ADMISSIONS PROCESSES FOR DENTISTRY PROGRAMS IN CANADA:

A REPORT FOR

THE CANADIAN DENTAL ASSOCIATION

AND

THE ASSOCIATION OF CANADIAN FACULTIES OF DENTISTRY

ON

CURRENT PRACTICES AND FUTURE DIRECTIONS

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Contents

1 GLOSSARY

ACFD	Association of Canadian Faculties of Dentistry
ADA	American Dental Association
AL	Accuracy Left
ASE	Anatomical Self-Efficacy
CAS	Confirmation of Acceptance for Study
CDA	Canadian Dental Association
CDS	Computer-assisted Dental Simulation
CEGEP	Collège d'enseignement général et professionnel (General and Vocational College)
CI	Confidence Interval
CMSENS	Computer-based Multiple Sample Evaluation of Skills
CRDTS	Central Regional Dental Testing Service
CVR	Content Validity Ratio
DAT	Dental Aptitude Test (Canada) or Dental Admission Test (US)
DAT-AA	DAT-Academic Average
DAT-BIO	DAT-Biology
DAT-CD	DAT-Carving Dexterity
DAT-DT	DAT Dexterity Test
DAT-OC	DAT-Organic Chemistry
DAT-PAT	DAT-Perceptual Ability Test
DAT-QR	DAT-Quantitative Reasoning
DAT-RC	DAT-Reading Comprehension
DAT-SNS	DAT-Survey of Natural Sciences
DEET	Dental Education Eligibility Test
DSM-III	Diagnostic and Statistical Manual of Mental Disorders
ECI	Emotional Competence Inventory
EI	Emotional Intelligence
GAMSAT	Graduate Australian Medical School Admission Test
GPA	Grade Point Average
HDS	Hogan's Development Survey
IRT	Item Response Theory
MBTI	Myer-Briggs Type Indicators
MCAT	Medical College Admission Test
MIST-VR	Minimally Invasive Surgical Trainer – Virtual Reality
MMI	Multiple Mini Interview
NBDE	National Board Dental Examination
NBDHE	National Board Dental Hygiene Examination
NEO-PI-R	NEO-Personality Inventory - Revised
NS	Non-significant
OR	Odds Ratio
OSCE	Objective Structured Clinical Examination
SD	Standard Deviation
SJT	Situational Judgement Test
TL	Time Left
TXAD	Treatment of Active Diseases (class)
URM	Underrepresented Minority
USMLE	United States Medical Licensing Examination

2 EXECUTIVE SUMMARY

2.1 Project aims

Given the mandate for the working group, we identified the following aims as a means to direct our work. We aimed to:

- Describe the admissions processes used for the dentistry programs in each dental school in Canada;
- Describe the problems and potential solutions and issues people working in Canadian dental schools have identified in relation to the current admissions processes for dentistry programs;
- Describe the problems and other issues people in the broader dental profession identify in relation to admissions to dentistry programs in Canada;
- Describe the research literature concerning the validity and reliability of various instruments and processes used in admissions to dentistry programs;
- Where relevant, compare this literature with that from medicine and nursing and veterinary medicine;
- Draw conclusions concerning the quality of the admissions instruments and processes currently used for dentistry programs in Canada; and
- Make recommendations concerning possible future means to ensure high quality admissions processes are used for dentistry programs in Canada.

With these aims in mind, working group members decided to use a mixed methods approach to address them. The approach included a review of the relevant literature and interviews with admissions personnel at all Canadian dental schools, plus interviews with some national dental organizations in Canada and the USA.

2.2 The literature review on validity of admissions processes

After reviewing the literature and evaluating potential assessment tools used during the dental school admission process, we found that some DAT components (mainly DAT-AA [academic average], DAT-QR [quantitative reasoning] and DAT-RC [reading comprehension]) and Pre-dental Overall GPA and Science GPA scores represent the best predictors of academic performance of dental students. Also they have some correlation with clinical and board examination performance, although the strength of these relationships is only weak to moderate. Some questions remain concerning the concurrent validity of the DAT-PAT (perceptual ability test), since its results were not compared with those of any other forms of perceptual ability assessment. Our results also suggest that combining cognitive assessment tools together but also with non-cognitive assessment tools considerably increases their predictive validity. The debate still remains regarding which non-cognitive tools to use.

Interviews remain a popular way to assess non-cognitive and personality traits. Our findings show that increasing the structure of the interview, whether it is through a structured or MMI (Multiple Mini Interview) format, drastically increases its reliability and validity. As for comparing MMI and structured interviews, our findings seem to indicate that MMI have a slightly higher reliability, although more research is needed to be able to arrive at more definite results.

Manual dexterity test were found to have null to weak predictive validity on student performance. That being said, manual dexterity may be utilized as a screening tool in admissions and has been shown in the past to reduce attrition rates in dental school.

With respect to the quality of the validity testing for admissions processes, many aspects have to be investigated. Yet, most of the reviewed articles only focused on predictive and convergent/divergent validity, and to a lesser extent, on concurrent validity. Face, construct and content validities of the selection tools were only assessed in the case of MMI. Concerning the reliability, this aspect was only addressed by a few studies pertaining to manual dexterity tests (tweezers, computer-assisted dental simulation) and structured interviews. Therefore, based on this review, there are still many areas that need to be explored before any well-informed statement upon the validity and reliability of selection tools can be made. As for other limits of the articles reviewed, most of the results were based on correlations and/or descriptive statistical analyses, so inferences and conclusions can only be very limited.

When it came to achieving greater student diversity, our findings suggest that students of diverse backgrounds (e.g. rural or racial minorities) are not disadvantaged by the selection tools currently used in the dental admission processes. Therefore, other initiatives such as under-represented minorities recruitment and pipeline-type programs must be implemented if universities want to achieve greater student diversity. Our literature review suggested different possible avenues to achieve this goal.

2.3 The results of interviews with stakeholders

Most of the Canadian admissions officers agreed that there is value in having a battery of national, standardized admissions tests to choose from to assess cognitive ability, non-cognitive attributes and psychomotor skills. Used in conjunction with the GPA, a national standardized series of tests would address the concerns raised about GPA. These included: i) grade inflation in some courses within an institution; ii) grade variation by different instructors in the same course in a given institution; iii) variation in GPAs across institutions; and iv) grade variation across programs (e.g. Engineering versus a General Science program)

On the other hand, the Admissions Officers commented that the current test components of the Canadian DAT have some problems that need to be addressed:

- The Survey of Natural Sciences does not appear to be at the appropriate level to assess the CEGEP (Collège d'enseignement général et professionnel or General and Vocational College) students that apply to the three Quebec dental schools. The standardized test battery that provides the benefits stated above are offset if all ten dental schools cannot use them;
- Another important problem is that the Reading Comprehension Test is only available in English. A national test battery must be available and accessible for students applying at all ten dental schools in both English and French;
- The validity and reliability of the DAT test components are not being evaluated at all by the current CDA Admissions Committee. The only current statistical data available is from the ADA Department of Testing Services. Since the Canadian and US DAT test components are different, no analysis is being performed on the Manual Dexterity Test (DAT-CD).

Concern was expressed regarding the limited mandate of the CDA Dental Aptitude Test Sub-Committee. The CDA develops and makes available the DAT and CDA Structured Interview to the dental schools. It has a process to grade the Manual Dexterity Test. However, assessment of the validity and reliability of these tests through the CDA does not occur. Comments from the admissions officers indicated that they tended to attempt to assess various admissions tools at a local level (Faculty Admissions Committee level). This is a direct result of the limitations in the mandate and funding of the current CDA Dental Aptitude Test Sub-Committee. Assessment of non-cognitive

attributes in the admissions process was desired by all of the admissions officers. In the absence of a national Committee with the mandate to assess new admissions tools to assess non-cognitive attributes among others, individual schools tend to work in a vacuum. This is not cost-effective or efficient, and does not allow for the collection of data to improve research on admission tool use.

2.4 Recommendations

Based on the findings of the literature review and interviews, the working group makes the following recommendations:

1. The current CDA Dental Aptitude Test Sub-Committee should be replaced by a national Admissions Committee jointly administered by the CDA and the ACFD. The membership of the new Admissions Committee should include:
   - admissions officers from each of the 10 dental schools
   - individuals with expertise in admissions and relevant research
   - individuals with expertise in assessing the validity and reliability of admissions tools
   - individuals with expertise in generating items, scenarios and elements of non-cognitive tests (e.g. MMIs and structured interviews)
   - administrative support
2. The mandate of the new national Admissions Committee needs to be broadened to include the following functions:
   - Development of guidelines concerning overall student selection and admissions processes (i.e. beyond simply oversight of the DAT);
   - Development of guidelines on the use of specific tools and processes to ensure they are used appropriately e.g. cut-off scores, use for screening etc.;
   - Training on the use of admissions tools;
   - Development of elements of tests and processes (e.g. questions for structured interviews or scenarios for MMI's); and
   - Oversight of evaluating the validity of admissions tools and processes.
3. The new national Admissions Committee needs to be appropriately funded to enable the performance of the expanded mandate outlined above.
4. All admissions tools that the new national Admissions Committee recommends to the schools for consideration in their admissions processes:
   - must be available in both English and French
   - must be at an appropriate academic level to be able to be administered to all applicants to dental programs in Canada, specifically to have a level playing field for University-based and CEGEP-based applicants
5. Efforts to investigate validation of tests should focus on those showing promise:
   - DAT-AA (Academic Average), DAT-QR (Quantitative Reasoning), DAT-RC (Reading Comprehension);
   - Overall predental GPA, Science GPA;
   - MMI, structured interviews; and
   - Combinations.
6. As the DAT-CD (Manual Dexterity Test) is currently being used by seven of the ten dental schools in Canada, evaluation of the validity and reliability of this admission test component needs to be undertaken, including its most appropriate use.

7. Efforts should be made by dental schools to focus their admissions processes on tools with the strongest evidence to support them, while ceasing the use of approaches that have little evidence to support them and/or with evidence that shows the tools are not effective in the admissions process.
8. Efforts should be focused on the recruitment of appropriate candidates as well as the processes used to select them.

3 WORKING GROUP MANDATE

To provide advice to the Canadian Dental Association (CDA) Board of Directors and Association of Canadian Faculties of Dentistry (ACFD) on all aspects of the DAT program and broader admissions processes, and propose changes required to enhance their value in the student selection process.

3.1 Objectives

1. To review the current DAT and evaluate the validity and reliability of its current components.

2. To identify other selection tools that could provide information for the admissions process at Canadian dental schools.

3. To identify issues related to use of the DAT and other selection tools in the admissions process at Canadian Dental Schools and propose potential solutions.

4. To identify opportunities for collaboration between dental schools, CDA and other stakeholders to enhance the admissions process.

3.2 Composition and Length of Term

The Working Group will be composed of up to three members recommended by ACFD. These members are expected to serve for the duration of the mandate of the working group.

3.3 Meetings

The working group will meet as needed for the accomplishment of its mandate both in person and electronically.

Given the budgetary implications for CDA, in-person meetings will be approved in advance by CDA.

3.4 Reporting/Accountability

The Working Group will present its final report to the CDA Board of Directors and to ACFD no later than 24 months after the appointment of its members.

3.5 Members

Paul Allison, Faculty of Dentistry, McGill University (Chair)

Blaine Cleghorn, Faculty of Dentistry, Dalhousie University

John Perry, Faculty of Dentistry, University of Manitoba

4 INTRODUCTION

In recent years, there have been increasing questions concerning the admissions process for dentistry programs among Canadian dental schools and elsewhere in the world. This questioning has arisen as society and the health professions have focused on issues of ethics and professionalism. With increasing media attention on ethics and professional behavior in government, leadership roles and the professions, attention has begun to focus on how the profession of dentistry can maintain the highest standards of ethics and professionalism. One of those means is to focus on who becomes a dentist, how they are being chosen to become dentists and how we are training them.

As part of this questioning of the big picture, academics at Canadian dental schools are also making the observation that they regularly have problems with a small proportion of trainees' ethical and professional behavior. That is, Canadian dental schools regularly have a small proportion of dental students behaving unethically or unprofessionally, and while the vast majority of these behaviours are dealt with and not repeated, there is a very small number of trainees whose behavior remains unchanged. These trainees present multiple problems in terms of evaluation and remediation in dental school. However, it has also been observed in medical programs that those individuals with multiple unethical or unprofessional behaviours are more likely to become those with disciplinary problems with licensing bodies once they graduate (1). Given these observations, those involved in the selection and admission of students for dentistry programs in Canada are keen to identify valid instruments and/or processes to identify candidates with strong ethical and professional principles and characteristics likely to promote empathetic and socially responsible behaviours. Thus, there is a strong desire to identify valid indicators of non-cognitive attribute that are desired in a dentist, while at the same time identifying candidates whose behaviour and approach suggests they would not make good health professionals.

On top of this, and for further information on the context in which this report is prepared, there is an increasing recognition in the dental professions in Canada of the difficulties certain underprivileged groups in Canada have accessing dental care. With this, there is a focus on how we can begin to deal with these issues of access in terms of recruiting people into the profession who are more likely to be interested in caring for such groups, and training students to work with people with underprivileged backgrounds and to provide dental care in non-conventional settings (e.g. using mobile dental care units). In recent years, in the USA, the Dental Pipeline Program has been running with the goal of recruiting and selecting more diverse and under-represented minority groups into dental programs, as well as providing students with more diverse community experiences (2). The ultimate goal is to use these recruitment and training strategies to begin to address the problems of access to dental care observed in the USA, and which are mirrored in Canada.

Finally, and more specific to the admissions process for dentistry programs in Canada, there has been an increasing questioning of the value of the Dental Aptitude Test (DAT) as a whole or parts of the test (e.g. the manual dexterity test) as a means to help select candidates for dentistry programs. As will be documented in this report, and is widely known, there is significant variety in the sections of the DAT used and the way in which the DAT scores are used in the admissions process among Canadian dental schools.

In summary therefore, there are several core issues driving the need for a review of admissions procedures for Canadian dentistry programs:

- there are societal level questions concerning the ethics and professionalism of many people with leadership and professional roles in society, including dentists;
- there is a strong desire to find instruments and/or processes that can be used in the selection of students to identify those with the non-cognitive attributes to make a good dentist, while at the same time identifying those whose non-cognitive behaviours would mean they are unlikely to be good dentists;
- there is an increasing recognition in the dental professions and certain sectors of society of the problems of access to dental care for underprivileged groups in Canada, and that selecting students for dental programs from more diverse and under-represented groups in the Canadian population may make a contribution to improving access to dental care for marginalized groups;
- there is a recognition within dental, and other health professional schools that there is a very small number of dental students regularly behaving unethically or unprofessionally and evaluating and remediating these individuals is problematic; and
- there is questioning within dental schools in Canada of the value of the DAT and its parts in the dental student selection process.

With these issues in mind, it is important to understand the framework into which the admissions process fits. Canadian society desires dentists who are competent to provide high quality oral health care throughout their careers. To achieve this, the process involves the recruitment, selection and admission of excellent trainees, their training in the undergraduate dentistry program, their graduation and licensing, and their continuing professional development during their careers. It is important to understand that the subject of this report (the tests and processes used to select dentistry students) is just one part of the process in the creation of dentists who are competent to provide high quality oral health care throughout their careers.

