig, S. B. (2018). Relationship Between Dental Students' Pre-Admission Record and Performance on the Comprehensive Basic Science Examination. *Journal of Dental Education*, 82(4), 424–428. <http://doi.org/10.21815/JDE.018.044>
- Park, S. E., Susarla, S. M., & Massey, W. (2006). Do Admissions Data and NBDE Part I Scores Students ? *Journal of Dental Education*, 70(5), 518–524.

- Sadow, P. L., Jones, A. C., Peek, C. W., Courts, F. J., & Watson, R. E. (2002). Correlation of admission criteria with dental school performance and attrition. *Journal of Dental Education*, 66(3), 385–92. Retrieved from <http://www.ncbi.nlm.nih.gov/pubmed/11936229>
- Schultz-Robins, M., Markowitz, K., DeCastro, J., & Jiang, S. (2018). Comparison of Dental Students' PAT Scores with Their Performance in Preclinical Technique Courses: Identifying the Need for Early Interventions. *Journal of Dental Education*, 82(4), 406–410. <http://doi.org/10.21815/JDE.018.043>
- Stewart, C. M., Bates, R. E., Smith, G. E., & Young, L. (2006). Impact of gender on dental state licensure examination performance. *Journal of Dental Education*, 70(5), 525–30. <http://doi.org/70/5/525> [pii]