With this rationale in mind, in January 2012, the Canadian Dental Association (CDA), which runs the DAT, and the Association of Canadian Faculties of Dentistry (ACFD) set up a working group to look into the issues described in the mandate (see previous section), asking the working group members to prepare a report for the spring of 2014. This report is the product of the work performed by the working group.

5 METHODOLOGY

Given the aforementioned mandate for the working group, we identified the following aims as a means to direct our work. We aimed to:

- Describe the admissions processes used for the dentistry programs in each dental school in Canada;
- Describe the problems and potential solutions and issues people working in Canadian dental schools have identified in relation to the current admissions processes for dentistry programs;
- Describe the problems and other issues people in the broader dental profession identify in relation to admissions to dentistry programs in Canada;
- Describe the research literature concerning the validity and reliability of various instruments and processes used in admissions to dentistry programs;
- Where relevant, compare this literature with that from medicine, nursing and veterinary medicine;
- Draw conclusions concerning the quality of the admissions instruments and processes currently used for dentistry programs in Canada; and
- Make recommendations concerning possible future means to ensure high quality admissions processes are used for dentistry programs in Canada.

With these aims in mind, working group members decided to use a mixed methods approach to address them. The approach included a review of the relevant literature and two data gathering and two data analytic phases. The methods for each of these phases are described below.

5.1 Data collection

The questionnaire in Appendix A was sent by e-mail to the Chair/Director of Admissions for the dentistry program of each dental school in Canada. They were asked to complete the questionnaire electronically and return it, again by e-mail. This process occurred during April-June of 2012.

Following this, qualitative interviews were performed with two representatives of each dental school using the questions in Appendix B as a basis for each interview. Invitations to participate in these interviews were sent to the Dean of each dental school requesting the names of two participants of their choice to be interviewed. In addition, invitations were sent to the following organizations to participate in similar qualitative interviews, the outlines of which are shown in Appendix C:

- American Dental Association (ADA)
- American Dental Education Association (ADEA)
- Association of Canadian Faculties of Dentistry (ACFD)
- Canadian Dental Association (CDA)
- Canadian Dental Regulatory Authorities Federation (CDRAF)
- Commission on Dental Accreditation of Canada (CDAC)
- National Dental Examining Board (NDEB)

All participants were provided with the respective interview outlines (Appendices B and C) ahead of time. All these interviews were performed by telephone. Interviewers were always two or three members of the working group. At the beginning of each interview, participants from the dental schools and organizations were told that the interviews

would be recorded, that data would be reported anonymously with respect to participating individuals and organizations and that the only people with access to these data were the three members of the working group, plus an assistant loaned for the project by the CDA. All interviews lasted approximately 30-60 minutes and were recorded and transcribed by the assistant. Transcripts were returned to interviewees for verification and then kept by the working group members for analyses.

Consent for these data collection processes was not explicitly gathered but was implicitly understood as the dental schools and organizations' leaders and the individual participants all agreed to participate knowing the process described above.

5.2 Data analyses

The questionnaire data were used to generate a purely descriptive summary of the tests and processes used for admission to the 10 dentistry programs across Canada. Results of that process are shown in Tables 2 and 3 and the accompanying text (page 20).

Data gathered through the qualitative interviews were analyzed independently by two members of the working group to generate themes. These themes were then cross-checked to identify common themes, which were then used as a means to describe the data.

5.3 The literature review

This literature review focused on four main points:

a) It updates and compiles recent findings on the validity and reliability of the tests used in the admissions processes of dentistry programs in Canada;
b) It identifies biases and issues associated with these tools;
c) It examines how these tools should be used to attain optimal results; and
d) It expands the review to related fields such as medical, veterinary and advanced nursing studies to identify additional potential assessment tools that might be transferable to dental schools admissions processes.

5.3.1 Search method

To ensure rigour, our approach to this literature review is based on the "Five Stages of Integrative Research Review" by Cooper (3). Based on their relevance, three databases were identified: Web of Science (January 2007 – June 2013), FRANCIS (2007 – 2013) and Medline (January 2007 – June 2013). The keywords, used in combination in the English databases, were: "Dental" and "Admission"; "Medical" and "Admission," "Dental school" and "Selection", and finally "Medical school" and "Selection". The keywords used in the French database were "Médecine" and/or "Dentaire", "École" and "Admission". Once the duplicates were rejected, the search resulted in 3,786 potential references.

5.3.2 Inclusion criteria

Of the 3,786 references found through the databases search results, all documents whose title suggested that they pertained to selection tools used in high stakes and schools' admissions settings were selected. This resulted in 474 papers being identified for further analysis, and the elimination of 3,312 references. Then, a list of inclusion criteria was developed to further screen the articles. These inclusion criteria were that the paper:

a) must be either a literature review, a meta-analysis or an empirical study;
b) must be published in a peer-reviewed journal;

c) must be published in French, English or Spanish; and
d) must be related to either Medical school, Dental school, Veterinary school, or Advanced Nursing school selection tools or processes.

This second screening stage reduced the number of articles to 181, the others having been rejected because the selection tools or processes assessed by the authors were either not related or not transferable to dental schools settings (n=290), or because of the language of the article (German n=2; Arabic=1). The literature relating to dental schools' admission selection tools and processes (n=34) were then extracted from the rest (n=143). The bibliography of the documents selected was examined, and two additional articles relating to dental schools' admissions processes were consulted. Both of these articles were selected for this review. Out of the 183 articles, 36 related to dental schools' admissions procedures and tools: 24 were taken from Medline, 12 from Web of Science and none were taken from FRANCIS. The rest of the articles were assessed either a) to provide an insight to the validity, reliability and impact of the different non-cognitive ability assessment tools used in other fields during the admissions process, especially when few to none of the articles relating to the dental field addressed this criteria in question, and b) to broaden the search for new potential assessment tools that might be useful to dental schools' admissions committees. The results of this broadened search are presented in the last section of the review. Since none of the articles selected pertained to the Dental Aptitude Test (DAT) manual dexterity test (DAT-DT), a complimentary search was conducted using the same database, with the keywords "DAT", "Carving test" and "Manual dexterity", without time limits. This search resulted in only one reference, a literature review (4). After examining the article's bibliography and "quoted by" list, four other articles were found to pertain to manual dexterity tests - two of them pertaining to the DAT-DT, for a total of five articles. These articles will be reviewed in the section "non-cognitive selection tools", under "manual dexterity assessment".

5.3.3 Concept definition

Of the articles reviewed, multiple criteria were used to evaluate the quality and value of the assessment tools used in dental and medical schools admissions' process. This is not only true for empirical articles, but also for the literature reviews and meta-analyses that attempted to make sense of the different individual findings. In their systematic review of the situational judgment test assessment of non-academic attributes in medical school students, Patterson et al. (5) based their assessment on three criteria: reliability, predictive validity, and incremental validity of the measurement's instrument. Koenig et al. (6) used the following eight criteria in evaluating six judgment and non-cognitive tools used in medical school students' selection: validity, reliability, group differences, susceptibility to faking and coaching, applicant reactions, user reactions, cost/resource utilization, and scalability for use in pre-interview screening. After consideration, four evaluation criteria were chosen, as we believe they encompass all others. Two of them (validity and reliability) pertain to the assessment of the selection tool itself, while the other two derive from the selection tool evaluation - its possible biases - and the implementation process - the issues relating to the admissions process. An instrument's initial purpose must be taken into account in any measurement validity assessment, especially when evaluating predictive validity. Therefore, a description of the different selection tools and their purpose will be provided at the beginning of each sub-section. A definition of all four criteria follows.

5.3.4 Validity

An instrument's validity relates to its ability to accurately measure what it is supposed to measure (7). Although researchers agree on most terms, describing the different types of validity when it comes to measurement instruments, their typologies of the different validities greatly differ. Drawing on the evaluation of field-specialized literature, we opted for three types of validity of measure classification: content, criterion and construct validities (see Table 1).

Content validity is “the extent to which a test or assessment matches the real requirements” in the opinion of a panel of experts (8) such as the measure of content validity through Lawshe’s Content Validity Ratio (CVR).

Criterion validity can be defined as an instrument’s ability to predict or estimate the outcomes (9). There are two kinds of criterion validity: predictive and concurrent validity. Predictive validity refers to an instrument’s ability to predict a desired outcome, while concurrent validity is the instrument’s ability to distinguish the difference between two groups that it should distinguish between (7).

Construct validity is an instrument’s ability to assess which constructs are responsible for the variation in test performances (10). The main approaches to determine construct validity are either demonstrating face validity, or establishing convergent validity (7). Face validity should be understood as the perception of the different parties involved - in this case, raters and users - of the correspondence between what the instrument is supposed to measure and what it actually measures (11). The introduction of an assessment tool perceived to be unfit is unlikely. Therefore, face validity will have a strong influence on acceptance.

As for convergent validity, it can be established either through a trait validation approach (i.e. comparing the results to those of another valid and reliable tool assessing the same construct), a multi-method multi-trait approach or a nomologic approach (7).

Table 1 shows the main validity types that will be explored for each assessment instrument in this literature review.

Table 1: Measure Instrument’s Validity

1. Content validity		
2. Criterion validity	**2.1 Predictive validity**	
	2.2 Concurrent validity	
3. Construct validity	**3.1 Face validity**	**3.1.1 Applicants**
		3.1.2 Examiners
	3.2 Convergent validity	**3.2.1 Trait validation approach**
		3.2.2 Multi-method multi-trait validation approach
		3.2.3 Nomologic approach

In assessing validity, a common analytic technique is correlation. Correlation coefficients (*r*) reported in this literature review were interpreted using the following guideline (12):

- -1.0 to -0.7 strong negative association;
- -0.7 to -0.3 negative association;
- -0.3 to +0.3 little or no association;
- +0.3 to +0.7 positive association; and
- 0.7 to 1.0 strong positive association.

5.3.5 Reliability

Reliability should be understood as the degree to which the results of a measurement tool or process can be reproduced (8). There are three ways to assess reliability in the context of admission selection tools: through intra-

rater reliability (or test-retest reliability), which is the reproducibility of an evaluation result with the same person evaluating the same thing more than once; through inter-rater reliability, which is the reproducibility of an evaluation result with different people evaluating the same thing; and through internal consistency (i.e. Cronbach alpha or Kappa coefficient) (13), which is the correlation of different elements of the same test. All together, these three measures allow us to assess a selection tool's reliability.

5.3.6 Potential biases associated with the selection tools application processes

Many variables may influence the validity of an evaluation process. Regarding selection tools, potential sources of biases include, for internal validity, the testing effect, and the experimenter biases; and for external validity, the subjects' hypotheses, and the experimenter expectancies biases. The probability of the occurrence of these four possible biases on the validity of dental admissions processes is explored through this literature review.

5.3.7 Issues deriving from the selection tools admission processes

Two main issues can potentially derive from the implementation of selection tools, namely: the scalability potential of selection tools, and the impact of these tools on student diversity.

Scalability potential

Derived from a computer process, the term scalability refers to the ability of an assessment tool to vary its size, performance and number of users without affecting its measurement abilities. Therefore, this criterion will encompass all the considerations regarding financial and resources costs (human, temporal and material), as well as other considerations that they might hinder.

Impact on student diversity

Recent studies have found that the presence of minority healthcare professionals and dentists helps increase access to care (14). It is therefore not surprising that consideration on how to improve student diversity has been expressed by Canadian dental schools. In this literature review, diversity was defined in many ways. While some studies conceptualize diversity essentially in an ethnic perspective (12), others define it more broadly to include "not only ethnic background, but also rural origin; gender; first generation; and other personal life experiences through work, volunteer activities, leadership in extracurricular activities, etc." (15). This analysis will concentrate on five levels of student diversity, namely: age group diversity, gender diversity, ethnic/racial diversity, socio-economic diversity and geographical diversity (rural/urban communities).

6 Results

6.1 Description of admission tools being currently used by Canadian dental schools

While there has been a great emphasis in the literature on the importance of non-cognitive abilities in dentistry, in practice, Canadian dental school admission decisions still rely mostly on academic and cognitive criteria. A student's GPA/academic records are central criteria of all ten Canadian dental school selection processes and range from 33.3% to 100% of the dental school's admission decisions (see Table 2). Nine of the Canadian universities also base their admission decisions on the Dental Aptitude Test (DAT) scores, which range from 10% to 45-50% of their decision, while another university uses the DAT as a screening tool. Five universities use the DAT-Academic Average (DAT-AA) scores, four use the DAT-Reading comprehension (DAT-RC) scores, one the DAT-Survey of Natural Science (DAT-SNS) scores, eight the DAT-Perceptual Ability Test (DAT-PAT) scores, and seven the DAT-Manual Dexterity (DAT-MD) scores in their admission decision processes.

Table 2: Summary of Canadian dental schools' admission criteria, 2011-2012

	Academic performance and cognitive ability assessment							Non-cognitive ability assessment							
University	**GPA/ Academic record**	**Dental Dental Aptitude Test (DAT)**						**NEO-PI-R**	**Ref. letter**	**Personal state-ment**	**Un-structured interview**	**Structured interview**	**PBL eval'n**	**CV**	**Personal inventory**
		Used?	DAT-AA	DAT-RC	DAT-NS	DAT-PA	DAT-CD								
Dental School 1	Yes (50%)	Yes (25%)	-	Yes	-	Yes	Yes	-	-	Yes (*)	-	Yes (25%)	-	-	-
Dental School 2	Yes (*)	Yes (*)	Yes	-	-	Yes	Yes	-	Yes (*)	Yes (*)	-	Yes (*)	Yes (*)	-	-
Dental School 3	Yes (45-50%)	Yes (45-50%)	-	Yes	Yes	Yes	Yes	-	-	-	-	-	-	-	Yes (0-5%)
Dental School 4	Yes (80%)	Yes (*)	-	-	-	Yes	Yes	-	-	-	-	Yes (20%)	-	-	-
Dental School 5	Yes (33%)	Yes (33 %)	Yes	-	-	Yes	Yes	-	-	-	-	Yes (33%)	-	-	-
Dental School 6	Yes (*)	No	-	-	-	-	-	-	Yes (*)	Yes (*)	Yes (*)	-	-	Yes (*)	-
Dental School 7	Yes (100%)	Yes (pass or fail)	-	-	-	Yes	Yes	-	-	Yes (pass or fail)	-	Perhaps	-	-	-
Dental School 8	Yes (65%)	Yes (15%)	Yes	Yes	-	Yes	Yes	-	-	-	-	Yes (20%)	-	-	-
Dental School 9	Yes (60%)	Yes (10%)	Yes	-	-	Yes	-	Yes (15%)	-	-	-	Yes (15%)	-	-	-
Dental School 10	Yes (60%)	Yes (15%)	Yes	Yes	-	-	-	-	-	-	-	Yes (25%)	-	-	-
Schools Using Tool	10	9	5	4	1	8	7	1	2	4	1	8	1	1	1
Schools using Percentage Weight	8	6	5	4	1	8	6	1	2	3	1	8	1	1	1
Schools using Minimum Cut Score	0	0	1	3	0	4	5	0	0	1	0	0	0	0	0
Cut Score			19	15-18**		10-15	3-15								

*Weighting not made public
**One school commented "if low, may reject"

The use of non-cognitive admission tools by Canadian universities is far less homogenous. The selection tools most commonly used in the 2011-2012 dental school admission processes were: the Structured interview (seven

universities, accounting for 15% to 33.3% of the total decision score), the personal statement analysis (four universities), and, to a lesser extent, the reference letter (two universities), the NEO-PI-R (one university), the unstructured interview (one university), the personal inventory (one university), the curriculum vitae (one university), and a problem-based learning evaluation (one university).

6.2. Results of semi-structured interviews

As described in section 5.1, using the interview guides in Appendices B and C, we performed a series of semi-structured interviews with personnel from all Canadian dental schools, plus several national dental organisations in Canada and the USA. All 10 Canadian dental schools and five of the seven organisations invited participated. The observations were made from these interviews are described in sections below categorized by admissions test type.

6.2.1 Dental Aptitude Test

The DAT is second only to the GPA as the most commonly used admissions tool for Canadian Faculties of Dentistry. One or more of the DAT test components is used by 9 of the 10 dental schools (see Table 2). One dental school does not use any components of the DAT in their admissions process as they feel it is not a good predictor of performance in dental school. Some of the Canadian dental schools also accept results of the US DAT in lieu of the Canadian DAT, therefore the similarities and differences between the two test batteries need to be explained.

The Canadian DAT consists of a series of four tests. The English DAT includes:

- Survey of the Natural Sciences (SNS) consisting of 40 Biology and 30 General Chemistry questions.
- Perceptual Ability Test (PAT) consisting of 90 questions.
- Reading Comprehension Test (RC) (English only) consisting of 50 questions.
- Manual Dexterity Test (CAR).

There are a total of 210 written questions on the English DAT, plus the Manual Dexterity Test. The French DAT has a total of 160 questions, plus the Manual Dexterity Test. The Reading Comprehension Test is not included in the French DAT test battery. Scores for the Canadian DAT are reported on a 1-30 scale in each of the following categories.

- Academic Average (AA) - average of Reading Comprehension, Biology and General Chemistry tests
- Science Total - average of Biology and General Chemistry tests
- Reading Comprehension
- Perceptual Ability Test
- Manual Dexterity Test

The US DAT differs slightly from the Canadian DAT. The Chalk Carving Test (or Manual Dexterity Test) was dropped in 1972 and replaced with the Perceptual Ability Test. The US DAT includes the following test components:

- Survey of Natural Sciences (Biology, General Chemistry and Organic Chemistry)
- Perceptual Ability Test
- Reading Comprehension
- Quantitative Reasoning

Scores for the US DAT are reported as:

- Total Science (average of biology, general chemistry and organic chemistry)

- Academic Average (average of quantitative reasoning, reading comprehension, biology, general chemistry, and organic chemistry)

Based on feedback from our Admissions Survey and a review of the Survey of Canadian Dental Schools 2011-2012 (Table 2), the reported DAT scores are used by individual schools in a variety of ways. Each school has a different admissions formula and each school uses different combinations of DAT components with a variety of weights. In addition, some schools set minimum cut scores for some test components in order for the applicant to be considered for admission. There is a wide variation in cut scores set by dental schools and the widest variation is in the Manual Dexterity Test (Table 2). The range is from 3/30 to 15/30. Some schools use both percentage weights and cut scores for some of the DAT components while some schools do not report how some of the tools are used.

6.2.1.1 Perceptual Ability Test

Eight of the ten dental schools include the Perceptual Ability Test (PAT) in their admissions formulae. This test was introduced and replaced the Chalk Carving Test in the US in 1972 (16). The Chalk Carving Test was reintroduced in the Canadian DAT in 1975 due concerns from Canadian dental about the validity of Perceptual Ability Test (17). Both the PAT and the Manual Dexterity Test (now using soap instead of chalk) are components of the Canadian DAT. Admissions officers include this paper-based PAT to assess special abilities.

6.2.1.2 Manual Dexterity Test

Seven of the ten dental schools currently utilize the Manual Dexterity Test in their admissions process. One admissions officer indicated that this test component will be dropped in the 2014-2015 admissions cycle. There are mixed opinions as to the value of this test. Some admissions officers feel that this is a very important test component while others do not. Although there is a desire by most admissions officers to include an assessment of psychomotor skills in the admissions process, the lack of a better test is one reason why this test continues to be used by some schools. Some admissions officers indicated that a test of psychomotor skills as an admissions test is not necessary as these skills can be learned during dental school. There was general agreement that there would be value in having a valid and reliable test that assessed psychomotor skills.

6.2.1.3 Survey of Natural Sciences

This Survey of Natural Sciences (SNS) test component includes questions in biology and general chemistry. Six of the 10 dental schools utilize this test component either separately as the Science Total score (biology and chemistry results only) or as the Academic Average (average of biology, chemistry and reading comprehension). This test component is not used by any of the three dental schools in Quebec. All of the Quebec admissions officers felt that the CEGEP applicants would be disadvantaged compared to university-based applicants. Admissions officers indicated support for this test component because of its ability to predict performance in the didactic component of the dental program.

6.2.1.4 Reading Comprehension

This test component is only offered in the English DAT and is utilized by 4 of the 10 dental schools. Two schools use the Reading Comprehension (RC) test results as a percentage in their admissions formulae and also set a minimum cut score. Two schools use the RC results only as a percentage weight in the admissions formulae. One admissions officer commented that they “may reject an applicant if the score was low”. One admissions officer indicated that this test component is an important indicator as to how well students do in the dental program.

6.2.1.5 Advantages and disadvantages of a DAT or DAT-like system

Most of the Canadian admissions officers agreed that there is value in having a battery of national, standardized admissions tests to choose from to assess cognitive ability, non-cognitive attributes and psychomotor skills. Used in conjunction with the GPA, a national standardized series of tests could address the concerns raised about GPA. These included:

- grade inflation and/or differences in difficulty obtaining good grades in some courses within an institution;
- grade variation by different instructors in the same course in a given institution;
- variation in GPAs across institutions; and
- grade variation across programs (e.g. Engineering versus a General Science program).

On the other hand, Canadian Dental School Admissions Officers reported that the current test components of the Canadian DAT have some problems that need to be addressed:

- The Survey of Natural Sciences does not appear to be at the appropriate level to assess the CEGEP students that apply to the three Quebec dental schools;
- The standardized test battery that provides the benefits stated above are offset if all ten dental schools cannot use them;
- The Reading Comprehension Test is only available in English. A national test battery must be available and accessible for students applying at all ten dental schools in both English and French;
- The validity and reliability of the Canadian DAT test components are not being evaluated at all by the current CDA Admissions Committee or any other group; and
- The only current statistical data available is from the ADA Department of Testing Services. Since the Canadian and US DAT test components are different, no analysis is being performed on the Manual Dexterity Test.

6.2.1.6 Possible Options/Solutions to address DAT limitations

In addition to highlighting advantages and disadvantages with the Canadian DAT, interviewees suggested some solutions. The current CDA Dental Aptitude Sub-Committee meets once a year for a one-day meeting. The Committee membership consists of Admissions officers or representatives from each dental faculty and CDA representatives. This committee structure does not allow for any statistical analysis to assess the validity and reliability of current admissions tools nor does it allow for assessment of new admissions tools, thus making it impossible to address the problems outlined above. A new Admissions Committee needs to be struck that has a broader mandate, is appropriately funded and has expertise to achieve the mandate.

Individual schools have indicated that they are attempting to evaluate new admissions tools on their own. This is inefficient and not very cost-effective. A national admissions committee could undertake this function and benefit all of Canadian dental schools.

Some admissions officers recommended that a new national admissions committee be a joint responsibility of ACFD and the CDA.

There was moderate interest in finding a new tool to assess psychomotor skills. Confidence is lacking, however, in the current Manual Dexterity Test. One criticism of this test is that is does not predict performance in dental school. While this may be true, the test was never intended to predict performance. This test was originally introduced as a part of the original ADA DAT to attempt to reduce the high attrition rates in US Faculties of Dentistry in the 1940's and it was effective in doing so. The Carving Dexterity Test was introduced as a screening tool to admit those

applicants that demonstrated some psychomotor skills in a Chalk Carving Test and screen out those applicants that demonstrated poor psychomotor skills. A national admissions committee should provide guidance to dental schools as to the value of each admissions tool and how best to use it.

A national admissions committee could also provide guidance to dental schools with respect to cut scores, especially for tests such as the Manual Dexterity Test. Currently, cut scores for the Manual Dexterity Test across Canadian dental schools range from as low as 3/30 to as high as 15/30. If Admissions officers have never been part of the grading of the Manual Dexterity Test, it may be appropriate to encourage each Admissions officer to attend a grading session. Alternatively, a visual representation of carvings at each mark in the grading system from 1 to 30, or a range of marks (e.g. 0-5, 6-10 etc.) could be provided. This might assist the Admissions officers in choosing an appropriate cut score for this test for those schools that value an assessment of psychomotor skills as a condition to admission..

The SNS component of the DAT must be re-evaluated to determine what needs to be altered for the test to be able to be fairly administered to all applicants to the 10 dental programs.

The lack of a Reading Comprehension Test in French is a real deficiency and currently precludes this test component as part of a national test battery. If the admissions officers agree that this is a valuable test component, reading comprehension, like all other test components must be available in both English and French.

There was universal agreement and strong support for the identification of appropriate tests to assess non-cognitive attributes. The DAT battery of tests does not address these important factors.

In summary, potential solutions highlighted were as follows:

- A new national admissions committee run by ACFD and CDA with a new mandate covering the following issues:
    - Development of guidelines concerning overall student selection and admissions processes (i.e. beyond oversight of the DAT);
    - Development of guidelines on the use of specific tools and processes to ensure they are used appropriately e.g. cut-off scores, use for screening, percentage weight, etc.;
    - Training on the use of admissions tools;
    - Development of elements of tests and processes (e.g. questions for structured interviews or scenarios for the MMI); and
    - Oversight of evaluating the validity of admissions tools and processes.
- Further evaluation of the need and utility of a test of manual dexterity and/or space perception
- Adaptation of tools and processes for French as well as English-speaking candidates
- Adaptation of tools and processes for all levels of applying candidates, including those without a university degree

6.2.2 Grade Point Average

Among all of the admissions tools used for selecting dental students in Canada, the Grade Point Average (GPA) is the only tool used by all programs. It is currently being used as a percentage in the admissions formula (45-100%) in all 10 dental schools as of 2012. One school sets a minimum GPA as a cut-off for the granting of an interview. Once applicants have achieved this minimum GPA and have been granted an interview, the GPA is no longer considered and acceptance is determined by other selection tools. The three Quebec schools admit students from CEGEP, which is a college system considered to be between secondary education and university. Students with 2 years of education in CEGEP are eligible to apply. GPAs are converted into Cote R (cote de rendement au collégial).

6.2.2.1 Advantages and Disadvantages of the GPA

The primary advantages given by most of the admissions officers were that the GPA was a good indicator of academic ability and that the GPA represented an indicator of whether the applicant could manage the rigours of the dental program. The pre-dental courses also provide a necessary prerequisite knowledge base for the dental program. It was felt that past academic success is a predictor of academic ability and future success in academic programs. Interviewees were aware of studies by the ADA showing that the GPA is a good predictor of performance in the first two years of the dental program.

Although most of the dental programs have some degree of latitude in assigning various weights to admissions tools, some programs indicated that they have limited ability to adjust weights in their admissions formula and one school indicated that the GPA percentage used in the admissions is dictated by their University. This school indicated that they are required to weight the GPA as a minimum of 50% in their admissions formula.

There are widespread concerns about mark inflation in some universities and in some programs, although there was no clear answer from interviewees as to how to adjust for this. Converting grades of courses with the same content from different universities, particularly when different grading scales may be used by the different universities, was an issue. There was also concern that applicants applying from more academically rigourous programs such as Engineering and Biophysics are at a distinct disadvantage compared to those students applying from other less rigourous programs. It was felt by some interviewees that good applicants were unfairly eliminated because of this discrepancy in the various programs. This was a real concern because it was felt by interviewees that those rigourous programs cited helped develop problem-solving skills in students that would be of value in candidates applying to dentistry.

6.2.2.2 Possible Options/Solutions to address GPA limitations

One suggestion to adjust for mark inflation and variability was to consider the rank of the student in the various programs to level the playing field to some extent. There was concern that the same courses at different universities may be graded differently, and even within the same university, different instructors teaching the same course may grade differently. Optional courses may be taken by students simply because they are known to be easy or have a probability of generating a strong grade.

GPA is clearly an important tool in the admissions process. However, GPA in isolation has limitations. Consideration should be given to:

- Ranking of students in a program to adjust for academically rigourous programs;
- Weighting the program or courses taken (i.e. consider a higher ranking for students in Biophysics programs versus a less rigourous program);
- Establishing a minimum GPA as a cut-off for further consideration in the admissions process instead of using GPA as a percentage in the admissions process;
- The GPAs of full students vs. part-time students;
- Whether students voluntarily withdraw or fail courses and subsequently retake the courses;
- The development of a truly national standardized series of tests to assess cognitive ability to offset and compare to the variability that is inherent in GPAs.

6.2.3 Interviews

It was noted by a US organisation interviewed that one of the three most important criteria for admission into US dental programs was a pre-admissions interview, the others being the science GPA and the overall GPA. All Canadian

dental programs recognized that an interview helps in assessing non-cognitive attributes of applicants. These attributes include professionalism, communication, conscientiousness, integrity, judgment and analysis, management of people, self-control, sensitivity to others, tact and diplomacy, ethical attitudes, organizational skills, community service, management of stress, empathy, and willingness for life-long learning.

Nine of the 10 Canadian dental programs use an interview of some sort as a selection tool. Three types of interview formats are used by Canadian dental programs when selecting applicants for admission: a structured interview; an unstructured interview; or a multiple mini interview (MMI).

6.2.3.1 Structured Interview

A structured interview consists of interview questions with a scoring rubric to evaluate applicants' responses. In 2000 the CDA provided interested Canadian dental schools with a structured interview (CDA structured interview) composed of questions related to seven competencies that allow the option of using either a situational format or a patterned behaviour description format. A situational interview question seeks a response related to a hypothetical situation, often job-related (18). A patterned behaviour description question relates to a candidate's past behaviour in a given situation, the rationale being that past behaviour should predict future actions (19). The CDA structured interview questions are based on the following seven competencies: communication, conscientiousness, integrity, judgment and analysis, self-control, sensitivity to others, and tact and diplomacy. Four dental programs use the CDA structured interview.

6.2.3.2 Unstructured Interview

An unstructured interview represents free-flowing exchange of information between the applicant and the interviewer(s). One dental program uses an unstructured interview, however this program intends to use an MMI in the upcoming year.

6.2.3.3 Multiple Mini Interview (MMI)

The multiple mini interview (MMI) is an interview format using a pre-determined number of stations – usually between seven and ten – where short structured scenarios are conducted, each station assessed by a different evaluator and sometimes more than one evaluator. In other words, an evaluator or evaluators assigned to a particular scenario will evaluate all candidates performing that scenario but will not see or evaluate any other of the 6-9 scenarios. Three dental programs use an MMI.

The one dental school that currently does not use any form of interview plans on introducing either a computer-based written interview or an MMI in the near future.

Weightings of the interviews in the selection processes by the Canadian dental programs vary from 15% to 33.3% of an overall score, or, in the case of two programs, either 50% or 100% for final selection once applicants have attained minimum scores in other criteria such as GPA and DAT.

6.2.3.4 Advantages and disadvantages of the various interview formats

According to the interviewees, the various interview format outlined above have several advantages and disadvantages, which are summarized below. Nevertheless, as an overall observation all schools and organisations recognised the importance of using means to identify non-cognitive skills and behaviours in dental school candidates and that interviews in some form are necessary to do that. However, the resources and infrastructure necessary to perform interviews of any sort is considerable. Furthermore, calibration of interviewers to ensure reliability of the

interview process was a concern expressed by most dental programs, regardless of the interview format. Advantages and disadvantages identified by interviewers, specific to each interview format, are listed below:

- Advantages of the CDA structured interview include
    - no-cost access by the dental programs to questions;
    - its ease of utilization;
    - transferability of scores across schools (i.e. a candidate could in theory perform the CDA structured interview once and have that score provided to all schools he/she applied to and which use that as part of their admissions process); and
    - the questions are directly related to non-cognitive attributes.

- Disadvantages of the CDA structured interview include
    - lack of security of questions (there was a strong perception among many dental school admissions personnel that candidates know of the questions and come already prepared with an answer);
    - no French version of the questions; and
    - currently no mechanism to develop and critique new questions.

- Advantages of an unstructured interview include:
    - ease of organisation

- Disadvantages of unstructured interviews include:
    - the difficulty in objectively comparing responses of interviewees across interview groups; and
    - It is recognised that this format has very little research to support its validity.

- Advantages of the MMI include:
    - An advantage to two of the three dental programs that use an MMI is their having access to expertise in developing this tool and the scenarios, mainly through other health care professional schools at their universities. As a result, new self-developed scenarios and questions can be formulated each year.
    - The other program primarily uses purchased questions/scenarios which are supplemented by self-developed ones.
    - Physical infrastructure in all three programs allows the use of the MMI format due to access to multiple interview rooms that are situated in close proximity to each other.
    - Two of the three programs using the MMI format are committed to research involvement related to the MMI.

- Disadvantages of the MMI include:
    - Although three dental programs use an MMI format, the inter-program use of the format is inconsistent. Differences in question types (dentistry-related versus medicine-related, self-developed versus purchased) and differences in the scoring and ranking of applicants exist.
    - lack of local expertise in the development of MMI questions/scenarios;
    - the high cost of purchasing already-developed MMI questions/scenarios;
    - the lack of physical infrastructure to support the format; and
    - a lack of strong research evidence indicating that an MMI format is superior to a traditional structured interview format.

6.2.3.5 Potential Options/Solutions to address Interview limitations

No matter the interview format, programs recognized the value of this tool in assessing the non-cognitive attributes of applicants. Potential best options/solutions related to the use of an interview as a selection tool include:

- Establish a national group to oversee the development and implementation of one or more valid interview processes;
- Identify mechanisms to ensure continuing development of high quality interview questions/scenarios;
- Ensure interview questions/scenarios are available in both English and French languages;
- Identify mechanisms to ensure high level of calibration of interviewers;
- Identify mechanisms to ensure security of interview questions/scenarios and scoring rubrics used;
- Identify mechanisms to allow confidence in transferring candidates' scores to other dental programs' selection processes;
- Seek support by participating dental programs to provide physical and human resources to allow application of the interview process at that institution; and
- Conduct research into the interview process(es) to enable evaluation of validity and reliability of the tools over time, and ultimately the identification of the best tools and processes.

6.2.4 Letters of Reference

At the time the initial questionnaire was sent out to the schools, three schools indicated that they used letters of reference in their respective admissions processes. By the time the Admissions officers were interviewed via teleconference, one of the three schools had dropped this tool. One school requests three letters of reference for each applicant. In addition, there is a standard questionnaire that includes a referees' ranking of the applicant from poor to outstanding in eleven non-cognitive attributes. These data used to be read and assessed for all applicants to the program but are now only assessed for those applicants who are granted interviews.

With respect to the advantages of reference letters, the Admissions officers indicated that very little discrimination results from this process but on rare occasions letters have been useful to screen out an applicant. An example was cited where one applicant with a GPA of 4.0 and who was currently in a PhD program was rejected because the supervisor advised the Admissions Committee that the applicant did not have very good interpersonal skills and was sometimes aggressive with his/her peers. The applicant was rejected on the basis of this reference letter. The same Admissions Officer indicated however, that many letters were so brief to be of little value.

With respect to the disadvantages for reference letters, the school that recently dropped them from their admissions process did so for the following reasons:

- The letters did not discriminate amongst the applicants because they all basically had the same content i.e. the referees indicated that they had known the applicant for a long time, that he/she was a great person and that they would make a great dentist;
- A lot of time was required to read the material with little or no value in return; and
- Because of the similarity in content of some of the letters, there was concern that the material was available on line.

Even the schools that continue to utilize letters of reference indicate they have some concerns. Very few poor letters of reference are received. None of the schools using letters of reference had the resources to follow up on the submissions to ensure statements made in the letters or in applicant CV's were genuine. In summary, letters of

reference have limited value in being able to discriminate among applicants and require a significant amount of time to evaluate the submissions.

6.2.5 Personal Statements/CVs

Three schools utilize personal statements in their admissions processes. They are used as screening tools and are used to assess non-cognitive attributes of the applicants. One of the schools has a timed (1 hour) on-line exercise that includes four questions. The questions were randomized and were drawn from a bank of questions so that applicants would not be able to prepare for the exercise in advance.

In terms of the advantages of personal statements and CV's, one school has used this admissions tool as a screening mechanism to eliminate applicants based on their responses. A scoring system has been developed and the intent is to use the scoring system for future admissions cycles.

With respect to the disadvantages, like the letters of reference, there was concern expressed regarding the time required and the difficulty in assessing the personal statements. To address this, interviewees suggested that personal statements could be made through a series of standardized questions and a scoring template currently in development by one of the schools might be of value to other schools if this admissions tool could be shared nationally.

6.2.6 NEO-PI-R Personality Inventory Test

The NEO-PI-R Personality Inventory Test is currently being used in one dental school to measure non-cognitive attributes. This tool had been used as an admissions tool in the near past by one other dental school, but it was dropped after a few years. The school currently using this tool does not have data indicating whether or not this is effective either as an admissions tool or as an indicator of how the person performs after graduating.

One other admissions officer indicated that they are interested in considering the NEO-PI-R at some point in the future. They have gone through significant changes to their admissions process recently and do not wish to make any substantive changes at this time.

The rationale for inclusion of this test is that there are numerous data to support its reliability and validity and that it may be a better tool than other means to evaluate personality traits and characteristics of candidates. The disadvantage however, is that the value of the test in the context of admissions is not known. Tests such as this need a thorough evaluation by a national admissions committee. The advantages, limitations and how the test should be interpreted and used need to be explained to Admissions officers so they can make informed choices and use the test appropriately.

6.3 Literature review results

Some authors have been reluctant to embrace a cognitive and non-cognitive selection tool divide, notably because of the moderate to weak correlation between the two sets of measurements (20). Yet, since we believe what differentiates the selection tools are their purposes, we decided to keep this typology since it facilitates analysis. Also, predictive validity of cognitive and non-cognitive selection tools has been shown to vary by year in dental school, so the results will take the measurements temporality into account. The following section will describe the results of our literature review; first for cognitive and academic performance assessment tools, and second for non-cognitive selection tools.

6.3.1 Academic and cognitive assessment tools

6.3.1.1 Grade Point Average (GPA)

Grade Point Average (GPA[1]) is perceived as a long-term indicator of prior academic performance. The general purpose of GPA scoring is to give insights into a candidate's prior academic performance, either overall or in a specific field, and to help identify which candidates should be high performers. The rationale behind the use of GPA as a dental school performance predictor is that prior performance should be an indicator of future academic performance. Therefore, GPA should be predictive of pre-clinical dental school (academic) performance. Yet, its ability to discriminate between extremely competitive applicants, whose GPA variations are minimal, is dubious. Because of this fact, some dental schools prefer to use GPA as a threshold in order to separate weak from strong academic performers.

Eight out of the thirty-six studies pertain to the criterion validity or potential bias on ethnic/racial or gender diversity of using grade point average (GPA) as part of dental school admission processes. None assessed nor reported on the construct or content validity of the selection tool, nor its reliability or scalability (see Table 3 and Appendix D Table D1). As there are many ways to calculate GPA, its exact definition varies widely (21). According to our review, the two main methods for calculating GPA used in the dental school admission's process consist of overall GPA and science-specific GPA. Of the thirty-six studies reviewed, eight assessed the overall Pre-dental GPA's validity, and five assessed the Pre-dental Science GPA's validity.

Overall Pre-Dental Grade Point Average

The American Dental Association (ADA) defines Overall Pre-dental GPA as the "average calculated for all courses taken by the student during his/her undergraduate years" (22). As our results indicate, Overall Pre-dental GPA seems to have moderate to weak predictive validity for all four years of dental school when taken separately, although the results are equivocal for overall dental school GPA (see Table 3).

First-year performance: Overall Pre-dental GPA has a moderate positive correlation with first-year Biomedical grades (22), and with Natural Science Examination (23). Overall GPA is also weakly positively correlated with first-year Pre-clinical dental techniques grades (22), first dental examination (23) and first semester performance (24). Results concerning Overall Pre-dental GPA's predictive validity on overall first-year performance are less clear. On one hand, the ADA found a moderate positive correlation between the two variables (22); on the other, Curtis, Lind, Plesh and Finzen (25) found a weak positive correlation between Overall Pre-dental GPA and first-year dental school GPA, but the relationship was significant only for underachieving students.

Table 3: Summary of the results on the predictive validity of overall pre-dental GPA

Authors (year)	Study participants	Predictive validity – Strength of association
Alzahrani, M. J., E. M. Thomson, et al. (2007) (21)	N=146 graduation; N=130 NBDHE	Graduation within two years of admission – r= 0.4957, p=0.6625 NBDHE scores – r= -0.01884, p=0.9901
American Dental Association (2012) (22)	2009, n=49; 2010, n=47 dental schools	First-Year Biomedical- median r= 0.32, p<0.05 ***, R^2 = 0.10 First-Year GPA – median r= 0.33, p<0.05 ***, R^2 = 0.05 First-Year Pre-clinical Dental Techniques grades – median r= 0.23,

[1] In the articles reviewed, GPA was also referred to as incoming college grade point average, grade point average, pre-dental school grade point average and undergraduate grade point average.

		p<0.05 ***, R^2 = 0.11 Second-year Biomedical - median *r*= 0.35, p<0.05 ***, R^2 = 0.12 Second-year GPA – median *r*= 0.37, p<0.05 ***, R^2 = 0.08 Second-year Pre-clinical dental Techniques grades – median *r*= 0.29, p<0.05 ***, R^2 = 0.12
Arnold, W. H., P. Gonzalez, et al. (2011) (23)	n=194 for first dental exam, n=193 for national science exam, n=163 for state board exam	Natural science examination – *r*= 0.343, p<0.001* First dental examination – *r*= 0.268, p<0.001* State board examination scores – *r*= 0.269, p<0.001*
Curtis, D. A., S. L. Lind, et al. (2007) (25)	2001-2005 graduating classes' normally tracking students (n=49) and underachieving students (n=45)	Correlation: Normally tracking students: First-year GPA – *r*= 0.21, p>0.05 Fourth-year GPA – *r*= 0.33, p<0.05*** Underachieving students: First-year GPA – *r*= 0.26, p<0.05*** Fourth-year GPA – *r*= 0.23 p>0.05 Multivariate regression: Normally tracking students: First-year GPA – *β*= -0.25, p=0.56 Fourth-year GPA – *β*= 0.36, p=0.37 Underachieving students: First-year GPA – *β*= 0.37, p=0.24 Fourth-year GPA – *β*= 0.36, p=0.19
Holmes, D. C., J. V. Doering, et al. (2008) (26)	2000-2007 graduate students (n= 574)	Overall Dental School GPA – *r*= 0.529, p<0.05*** NBDE Part I – *r*= 0.497, p<0.05*** NBDE Part II – *r*= 0.433 p<0.05*** Final Clinical grade – *r*= 0.276, p<0.05***
Kim, M. and J. I. Lee (2007) (24)	2005 admission cycle matriculated first semester student (n=90)	First semester GPA – *β*= 0.242, p<0.01**
Kingsley, K., J. Sewell, et al. (2007) (12)	2002-2004 admission cycle's matriculated students (n=275)	NBDE- *r*= 0.286, p>0.05 Overall Dental school GPA - *r*= 0.224, p>0.05
		***** = p<0.05; ** = p<0.01; * = p<0.001**

Second-year performance: Overall Pre-dental GPA also seems moderately correlated with second-year Biomedical grades (22) and second-year GPA (22), and weakly correlated with second-year pre-clinical dental techniques grades (22).

Third and fourth-year performance: Overall Pre-dental GPA was found weakly correlated with third year final clinical grades (26), while Curtis et al. (25) found that Overall Pre-dental GPA was moderately correlated with fourth-year GPA, but only for normally tracking students, as the correlation was found not to be significant for underachieving students.

NBDE Board examination performance: The results concerning the validity of Overall Pre-dental GPA to predict state board examination scores also differ. Holmes et al. (26) found a moderate positive correlation between Overall Pre-dental GPA and NBDE Part I and Part II, while Arnold, et al. (23) reported only a weak positive correlation between state board examination and Overall Pre-dental GPA. As for Alzahrani et al. (21) and Kingsley et al. (12), both studies found Overall Pre-dental GPA to be not significantly correlated with national board examination scores. Furthermore, Holmes et al. (26) found Overall Pre-dental GPA only weakly able to distinguish between those who successfully passed the Central Regional Dental Testing Service (CRDTS) exam[2] (27) and those who failed, thus having weak concurrent validity.

Convergent/Divergent Validity: As for convergent validity of Overall Pre-dental GPA with other selection tools, our findings suggest a strong to moderate correlation with other cognitive tools, and a weak to non-significant correlation with non-cognitive tools. Holmes et al. (26) reported a strong positive correlation with Pre-dental Science, and moderate positive correlations in parts of the DAT (DAT-Academic Average, DAT-Perceptual Ability Test, and DAT-Survey of the Natural Science[3] scores). As for non-cognitive assessment tools, Arnold et al. (23) found a weak positive correlation between Overall Pre-dental GPA and an unstructured interview, while Kim and Lee (24) found no significant relationship between the latter, oral exam and interview scores, which could corroborate that they do in fact assess different constructs.

Pre-dental Science GPA

The ADA defines Pre-dental Science GPA as the score "calculated for all science courses taken by the student during his/her undergraduate years" (22). As these science courses are often prerequisites for dental school coursework, the rationale in using Pre-dental Science GPA rather than Overall GPA is that student performance in science courses should be better predictors of academic performance in dental school than, for example, courses in literature and foreign languages. Yet, as for overall Pre-dental GPA, moderate to weak positive correlations were found between Pre-dental Science GPA and most dental school academic indicators, but showed contradictory results for dental school GPA and board examination scores (see Table 4 and Appendix D Table D1).

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[2] The Central Regional Dental Testing Service (CRDTS) regroups seventeen US State Boards of Dentistry that decided to join forces to "develop and administer fair, valid and reliable examinations of competency to practice dentistry and dental hygiene". Success in passing the CRDTS exam is prerequisite in most member state board licensing processes. The examination consists of five parts. The first part consists of Part I and II of the National Board Examination. Part II of the CRDTS exam consists of a 3 hours endodontic evaluation (100 points) performed on a manikin. Part III consists of a four hour fixed prosthodontics examination (100 points) performed on a manikin. Part IV consists in a periodontal examination (100 points) and part V is a restorative examination, both performed on a patient. For more information on the content of the different sections, see http://www.crdts.org/Default.aspx?PageID=47

[3] Holmes et al. 26. Holmes DC, Doering JV, Spector M. Associations among predental credentials and measures of dental school achievement. Journal of Dental Education 2008;72(2):142-152.'s calculation refers to Survey of the Natural Sciences as Total Science, whose score is a combination of Biology, General Chemistry, and Organic Chemistry.

First-year performance: In the first year of dental school, Pre-dental Science GPA was found to have a moderate positive correlation with Biomedical grades (22), first year GPA (22), while being weakly correlated with the first Pre-clinical Dental Techniques grades (22). A weak positive correlation was also found with first-year GPA, but only for normally tracking students (25). Pre-dental Science GPA was also found to be strongly and positively correlated with one of the two classes in pre-clinical portion of Harvard's dental school, although this correlation only reached the p=0.10 level (28).

Table 4: Summary of the results on the predictive validity of Pre-dental Science GPA

Authors (year)	Study participants	Predictive validity – Strength of association
Alzahrani, M. J., E. M. Thomson, et al. (2007) (21)	n=146 graduation; n=130 NBDHE	Graduation within two years of admission – *r*= -0.6177, p=0.6784 NBDHE scores – *r*= 1.3257, p=0.5016
American Dental Association (2012) (22)	2009, n=49; 2010,n=47 dental schools	First-Year Biomedical-median *r*= 0.33, p<0.05***, R^2 = 0.11 First-Year GPA – median *r*= 0.35, p<0.05***, R^2 = 0.06 First-Year Pre-clinical Dental Techniques grades – median *r*= 0.24, p<0.05***, R^2 = 0.12 Second-year Biomedical – median *r*= 0.32, p<0.05***, R^2 = 0.09 Second-year GPA –median *r*= 0.37, p<0.05***, R^2 = 0.08 Second-year Pre-clinical dental Techniques grades – median *r*= 0.28, p<0.05***, R^2 = 0.13
Arnold, W. H., P. Gonzalez, et al. (2011) (23)	n=194 for first dental exam, n=193 for national science exam, n=163 for state board exam	Natural science examination: Biology scores– *r*= 0.276, p=0.008**, R^2 = 0.07 Chemistry – *r*= 0.623, p=0.023***, R^2 = 0.38 Physics score – *r*= 0.362, p=0.27, R^2 = 0.12
Curtis, D. A., S. L. Lind, et al. (2007) (25)	Normally tracking students (n=49) and underachieving students (n=45)	Correlation: Normally tracking students: First-year GPA – *r*= 0.27, p<0.05*** Fourth-year GPA – *r*= 0.32, p<0.05*** Underachieving students: First-year GPA – *r*= 0.21, p>0.05 Fourth-year GPA – *r*= 0.15, p>0.05 Multivariate regression: Normally tracking students: First-year GPA – *β*= 0.41, p=0.24 Fourth-year GPA – *β*= -0.02, p=0.94 Underachieving students: First-year GPA – *β*= -0.19, p=0.50 Fourth-year GPA – *β*= -0.19, p=0.44
Holmes, D. C., J. V. Doering, et al. (2008) (26)	n= 574	Overall Dental School GPA – *r*= 0.537, p<0.05*** NBDE Part I – *r*= 0.527, p<0.05*** NBDE Part II– *r*= 0.460, p<0.05***

		Final Clinical grade – *r*= 0.277, p<0.05***
Kingsley, K., J. Sewell, et al. (2007) (12)	n=275	Linear regression: NBDE Part I – β= 2.938, p=0.229
Park, S. E., J. D. Da Silva, et al. (2010) (28)	n=159	TXAD with Honours – OR=3.9, p=0.10
Alzahrani, M. J., E. M. Thomson, et al. (2007) (21)	n=146 graduation; n=130 NBDHE	**GPA-Pathology:** Graduation – β= 1.0967, p=0.0008** NBDHE scores – β= 2.9809, p≤0.0001* **GPA-Microbiology:** Graduation – β= -0.5773, p=0.2958 NBDHE scores – β= 0.25762, p=0.7420 **GPA- Chemistry I:** Graduation – β= -0.4975, p=0.4296 NBDHE scores – β=-0.4996, p=0.5307 **GPA- Oral Anatomy:** Graduation – β= 0.7684, p=0.1196 NBDHE scores – β= 3.3119, p≤0.0001* **GPA- Anatomy:** Graduation – β= -0.3987, p=0.5332 NBDHE scores – β= -0.66257, p=0.1260

Second-year performance: As for second-year performance, Pre-dental Science GPA is moderately correlated with second-year Biomedical grades (22), second-year GPA (22), and weakly correlated with Pre-clinical Dental techniques grades (22).

Third and fourth-year performance: Pre-dental Science GPA scores show a weak positive correlation with the Final Clinical Grade (26), and with fourth-year GPA for normally tracking students (25), but was not found significantly correlated with fourth-year GPA for underachieving students (25).

Overall Dental School GPA and graduation: While Holmes et al. (26) found Pre-dental Science GPA to be moderately correlated to Dental School GPA, at the opposite no significant relationship between the two variables were observed by Kingsley et al. (12). Overall Dental School GPA was also found not to be correlated with graduation on time at a significant level (21).

NBDE Board Examination performance: Similar contradictory results were also observed when it came to predicting licensing examinations scores. While Holmes et al. (26) found Pre-dental Science GPA to be moderately correlated to the US NBDE Part I and II, Alzahrani et al. (21) and Kingsley et al. (12) found that the two variables were not significantly correlated. As for Overall Pre-dental GPA, Pre-dental Science GPA score was unable to distinguish between those who passed CRDTS exam and those who failed (26).

In an effort to determine the courses with the highest predictive value on dental hygiene student's subsequent performance, Alzahrani et al. (21) investigated each of the Pre-dental Science GPA subjects scores (Pathology, Microbiology, Chemistry, Oral Anatomy and Anatomy GPA). The authors found that only Oral Anatomy GPA and

Pathology GPA were significantly related to NBDHE, while only Pathology had a significant relationship with graduation on time. All other sub-scores didn't reach significant value ($p>0.05$).

Convergent/Divergent Validity: As for convergent/divergent validity, Pre-dental Science GPA was found to be strongly correlated with Overall Pre-dental GPA, and moderately correlated with DAT-Academic Average, DAT-Perceptual Ability, and DAT-Total Science scores (26).

As our results exhibit, Pre-dental Science GPA shows similar trends in predictive validity as Overall Pre-dental GPA. This is possibly explained by the high correlation between the two variables. Both Overall Pre-dental GPA and Pre-dental Science GPA show weak to moderate correlation to dental students' performance, although this relationship is stronger for the first and the second year of dental school, and tends to get weaker for the third and fourth years. Results are also ambiguous as for Overall Pre-dental GPA and Pre-dental Science GPA's ability to predict performance at the National Board examinations, as studies have reported contradictory results (either moderate or non-significant correlations). GPA is also moderately correlated to sub-scores of another central cognitive tool used in the dental school admission process: the Dental Admission Test.

6.3.1.2 Dental Admission Test (DAT)

In 1945, US dental schools were confronted with three major concerns. First, they were faced with high attrition rates, sometimes reaching 20-25% over the four years of dental school. Second, grade inflation made it difficult to compare academic records of different high schools and colleges. And third, there were concerns over comparing recent and older academic records (due to the influx of World War II Veterans as applicants). These concerns highlighted the need for a national standardized test to compare dental school applicants in an equitable manner, and led to the creation of the Dental Admission Test (DAT) program. The purpose of the initial DAT was to assess basic abilities in "mathematics, verbal reasoning, reading comprehension in the sciences, and academic achievement in the natural sciences and manual dexterity through object visualization and a chalk carving test (22). The content of the US DAT has remained relatively static since 1945, with some minor changes in 1972 (addition of the Organic Chemistry subtest, and replacement of the Chalk Carving Test by the Perceptual Ability Test[4]), and elimination of the Verbal Reasoning Test in 1981 because of its cost and lack of predictive validity. The standard score scale was also changed in 1988 from 1-9 to a 1-30 log ability scale defined by the Rasch Model, which increased its reliability. No other major changes have occurred since.

Differences between the Canadian and American versions of the DAT: The American Dental Association Test (ADA-DAT) contains four different sections, each evaluating different subject matter. The first, the Survey of Natural Sciences, is a 100 multiple-choice items test, where 40 items relate to biology, 30 to general chemistry, and 30 to organic chemistry. The second section, the DAT-Quantitative Reasoning Test, contains 40 mathematics problems, 10 of which are applied problems. The third section, DAT-Reading Comprehension, contains three 1,500 word passages followed by 16-17 questions assessing comprehension. Finally, the fourth section, the DAT-Perceptual Ability Test, contains 90 two-dimensional or three-dimensional problems. Even if the CDA-DAT were modeled on the ADA-DAT, some minor differences exist between the two tests. The CDA-DAT includes a manual dexterity test (soap carving test), but not the Organic Chemistry and Quantitative Reasoning Tests (both present in the ADA-DAT version).

[4] For more details on the DAT Dexterity Test, see "Manual test" in the non-cognitive section of this report.

Differences between the French Canadian DAT and the English Canadian DAT: Differences are also observed between the French and the English versions of the Canadian DAT. Adopted for use in 1967, the French Canadian DAT (F-CDA-DAT) includes three evaluations (Perceptual Ability, Survey of Natural Sciences, and Manual Dexterity), while the English (E-CDA-DAT) version includes four (the first three plus Reading Comprehension).

Over the years, the DAT was found to be a reliable and valid instrument in predicting dental school performance and in reducing attrition (29). Our results show similar findings. Nine out of the thirty-six studies pertain to the criterion validity or potential bias on ethnic/racial or gender diversity of the DAT as part of the dental admission process (7 for ADA-DAT, 1 for CDA-DAT, 1 for Dental Education Eligibility Exam (DEET)[5]). As for GPA scores, none of the studies reviewed assessed nor reported on the reliability, scalability, construct or content validity of the DAT (see Appendix A Table A2). Each of the different subsets of the DAT will be explored in the next section.

DAT-Survey of Natural Science (DAT-SNS)

The ADA defines the DAT Survey of Natural Science[6], also known as Total Science (DAT-SNS), as the "average of the standard scores on the Biology, General Chemistry, and Organic Chemistry tests" (22). Three of the thirty-six studies assessed DAT-AA's validity, all three using the ADA-DAT version. Four other studies assessed each subsection's predictive validity, all using the American version of the DAT (see Table 5 and Appendix D Table D2).

Table 5: Summary of the results on the predictive validity of DAT-Survey of Natural Science and its subtests

Authors (year)	Study participants	Predictive validity – Strength of association
Allareddy, V., T. H. Howell, et al. (2012) (30)	N=66	Obtaining Honours in first comprehensive evaluation – OR 0.78, p=0.61 Obtaining Honours in second comprehensive evaluation – OR 14.17, p=0.01** Obtaining Honours in third comprehensive evaluation – OR 1.44 p=0.50
American Dental Association (2012) (22)	2009, n=49; 2010, n=47 dental schools	First-Year Biomedical-median *r*= 0.28, p<0.05*** First-Year GPA – median *r*= 0.26, p<0.05*** First-Year Pre-clinical Dental Techniques grades – median *r*= 0.16, p<0.05*** Second-year Biomedical – median *r*= 0.20, p<0.05*** Second-year GPA –median *r*= 0.21, p<0.05*** Second-year Pre-clinical dental Techniques grades – median *r*= 0.15, p<0.05***
Holmes, D. C., J. V. Doering, et al. (2008) (26)	N= 574	Overall Dental School GPA – *r*= 0.449, p<0.05*** NBDE Part I – *r*= 0.582, p<0.05*** NBDE Part II– *r*= 0.469, p<0.05***

[5] The Dental Education Eligibility Test (DEET) is the Korean equivalent of the DAT. Before 2005, admission to dental school in Korea was based only on the Scholastic Aptitude Test (SAT) and academic performance. Faced with the "lack of awareness of social diversity and limited creativity in biomedical research in dentistry" 24. Kim M, Lee JI. Variables predicting students' first semester achievement in a graduate-entry dental school in Korea. Journal of Dental Education 2007;71(4):550-556, 24. ibid., some universities drastically altered their program's structure (to graduate-entry programs) and admission procedure. The DEET was developed in this context, and includes similar subtests as the DAT: Reading Comprehension, Reasoning Part I (Biology) and II (Chemistry and Physics), and Perceptual Ability. For more information, see Kim and Lee 24. ibid..

[6] As for the CDA-DAT-NS, it would be calculated as the average of the standard scores of Biology and General Chemistry, as the CDA-DAT does not include the Organic Chemistry subtest.

		Final Clinical grade – *r*= 0.152, p<0.05***
1- Subsection: Biology		
American Dental Association (2012) (22)	2009, n=49; 2010, n=47 dental schools	First-Year Biomedical-median *r*= 0.19, p<0.05*** First-Year GPA – median *r*= 0.19, p<0.05*** First-Year Pre-clinical Dental Techniques grades – median *r*= 0.10, p<0.05*** Second-year Biomedical – median *r*= 0.14, p<0.05*** Second-year GPA –median *r*= 0.13, p<0.05*** Second-year Pre-clinical dental Techniques grades – median *r*= 0.11, p<0.05***
Behar-Horenstein, L. S., C. W. Garvan, et al. (2011) (31)	N=209	Correlation: NBDE Part I – *r*= 0.44, p<0.0001* NBDE Part II – *r*= 0.27, p<0.0001* Multivariate regression: NBDE Part I – β undisclosed, p=0.0182** NBDE Part II – β undisclosed, p=0.0092**
Kim, M. and J. I. Lee (2007) (24)	N=90	First-semester GPA – β 0.317, p<0.05***
Kingsley, K., J. Sewell, et al. (2007) (12)	N=275	Correlation: NBDE – *r*= 0.304, p<0.05*** Overall Dental school GPA – *r*= 0.148, p>0.05 *** Regression: NBDE-I – β = 0.585, p=0.001**
2- Subsection: General Chemistry		
American Dental Association (2012) (22)	2009, n=49; 2010, n=47 dental schools	First-Year Biomedical-median *r*= 0.12, p<0.05*** First-Year GPA – median *r*= 0.15, p<0.05*** First-Year Pre-clinical Dental Techniques grades – median *r*= 0.10, p<0.05*** Second-year Biomedical – median *r*= 0.16, p<0.05*** Second-year GPA –median *r*= 0.18, p<0.05*** Second-year Pre-clinical dental Techniques grades – median *r*= 0.09, p<0.05***
Behar-Horenstein, L. S., C. W. Garvan, et al. (2011) (31)	N=209	NBDE Part I – *r*= 0.26, p=0.00025** NBDE Part II – *r*= 0.08, p=0.2459
3- Subsection Organic Chemistry		
American Dental Association (2012) (22)	2009, n=49; 2010, n=47 dental schools	First-Year Biomedical-median *r*= 0.23, p<0.05*** First-Year GPA – median *r*= 0.23, p<0.05*** First-Year Pre-clinical Dental Techniques grades – median *r*= 0.09, p<0.05*** Second-year Biomedical – median *r*= 0.21, p<0.05*** Second-year GPA –median *r*= 0.24, p<0.05*** Second-year Pre-clinical dental Techniques grades – median *r*= 0.14, p<0.05***

Behar-Horenstein, L. S., C. W. Garvan, et al. (2011) (31)	N=209	NBDE Part I – *r*= 0.29, p<0.0001*** NBDE Part II – *r*= 0.09, p=0.2092**
Kim, M. and J. I. Lee (2007) (24)	N=90	First-semester GPA – β 0.229, p<0.05***
Kingsley, K., J. Sewell, et al. (2007) (12)	N=275	Correlation: NBDE- *r*= 0.152, p>0.05*** Overall Dental school GPA – *r*= 0.132, p>0.05*** Regression: NBDE-I – β 0.069, p=0.600

The DAT-SNS seems to have moderate to weak predictive validity for most academic performance outcomes (22, 26), and moderate predictive validity for board examinations scores with the US NBDE Part I and II (26). Also, the DAT-SNS showed weak concurrent validity, as it was unable to distinguish between those who passed CRDTS exam and those who failed (26). As for convergent/divergent validity, Holmes et al. (26) observed a strong positive correlation with DAT Academic Average and moderate positive correlation with DAT Perceptual Ability (DAT-PAT), but that was not significantly correlated with GPA scores.

Similar results were found with individual subsections of the DAT-SNS. The ADA (22) found DAT-Biology to have a weak positive correlation with first and second-year Biomedical grades, first and second-year GPA, and first and second-year Pre-clinical techniques grades. Kim and Lee (24) also found DAT-Biology to have a positive relationship with performance in the first semester of dental school. As for national board examination performance, DAT-Biology was found to have a positive relationship with NBDE Part I (12, 31) and Part II (31).

DAT-Quantitative Reasoning (DAT-QR)

DAT-Quantitative Reasoning (DAT-QR) is one of the sections of ADA-DAT, which assesses problem-solving skills through mathematical skills. Four of the thirty-six studies assessed DAT-PAT's validity, all using the ADA-DAT version (see Table 6 and Appendix A Table A2). Results show that DAT-QR has weak to moderate predictive validity on student performance during the first and second year of dental school, although the strength of this association decreases slightly in the second year of dental school (22) and was found not significant for global dental school GPA (12). Also, Allareddy, Howell & Karimbux (30) found DAT-QR to be non-significantly correlated with obtaining Honours mention in first and third comprehensive examination, but significantly correlated with obtaining Honours mention in the second year examination. As for licensing exams, DAT-QR was found to be non-significantly correlated with the US NBDE Part I (12, 31) and Part II (31).

Table 6: Summary of the results on the predictive validity of DAT-Quantitative Reasoning

Authors (year)	Study participants	Predictive validity – Strength of association
Allareddy, V., T. H. Howell, et al. (2012) (30)	n=66	Obtaining Honours in first comprehensive evaluation – OR 0.99, p=0.95 Obtaining Honours in second comprehensive evaluation – OR 2.48, p=0.03*** Obtaining Honours in third comprehensive evaluation – OR 0.89, p=0.70
American Dental Association (2012) (22)	2009, n=49; 2010, n=47 dental schools	First-Year Biomedical - median *r*= 0.36, p<0.05*** First-Year GPA - median *r*= 0.34, p<0.05*** First-Year Pre-clinical Dental Techniques grades – median *r*= 0.20, p<0.05***

		Second-year Biomedical - median *r*= 0.27, p<0.05*** Second-year GPA - median *r*= 0.29, p<0.05*** Second-year Pre-clinical dental Techniques grades – median *r*= 0.16, p<0.05***
Behar-Horenstein, L. S., C. W. Garvan, et al. (2011) (31)	n= 209	NBDE Part I - *r*= 0.32, p<0.0001* NBDE Part II - *r*= 0.22, p=0.0015**

DAT-Reading Comprehension (DAT-RC)

DAT-Reading Comprehension (DAT-RC) is one of the sections that is present in both the ADA-DAT and the English version of the CDA-DAT, but not in its French version. Seven of the thirty-six studies reviewed pertained to the validity and reliability of the DAT-RC (4- US, 1-Canada, 1 – UK, 1- Belgium, see Table 7 and Appendix A Table A2). The results show weak to moderate predictive validity for the DAT-RC, and the strength of this relationship decreases with years in dental school (see Table 7). Weak positive correlations were observed between DAT-RC and first and second-year Biomedical grades (22), first and second-year GPA (22), and first and second-year Pre-clinical Dental Techniques grades (22). Poole et al. (19) observed a moderate positive correlation between DAT-RC and first-year GPA, but found this relationship to be non-significant in years 2 – 4 for DAT-RC and academic and clinical GPA. Buyse and Lievens (32) found similar results, observing no significant relationship between DAT-RC and first-year GPA, second-year GPA, third-year GPA, fourth-year GPA and fifth-year GPA.

The correlation between DAT-RC and Overall Dental School GPA also failed to reach significant levels in the two studies that assessed the relationship (12, 32). Foley and Hijazi (33) found similar results when assessing the correlation between DAT-RC and CAS scores. Allareddy et al. (30) found the DAT-RC to be positively correlated with the probability of obtaining an Honours mention in third-year examinations at Harvard's School of Dental Medicine, but that this relationship didn't reach significant levels for the odds of obtaining an Honours mention in first and second-year examinations (p> 0.05).

Table 7: Summary of the results on the predictive validity of DAT-Reading Comprehension

Authors (year)	Study participants	Predictive validity – Strength of association
Allareddy, V., T. H. Howell, et al. (2012) (30)	N=66	Obtaining Honours in first comprehensive evaluation - OR 1.00, p=0.99 Obtaining Honours in second comprehensive evaluation - OR 1.36, p=0.35 Obtaining Honours in third comprehensive evaluation - OR 1.81, p=0.01**
American Dental Association (2012) (22)	2009, n=49; 2010, n=47 dental schools	First-Year Biomedical - median *r*= 0.18, p<0.05*** First-Year GPA - median *r*= 0.22, p<0.05*** First-Year Pre-clinical Dental Techniques grades - median *r*= 0.27, p<0.05*** Second-year Biomedical - median *r*= 0.12, p<0.05*** Second-year GPA - median *r*= 0.22, p<0.05*** Second-year Pre-clinical Dental Techniques grades - median *r*= 0.27, p<0.05***
Behar-Horenstein, L. S., C. W. Garvan, et al. (2011) (31)	N= 209	Correlation: NBDE Part I – *r*= 0.27, p<0.0001* NBDE Part II- *r*= 0.31, p<0.0001* Multivariate regression

		NBDE Part I - not included in the model NBDE Part II - p=0.0023 (range undisclosed)**
Buyse, T. and F. Lievens (2011) (32)	Y1 n=781, Y2 n=489, y3 n=343, Y4 n=274	First-year GPA - *r*= 0.18, p>0.05 Second-year GPA - *r*= 0.11, p>0.05 Third-year GPA - *r*= 0.10, p>0.05 Fourth-year GPA - *r*= 0.04, p>0.05 Fifth-year GPA - *r*= 0.20, p>0.05 Overall Dental School GPA - *r*= 0.14, p>0.05
Foley, J. I. and K. Hijazi (2013) (33)	N=75	CAS scores - *r*= 0.27, p=0.304
Kingsley, K., J. Sewell, et al. (2007) (12)	N=275	Correlation: NBDE - *r*= 0.318, p<0.05*** Overall Dental school GPA - *r*= 0.322, p<0.05*** Regression: NBDE-I - β 0.310, p=0.041***
Poole, A., V. M. Catano, et al. (2007) (19)	Y1 n=373, Y2 n=237, Y3 n=176, and Y4 n=161	First-year GPA - *r*= 0.25, p<0.05*** Second-year Clinical GPA - *r*= 0.02, p>0.05 Second-year Academic GPA - *r*= 0.13, p>0.05 Third-year Clinical GPA - *r*= 0.13, p>0.05 Third-year Academic GPA - *r*= 0.04, p>0.05 Fourth-year Clinical GPA - *r*= 0.11, p>0.05 Fourth-year academic GPA - *r*= 0.11, p>0.05

As for Board Examination performance, contradictory results were found. In one case, Kingsley et al. (12) found a positive relationship between DAT-RC and NBDE Part I, while in another, Behar-Horenstein et al. (31) found no significant relationship between the two variable (p>0.05), but observed a moderate positive correlation between DAT-RC and NBDE Part II.

DAT-Perceptual Ability Test (DAT-PAT)

DAT-Perceptual Ability Test (DAT-PAT) is one of the sections of the DAT, which aims to assess the perceptual ability of a candidate in angle discrimination, form development, cubes, orthographic projections and apertures (34). As stated by the ADA (29), "those factors [...] constitute the major attributes of one's ability to perceive small differences [and therefore] are valuable in selecting applicants who need fine manual dexterity". Twelve of the thirty-six studies assessed DAT-PAT's validity (nine using the ADA-DAT version, one the CDA version). The results show weak to moderate predictive validity for the DAT-PAT, although strength of the correlation seems to decrease with the years (see Table 8 and Appendix A Table A2).

First-year performance: DAT-PAT scores were found weakly correlated to first-year GPA. DAT-PAT was also weakly correlated to first-year individual courses grades, such as first-year biomedical grades (22), first-year Pre-clinical GPA (22), and first-year laboratory and study skills grades (35).

Second-year performance: DAT-PAT were found to be weakly correlated with second-year pre-clinical GPA (19, 22), but not significantly correlated with second-year academic GPA (19). The ADA (22) found a weak positive correlation between DAT-PAT and second-year Biomedical and GPA. Victoroff and Boyatzis (36) even found DAT-PAT to be negatively correlated with Preclinical GPA.

Table 8: Summary of the results on the predictive validity of DAT-Perceptual Ability Test		
Authors (year)	**Study participants**	**Predictive validity – Strength of association**
Allareddy, V., T. H. Howell, et al. (2012) (30)	n=66	Obtaining Honours in first comprehensive evaluation - OR 93, p=0.69 Obtaining Honours in second comprehensive evaluation - OR 89, p=0.60 Obtaining Honours in third comprehensive evaluation - OR 0.87, p=0.53
American Dental Association (2012) (22)	2009, n=49; 2010, n=47 dental schools	First-Year Biomedical - median *r*= 0.27, p<0.05*** First-Year GPA - median *r*= 0.24, p<0.05*** First-Year Pre-clinical Dental Techniques grades - median *r*= 0.12, p<0.05*** Second-year Biomedical - median *r*= 0.12, p<0.05*** Second-year GPA - median *r*= 0.19, p<0.05*** Second-year Pre-clinical dental Techniques grades - median *r*= 0.12, p<0.05***
Behar-Horenstein, L. S., C. W. Garvan, et al. (2011) (31)	n=209	Correlation: NBDE Part I - *r*= 0.06, p=0.3865 NBDE Part II - *r*= 0.13, p=0.0618 Multivariate regression NBDE Part I and Part II - not included in the model
Curtis, D. A., S. L. Lind, et al. (2007) (25)	Normally tracking students (n=49) and underachieving students (n=45)	Correlation: Normally tracking students: First-year GPA - *r*= 0.05, p>0.05 Fourth-year GPA - *r*= 0.03, p>0.05 Underachieving students: First-year GPA - *r*= 0.15, p>0.05 Fourth-year GPA - *r*= 0.14, p>0.05 Multivariate regression: Normally tracking students: First-year GPA - β = 0.00, p=0.08 Fourth-year GPA - β = 0.00, p=1.00 Underachieving students: First-year GPA - β = 0.01, p=0.74 Fourth-year GPA - β = 0.01, p=0.49
Holmes, D. C., J. V. Doering, et al. (2008) (26)	n= 574	Overall Dental School GPA - *r*= 0.370, p<0.05 NBDE Part I - *r*= 0.363, p<0.05NBDE Part II– *r*= 0.344, p<0.05 Final Clinical grade - *r*= 0.259, p<0.05
Kim, M. and J. I. Lee (2007) (24)	n=90	First-semester GPA - range undisclosed, p>0.05
Lundergan, W. P., E. J. Soderstrom, et al. (2007) (35)	n=51	First-year Laboratory and study skills - *r*= 0.271, p<0.05*** Operative Dentistry grades - *r*= 0.308, p<0.05*** Fixed Prosthodontics grades - *r*= 0.318, p<0.05*** Endodontics grades - range undisclosed, p>0.05*** Dental Anatomy grades - *r*= 0.447, p<0.05***

		Clinical GPA - r= 0.423, p<0.05*** Class rank - range undisclosed, p>0.05
Park, S. E., J. D. Da Silva, et al. (2010) (28)	n=159	TXAD with Honours - OR 11, p=0.13
Poole, A., V. M. Catano, et al. (2007) (19)	Y1 n=373, Y2 n=237, Y3 m= 176, Y4 n=161	First-year GPA - r= 0.21, p<0.05*** Second-year clinical - r= 0.27, p<0.05*** Second-year academic - r= 0.16, p>0.05 Third-year clinical - r= -0.02, p>0.05 Third-year academic - r= 0.09, p>0.05 Fourth-year clinical - r= - 0.15, p>0.05 Fourth-year academic - r= -0.08, p>0.05
Victoroff, K. Z. and R. E. Boyatzis (2013) (36)	n=100	Didactic GPA - Model I: β= 0.038, p>0.05 Model II β= 0.041, p>0.05 Pre-clinical GPA - Model I: β= 0.388, p≤0.0001* Model II: β= 0.373, p≤0.0001*, Model III: β= 0.360, p≤0.0001* Clinical GPA - Model I: β= -0.028, p>0.05 Model II β= -0.163, p>0.05 Model III: β= -0.134, p>0.05

Third and fourth-year performance: DAT-PAT was found to be insignificantly correlated with third-year academic and clinical GPA (19) and fourth-year academic and clinical GPA (19). Similarly, Victoroff and Boyatzis (36) found DAT-PAT to be not significantly correlated to clinical and didactic GPA (p>0.05).

NBDE Board examination performance: As for predicting board examination results, DAT-PAT scores were found to be insignificantly correlated to the US NBDE Part I (12, 31) and Part II (31).

Concurrent and Convergent/Divergent validity: Finally, the DAT-PAT shows not only weak concurrent validity but also weak convergent validity, only being correlated with DAT Reading Comprehension (19), and DAT Academic Average (19).

DAT-Academic Average (DAT-AA)

The ADA defines the DAT Academic Average (DAT-AA) as the "average of the standard scores on the Quantitative Reasoning, Reading Comprehension, Biology and General and Organic Chemistry tests"(22). Eight of the thirty-six studies assessed DAT-AA's validity. The DAT seems to have weak to moderate predictive validity for most academic performance outcomes, and debatable predictive validity for Board examinations scores (see Table 9 and Appendix A Table A2).

First-year performance: Results show a moderate to weak correlation to first-year GPA[7] (19, 22) as well as moderate positive correlation with first-year Biomedical grades (22) and weak positive correlation with first Pre-clinical grades (22). Furthermore, Allareddy et al. (30) found that the DAT-AA scores do not appear to be significantly correlated with obtaining Honours mention in first-year comprehensive examination.

Second-year performance: In the second-year, a weak correlation is observed with second-year Biomedical grades (22), second year GPA (22) and second year Pre-clinical Dental Techniques grades (22). Oddly, Allareddy et al. (30)

[7] Curtis et al. 25. Curtis DA, Lind SL, Plesh O, Finzen FC. Correlation of admissions criteria with academic performance in dental students. Journal of Dental Education 2007;71(10):1314-1321. observed a correlation between DAT-AA and first and fourth-year GPA, but only for normally tracking students, and this relationship was not found statistically significant in the multivariate regression model.

found the DAT-AA scores to be negatively associated with obtaining Honours mention in second-year examination (OR 0.08, although this association didn't reach significance levels (p=0.06). Victoroff and Boyatzis (36) also found that DAT-AA positively correlated with Didactic GPA, but, surprisingly, was negatively correlated with Preclinical GPA.

Third and fourth-year performance: As for clinical performance, results suggest weak to null predictive validity. DAT-AA scores were not significantly correlated with obtaining Honours mention in third-year comprehensive examination (30) and clinical GPA (36), and Holmes et al. (26) only observed a weak correlation between DAT-AA and Final Clinical Grade. Curtis et al. (25) also observed a weak positive correlation with fourth-year GPA for normally tracking students, but DAT-AA was not significantly correlated with fourth-year GPA for underachieving students (p>0.05).

Table 9: Summary of the results on the predictive validity of DAT-Academic Average

Authors (year)	Study participants	Predictive validity – Strength of association
Allareddy, V., T. H. Howell, et al. (2012) (30)	n=66	Obtaining Honours in first comprehensive evaluation - OR 2.68, p=0.20 Obtaining Honours in second comprehensive evaluation - OR 0.08, p=0.06 Obtaining Honours in third comprehensive evaluation - OR 2.49, p=0.34
American Dental Association (2012) (22)	2009, n=49; 2010, n=47 dental schools	First-Year Biomedical - median *r*= 0.32, p<0.05***, R^2 = 0.13 First-Year GPA - median *r*= 0.30, p<0.05***, R^2 = 0.12 First-Year Pre-clinical Dental Techniques grades - median *r*= 0.17, p<0.05***, R^2 = 0.14 Second-year Biomedical - median *r*= 0.24, p<0.05***, R^2 = 0.11 Second-year GPA - median *r*= 0.26, p<0.05***, R^2 = 0.12 Second-year Pre-clinical dental Techniques grades - median *r*= 0.15, p<0.05***, R^2 = 0.13
Behar-Horenstein, L. S., C. W. Garvan, et al. (2011) (31)	N=209	Correlation: NBDE part I - *r*= 0.45, p<0.0001* NBDE Part II - *r*= 0.27, p<0.0001* Multivariate regression: NBDE part I - scope undisclosed, p≤0.0001 NBDE Part II - not included
Curtis, D. A., S. L. Lind, et al. (2007) (25)	Normally tracking students (n=49) and underachieving students (n=45)	Correlation: Normally tracking students: First-year GPA - *r*= 0.36, p<0.05*** Fourth-year GPA - *r*= 0.28, p<0.05 *** Underachieving students: First-year GPA - *r*= 0.21, p>0.05 Fourth-year GPA - *r*= 0.08, p>0.05 Multivariate regression: Normally tracking students: First-year GPA - β = 0.04, p=0.11

		Fourth-year GPA - β = 0.03, p=0.23 Underachieving students: First-year GPA - β = 0.02, p=0.38 Fourth-year GPA - β = 0.00, p=0.89
Holmes, D. C., J. V. Doering, et al. (2008) (26)	N= 574	Overall Dental School GPA - *r*= 0.494, p<0.05*** NBDE Part I - *r*= 0.610, p<0.05*** NBDE Part II - *r*= 0.524, p<0.05*** Final Clinical grade - *r*= 0.204, p<0.05***
Poole, A., V. M. Catano, et al. (2007) (19)	Y1 n=373, Y2 n=237, Y3 m= 176, Y4 n=161	First-year GPA - *r*= 0.46, p<0.01** Second-year clinical - *r*= 0.23, p<0.05*** Second-year academic - *r*= 0.52, p<0.01** Third-year clinical - *r*= -0.00, p>0.05 Third-year academic - *r*= 0.07, p>0.05 Fourth-year clinical - *r*= - 0.01, p>0.05 Fourth-year academic - *r*= -0.17, p>0.05
Victoroff, K. Z. and R. E. Boyatzis (2013) (36)	N=100	Didactic GPA - Model I: *β*= 0.424, p≤0.01** Model II *β*= 0.442, p≤0.01** Pre-clinical GPA - Model I: *β*= - 0.180, p>0.05 Model II: *β*= - 0.342, p≤0.0001*, Model III: *β*= 0.336, p≤0.0001* Clinical GPA - Model I: *β*= -0.012, p>0.05 Model II *β*= 0.018, p>0.05 Model III: *β*= 0.012, p>0.05

NBDE Board Examination performance: When it came to predicting performance in Board examination scores and Dental school GPA, we found confounding results. On one hand, Holmes et al. (26) observed moderate positive correlation with Dental school GPA, on the other Kingsley et al. (12) found the two variables not to be significantly correlated. Behar-Horenstein et al. (31) and Holmes et al. (26) found DAT-AA to be (26) moderately correlated with the US NBDE Part I (26, 31) and Part II (26) while others found no significant correlations between the variables (Part I: (12); Part II: (31)).

Concurrent validity of the DAT-AA was found to be weak, as the selection tool was not able to distinguish between those who passed the CRDTS exam and those who failed and that matriculated participants have only a slightly higher DAT scores than the applicant pool (19). As for convergent/divergent validity, results indicated a strong positive correlation between DAT-AA scores and DAT Total Science scores (26), a weak to moderate correlation to DAT-Perceptual Ability scores (26, 36) and weak correlation with DAT-Reading Comprehension (19).

In summary, all DAT sub-scores seem to be a good predictor of dental students' first and second-year academic performances, although this association seems the strongest for DAT-AA, DAT-RC and DAT-QA. DAT-AA, DAT-PAT and DAT-SNS were found to have weak to moderate correlation with Overall Dental School GPA and National Board Examination performance, while both relationships were found to be insignificant for DAT-QA and DAT-RC.

6.3.2 Non-cognitive assessment tools

Cognitive abilities are not enough to define what makes a good dentist. But what does the perfect dental school applicant look like? In their comprehensive review of the literature, Allison et al. (quoted by (37)) compiled a list of personal attributes regarded as desirable for dental professionals. Those consist of: communication with patients, communication with staff, sensitivity to others, ethical behaviour, judgment and analysis, management of people, conscientiousness, professionalism, life-long learning and clinical, academic, and technical competence. While there

seems to be a consensus on the importance of these abilities, the way they could be evaluated through the admission process is still up for debate. As our results will show, there is a high degree of variability in the validity and reliability of the different tools used in the dental school admission process. Our analysis will concentrate on four types of selection tools: interview, manual dexterity evaluations, personality and values assessment tests, and situational judgment tests.

6.3.2.1 Interviews

Nine out of the thirty-six articles explored the validity and reliability of a type of interview admission tool for the dental admission process. The purpose of these tools is to assess non-cognitive abilities such as communication skills and personality traits, and to validate the applicant's interest in the dental profession. The review highlighted three main types of interview formats currently being used: unstructured interviews, structured interviews, and multiple mini-interviews (see Table 10 and Appendix D Table D3). All three formats will be explored in this section.

Table 10: Summary of the results on the predictive validity of Interview formats

Authors (year)	Study participants	Predictive validity – Strength of association
Unstructured/semi-structured interview		
Kim, M. and J. I. Lee (2007) (24)	n=90	First-semester GPA – β=-0.272, p<0.01**
Structured interview		
Gardner, S. P. and K. F. Roberts-Thomson (2012) (38)	n=216	Achieving more three credits and more in first-year Excellent (1 – reference) Very good RR 0.88, p=0.545 Adequate/barely adequate RR 0.86, p=0.554 Achieving more three credits and more in second-year Excellent (1 – reference) Very good RR 0.93, p=0.731 Adequate/barely adequate RR 0.89, p=0.644 Achieving more three credits and more in third-year Excellent (1 – reference) Very good, RR 0.63, p=0.074 Adequate/barely adequate RR 0.57, p=0.123
Poole, A., V. M. Catano, et al. (2007) (19)	Y1 n=373, Y2 n=237, Y3 n=176, and Y4 n=161	First-year GPA – *r*= 0.11, p>0.05 Second-year clinical – *r*= -0.06, p>0.05 Second-year academic – *r*= 0.10, p>0.05 Third-year clinical – *r*= -0.31, p<0.05*** Third-year academic – *r*= 0.21, p>0.05 Fourth-year clinical – *r*= 0.44, p<0.001*** Fourth-year academic – *r*= 0.10, p>0.05
Rich, A. M., K. M. S. Ayers, et al. (2012) (39)	n= 411	Top half of the class – second-year – Total score 12 = n=93, p>0.05; Total score <12 = n= 17, p>0.05 Top-half of the class – fifth-year - Total score 12 = n=93, p>0.05; Total score <12 = n= 17, p>0.05 Graduation with credit or distinction - Total score 12 = n=19, p>0.05; Total score <12 = n= 24, p>0.05 Any subject prize - Total score 12 = n=4, p>0.05; Total score <12 = n= 9, p>0.05

		Any subject distinction - Total score 12 = n=1, p>0.05; Total score <12 = n= 2, p>0.05 Remedial Examination Required – Total score 12 = n=3, p>0.05; Total score <12 = n= 7, p>0.05
Multiple Mini-Interview		
Foley, J. I. and K. Hijazi (2013) (33)	n=75	CAS scores – Teamwork - *r*= 0.097, p=0.024*** CAS scores – Communication skills - *r*= 0.31, p=0.035 CAS scores – Work experience - *r*= 0.189, p=0.001** CAS scores – Manual dexterity - *r*= 0.126, p=0.03*** CAS scores – Commitment to Aberdeen - *r*= 0.112, p=0.119 CAS scores – Core Qualities - *r*= 0.046, p=0.282 CAS scores – Article review - *r*= 0.051, p=0.304

Unstructured interviews

Also called non-directive interviews, unstructured interviews can be defined as a free-flowing exchange of information between candidate and examiner, on a predetermined subject. In some cases, the questions are pre-determined. These can be referred to as semi-structured interview, but are still considered to fall under the unstructured format. Over the years, the validity and reliability of these interview-types have been widely questioned, especially given the high stakes nature of the dental admission process. The only article in our review that assessed the validity of a semi-structured interview seems to corroborate this view. In 2005, Seoul National University started to use a semi-structured interview in their admission process, which covered three domains: "aptitudes (interest, career knowledge, and motivation), professional attitude (ethics and service experiences) and interpersonal skills (communication and personality)" (24). While exploring the factors that influence student performance, Kim and Lee (24) found that unstructured interview scores were negatively correlated to achievement in first semester. Thus, in that case, not only was the selection tool unable to predict performance, but relying on its results may in fact be counter-productive.

Structured interviews

In the mid-1980s, researchers observed that the degree of structure of an interview influenced both its reliability and validity. Therefore, a new format known as a "structured interview" was developed. There are two common types of structured interviews: the situational interview and the patterned behaviour description interview (19). A situational interview consists of asking a candidate how she or he would respond in a variety of hypothetical situations, often job-related (18). On the other hand, in a patterned behaviour description interview, candidates are asked about past behaviour in a given situation, the rational being that past behaviour should predict future actions (19). Both rely on a high level of interview structure, which can be defined by "the use of a scoring rubric, question standardization, the use of probing, and other factors" (40). Overall, structured interviews seem to have a slightly better predictive validity than the unstructured format (see Table 10).

Poole et al. (19) found that CDA structured interview[8] scores, once corrected for range restriction and measurement error, were moderately correlated with third and fourth-year clinical GPA, but not with first-year GPA, second-year

[8] Faced with concerns over the validity of the old (1980) CDA semi-structured interview, a new CDA structured interview was developed by the DAT Committee and used in participating dental schools in the year 2000. This interview covers seven core competencies that were identified by a previous study using job analysis techniques, which are: communication, conscientiousness, integrity, judgment and analysis, self-control, sensitivity to others, and tact and diplomacy. To assess each of these competencies, more than 500 critical incidents pertaining to these competencies were retained, and each incident was edited in both a situational

clinical and academic GPA, and third and fourth-year academic GPA. Yet, in other contexts, structured interviews were non-significantly correlated with achieving three or more credits in years 1, 2, and 3 (38), nor with predicting top half of the class in years 2 and 5, graduation with credit or distinction, any subject distinction, any subject prize or remedial examination required (39). Results suggest that structured interviews' convergent/divergent validity with other cognitive and non-cognitive selection tools is weak (NS for DAT-AA, DAT-RC, and DAT-PAT but weak positive correlation with NEO-PI-R extraversion and openness to experience factors r= 0.27- 0.21, p<0.01, n= 161 (19) to non-existent (Graduate Australian Medical School Admission Test (GAMSAT)[9], first-year progress scores (37). Content validity was also found to be weak, as structured interview scores were unable to predict top half of the class in the second and fifth-year, graduation with credit or distinction, any subject distinction, any subject prize, or remedial examination required (39).

Multiple Mini-Interviews (MMI)

Pioneered at McMaster University in 2002, multiple mini-interviews is an interview format whereby applicants pass through a pre-determined number of stations – usually between seven to ten – where short structured interviews are then conducted, each time assessed by different evaluators. This multiple sampling approach to assessment, derived from techniques used by the evaluation research discipline, aims to increase reliability of the interview as an assessment tool by reducing context specificity of applicant's responses. As Eva and al. (41) highlighted, MMI show multiple potential strengths, notably:

- Flexibility, in the sense that station's design can be modelled around a blueprint of desired qualities or competencies established locally by each university;
- Multiple insights into applicant's abilities of competencies;
- Increased validity, notably by diluting the effect of examiner's bias and chance;
- Opportunities for candidates to recover from a bad performance on a station;
- Lower resources utilization during the interview process – and by extension lower costs;
- And finally, a structured format where all candidates respond to the same questions, more easily permitting comparisons.

Although the potential of Multiple Mini Interview (MMI) in dental admission context has been widely discussed, only three articles out of the thirty-six assessed MMI's validity.

Foley and Hijazi (33) assessed the predictive validity of MMI as a selection tool in the 2008-2011 admission process at the University of Aberdeen Dental School (UK). The MMI consisted on a series of seven seven-minute stations, each assessed by one trained admission selector. The MMI assessed the following domains: Commitment to the University of Aberdeen Experience of teamwork; Exploration of the core qualities of a dental practitioner; Communication skills; Review and assessment of a research article; Previous work experience within dentistry; and Manual dexterity skills. The results for these stations were then compared with the University's Common Assessment Scale (CAS[10]) scores.

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interview and a patterned behaviour description interview formats. All interviews were conducted by a panel of two trained interviewers, who were free to choose either of the two questions designated for each competency. To reduce the potential for test-retest bias, the question pool differed slightly between universities. Each question is scored on a five-point scale, for a maximum total of 35 points per interviewer (70 points maximum in total).

[9] The Graduate Australian Medical School Australian Admission Test (GAMSAT) is a test similar to the DAT used in the selection of medical, dental, podiatric, pharmacy, and veterinary science students in Australia.

[10] CAS is a score calculated by UK universities that represent the scores for all end-of-term and end-of-year examination performance. The CAS is not a linear scale, and its range is from 1 to 20, where 9 normally represent the minimum score to be awarded a pass 33. Foley JI, Hijazi K. The admissions process in a graduate-entry dental school: can we predict academic performance? British Dental Journal 2013;214(2).

The authors found four of the stations weakly but significantly positively correlated to CAS scores, namely: the communication skills station, the work experiences station, the manual dexterity station, and the teamwork station, although in the teamwork station case, the limited magnitude of the correlation makes it unlikely that this association will have a tangible influence on CAS performance.

McAndrew, R. and J. Ellis (42) questioned one hundred and ninety applicants and thirty-eight examiners who participated in Cardiff University's 2011 admission process to evaluate MMI's acceptability by prospective undergraduate students and interviewers as part of the admission procedure for dental school. The ten MMI stations covered the following seven areas: "dentistry as a career, logic, reasoning, ethics and plagiarism, manual dexterity, breaking bad news, research and data interpretation" (42). Both from the applicants' and the examiners' points of view, the MMI format seemed to have high face validity. A total of 64.8% (n=114) of applicants and 89.4% (n=34) of examiners considered the MMI to be better than unstructured interviews. Applicants' main critiques of the MMI were the lack of control/flexibility linked to the structured format, the feeling of anxiety and nervousness when confronted with a bad performance; the impossibility of preparing for MMI in advance; and the difficulty in understanding what is being assessed (42). As for examiners, the main critique expressed related to assessors' fatigue throughout the day given the repetitive nature of asking multiple candidates the same question, especially when the responses did not vary (one example was of a interview station where candidates were asked why they wanted to be a dentist and most responses were similar).

Although the primary purpose is to assess non-cognitive constructs such as personality traits, motivation and competencies, it seems that MMI could have predictive value in evaluating cognitive abilities. Using Item Response Theory (IRT), Roberts, C., N. Zoanetti, et al. explored the validity of a structured 7 station - 39 question bank MMI on what they call "level-entry reasoning skills in professionalism", or basic cognitive reasoning skills (43). The authors used data for the 2007 admission in a graduate-entry program at the Faculty of Medicine and Dentistry at the University of Sydney. IRT assumes that the probability of getting a satisfactory score depends on: a) the candidate's general ability, b) the leniency/stringency of the evaluator, and c) the difficulty of the items. MMI's standard deviations (SDs) by facets were: stringency or leniency 0.52, candidate ability 0.75, and MMI question difficulty 0.27, which indicates that half of the response's variations are a reflection of the candidate's abilities. Their results also show that the questions are not only conceptually equivalent (overall infit[11] mean = 1.03, SD=0.19, range 0.63-1.26; overall outfit mean 1.03, SD = 0.12, range 0.67-1.26), but also that they could significantly separate the items according to their level of difficulty, which indicates that the MMI questions fit the assumptions of the IRT model. Yet further research is needed to definitively assess the validity of MMI as a selection tool, especially for non-cognitive ability assessment.

In summary, the reliability and validity of interviews vary widely depending on their format. The less structured the interview is, the lower the reliability and validity it seems to have. Structured interviews were found to be insignificantly correlated with first and second-year GPA, while being moderately correlated with third and fourth-year clinical GPA. Structured interviews were also found to be incapable of significantly predicting high or low performers, as calculated by the probability of receiving distinction or credits, or needing remedial examinations. MMIs were found to be slightly better predictors of student performance, as MMI scores were found weakly correlated to CAS scores. Furthermore, MMI was found to have higher face validity than its unstructured counterpart.

[11] In a Rasch context, Infit, also called information weighted sum, refers to the extent a model fits the predicted global pattern of responses (inlying responses pattern). As for Outfit, also called outlier-sensitive fit, it refers to the extent a model fits the predicted pattern of responses on extreme items (i.e. either extremely easy or very difficult items).

6.3.2.2 Manual dexterity tests

Dentistry requires high psychomotor abilities (35). Yet, "there is considerable variation in the speed and degree to which students acquire the necessary manual dexterity to perform standard clinical procedures in consistent and clinically acceptable manner." (44). Hence the interest in adding a manual dexterity test to a dental admission process that dates as far back as 1937 (45). The original purpose of the ADA Chalk Carving Test was to be used as a screening tool, to try to isolate applicant with "five thumbs" (46), and to help reduce attrition rate, which as we previously stated, was considerably high. The rationale behind this assumption is that when low scoring in manual dexterity test, candidates might reflect on their career choice when faced with their limitations. With increasing comments on its lack of predictive validity (47), and its debatable construct validity and high utilization costs (48) combined with the innate-acquired debate around dexterity skills (48), the DAT-PAT was developed and replaced the Chalk Carving test in 1972 for both Canada and the US. Still, in 1975, with new reports on manual dexterity ability to predict operative and fixed prosthodontic grades (49, 50), Canada reinstated the CDA-DAT-Chalk carving test. Yet, the debate around manual dexterity test, and their purpose in admission process, still rages on (51).

To date, there are no standardized methods of assessing dexterity skills (52). Out of the thirty-six studies selected for this literature review, seven had results pertaining to manual dexterity tests, one being a literature review[12]. Only one of the studies assessed manual dexterity tests' concurrent validity (53), while none assessed their content validity. Our results found that, although the reliability and predictive abilities of these tools are still debatable, there is evidence to suggest that these tests are effective in identifying the least favourable candidates from the applicant pool (see Table 11 and Appendix D Table D4).

Table 11: Summary of the results on manual dexterity tests

Authors (year)	Study participants	Predictive validity – Strength of association
Dental laboratory test		
Al-Johany, S., M. AlShaafi, et al. (2011) (53)	N=71	Dental skills as assessed by a local performance assessment – descriptive
Handwriting test		
Al-Johany, S., M. AlShaafi, et al. (2011) (53)	N=71	Dental skills as assessed by a local performance assessment – descriptive
Drawing test		
Al-Johany, S., M. AlShaafi, et al. (2011) (53)	N=71	Dental skills as assessed by a local performance assessment – descriptive
Composite manual test – content non disclosed or components impossible to differentiate		
Beier, U.S., I. Kapferer, et al. (2010) (54)	N=97	Average grades after first clinical year – r= -0.373, p<0.01 (negative because of the reverse polarity of the Austrian grade system)** Graduation on time – Yes: Mean 200.04 (SD 35.02), No: 176.76 (SD 41.87), p<0.05***
Giuliani, M., C. Lajolo, et al. (2007) (55)	N= 433	Overall dental school performance (average of all five years' exams) – β = -0.4428, p=0.672, R^2= 0.0024

[12] Six other studies were published prior to 1972, but only the citations were available through our university's article database. Yet, as these studies were quite extensively assessed by Oudshoorn 4. Oudshoorn WC. The utility of Canadian DAT Perceptual Ability and Carving Dexterity scores as predictors of psychomotor performance in first-year operative dentistry. Journal of Dental Education 2003;67(11):1201-1208., we will use this literature review as a baseline and complete it with recent articles.

Foley, J. I. and K. Hijazi (2013) (33)	N=75	CAS Scores – r = 0.126, p=0.003***
Tweezers Dexterity test		
Lundergan, W. P., E. J. Soderstrom, et al. (2007) (35)	N=51	Test #32022 (adjusted for PAT): First-year Operative Dentistry – *r* = 0.431, p<0.05*** Fixed Prosthodontics – *r* = 0.397, p<0.05*** Endodontic – NS – range and p undisclosed Dental Anatomy – *r* = 0.285, p<0.05*** Clinical GPA – *r* = 0.279, p<0.05*** Graduation rank – NS – range and p undisclosed Test #18: First-year Operative Dentistry – NS – range and p undisclosed Fixed Prosthodontics – *r* = 0.335, p<0.05* Endodontic- *r* = 0.329, p<0.05* Dental Anatomy – NS – range and p undisclosed Clinical GPA – *r* = 0.260, p<0.05* Graduation rank – *r* = 0.242, p<0.05*
Haptics		
Urbankova, A. and S. P. Engebretson (2011a) (44)	N=39	First exam scores and Line exercise: Time Left – *r* = 0.16, p=0.32 Time Left Completed - *r* = 0.16, p=0.32 Accuracy Left – *r* = 0.24, p=0.14 Accuracy Left Completed - *r* = 0.25, p=0.13 First exam scores and Circle exercise: Time Left – *r* = 0.38, p=0.0016** Time Left Completed - *r* = 0.25, p=0.13 Accuracy Left – Moderate *r* = 0.43, p=0.006** Accuracy Left Completed - *r* = 0.17, p=0.17 First exam scores and Mirror exercise: Time Left – *r* = 0.31, p=0.05*** Time Left Completed – Moderate *r* = 0.33, p=0.039*** Accuracy Left – *r* = 0.30, p=0.060 Accuracy Left Completed – *r* = 0.30, p=0.068 First exam scores and Total haptics scores: Time Left Completed – *r* = 0.35, p=0.028*** Accuracy Left Completed – *r* = 0.34, p=0.035*** Time and Accuracy Left Competed – *r* = 0.37, p=0.019***
Computer-assisted simulation		
Urbankova, A. and S. P. Engebretson (2011a) (44)	N=38	First exam scores and Line exercise: Exam I scores – 73.4 vs. 68.3, two-sided Students p< 0.0001* Exam II scores – 76.3 vs. 74.7, two-sided Students p =0.35

CDA DAT - Carving Dexterity (DAT-CD)

For Peterson (46), one of the reasons the DAT carving test lacks predictive validity was due to its scoring format. In 1999, CDA DAT-CD scores began to be reported as "ability-referenced standardized scores rather than normalized scores (4)", thus reducing the influence of confounding factors (such as year and location variations). Oudshoorn (4) investigated the utility of the CDA DAT-PAT and Carving Dexterity (DAT-CD) scores as predictors of psychomotor performance. The DAT-CD was found to be weakly correlated to overall first-year operative technical grades, although it only accounted for 5.03% of the course's grade variation. Yet, its ability to effectively discriminate between students (concurrent validity) was not assessed. The authors also found that together, DAT-CD and DAT-PAT accounted for 7 to 10% of the overall variation in operative techniques grades.

Handwriting, drawing and laboratory tests

Al-Johany et al. (53) explored the predictive value of three tests: a dental laboratory test consisting of "Class I amalgam cavity preparation" on a lower right molar ivorine plastic tooth; the quality of handwriting criteria: smoothness, beauty and continuousness of handwriting; and thirdly a drawing skills test that consisted of drawing lines as straight as possible. The authors concluded that although the dental laboratory test had no significant predictive value, 69.6% of students (n = 16) who had excellent drawing skills also had excellent dental skills, as assessed on a scale of 1 to 10 by two trained evaluators in laboratory settings (8 to 10/10; $p < 0.01$). Only one student with excellent drawing skills was considered to have poor dental skills (0 to 2/10). As for writing skills, all students with excellent or good writing skills had good (20%) to excellent (80%) dental skills (6 to 10/10). It has to be noted that the students used Arabic handwriting format, and that these results may not be transferable to an occidental context. Also, the small sample size (n= 71) and the fact that no statistical testing methods other than descriptive analysis were used makes drawing any inference impossible.

Haptics and computer-assisted dental simulation tests

Urbankova and Engebretson (44) assessed the predictive validity of a computer-assisted dental simulation (CDS), consisting of one four-hour cavity preparation simulation. The goal was to achieve the closest approximation of a completed cavity preparation during this period. The last two cavity preparations were submitted for evaluation, and assessed on the quality of the preparation. Exam I and II were preclinical operative dentistry exams on cavity preparations, where students were asked to complete two cavity preparations for amalgam – (MO on Tooth 4.6 FDI, #30 Universal, and MO on Tooth 4.5 FDI, #29 Universal), and one occlusal cavity preparation (Tooth 1.5 FDI, #4 Universal) and one amalgam restoration (Tooth 4.6 FDI, #30 Universal). The authors found that students who passed the CDS not only had significantly higher mean Exam I scores (73.4 vs. 68.3, two sided Students $p < 0.0001$, n=38) and mean Exam II scores (but NS) than the one that failed, but also that students who passed CDS test were 30.9 times more likely to pass Exam I. The only downside is the high cost of CDS, which hinders the scalability potential.

As an alternative to CDS, Urbankova and Engebretson (52) used a haptic device simulating multi-paths carving to try to predict preclinical operative performance and perceptual ability in dental students. Haptics "relies on computer force feedback to produce tactile sensation for the user" (p. 1549). Three haptic tests of different difficulty levels were assessed: the line, the circle and the mirror. The authors observed that the more complex the exercise (circle, mirror), the more strongly they were correlated to preclinical performance (as assessed by performance in Exam I and II – see above for description). While none of the assessment criteria of the line exercise was significantly correlated with preclinical performance, two of the circle tests were correlated with Exam I scores (Time left (TL) and Accuracy left (AL)), and one with DAT-PAT scores (TL completed). All four of the mirror test assessment criteria were significantly correlated with Exam I (TL, AL, Time left completed, Accuracy left completed), while only one was weakly correlated with DAT-PAT scores (AL).

Tweezer dexterity tests

Lundergan et al. (35) explored the predictive validity of two tweezers dexterity tests developed for aptitude for working with small tools, one measuring speed and accuracy (Test #32022), while the other one is a pure speed assessment (Test #18). The mean score for the first year dental students on the Tweezers dexterity test #18 was only slightly higher than the national norm (40.42 vs. 39.91), which could suggest that dental students' tweezers dexterity skills do not differ from the general population. These tests had limited predictive validity for assessing performance (grades and rankings) in dental school, and they did not add predictive validity when used in concert with the DAT–PAT. This was also the case for composite dexterity tests, which all show weak to null ability to predict students' performance throughout dental school (23, 33, 55).

Composite dexterity tests

Three studies explored the predictive validity of a composite dexterity test (33, 54, 55). Beier et al. (54)found the composite dexterity test to be moderately and negatively correlated with average grades after first clinical year (negative correlation because of the reverse polarity of the Austrian grade system) and associated with graduation on time. Giuliani el al. (55) found no correlation between the composite dexterity test assessed and Overall Dental School performance, while Foley and Hijazi (33) found a weak positive correlation between a composite dexterity test and CAS scores, although at r=0.12 this relationship is unlikely to have an actual influence on dental school performance. Yet, since the content of these tests are either undisclosed, or the influence of their components impossible to isolate, it is difficult to draw any inference from these studies.

Furthermore, there is great debate on whether dexterity skills can be developed through dental school clinical training and, in that case, if they should be required from dental school applicants. For some, "basic manual dexterity is affected by the cognitive and logic abilities acquired during high school, rather than from actually exercising such skills" (55). However, others believe these skills can be learned and improved through dental school clinical training. Using ten dexterity exercises (eight Montessori-type material, one used in the Frostig perception test and one in the Vayer psycho-motor profile), Giuliani et al. (55) found that initial dexterity could improve with training and clinical practice. Furthermore, they found not only that the dexterity test evaluated was not able to predict academic achievement (average score of all five years dental school exams), but that students admitted only on the basis of scientific knowledge still had the highest manual dexterity test scores of the applicant pool. Therefore, these authors postulate that dexterity tests should not be a part of the selection of dental students. Urbankova and Engerbreton (52) partially agreed with this point of view, suggesting instead that dexterity assessing should be used as a screening tool to determine which students could benefit from additional assistance, and to implement strategies to improve their learning experience. Behar-Horenstein et al. (31) also add that dexterity tests might be beneficial as a pedagogical tool, "so [students] can acquire insight about their own learning, modify their study habits as needed, and enhance their knowledge of faculty teaching methodologies". These views seem to indicate that manual selection tests, when used as screening tools (which is in fact their original purpose), could be beneficial for students' educational and academic experience.

6.3.2.3 Situational Judgement Tests

Situational Judgement Tests (SJT) are a "measurement method designed to assess individuals' judgement regarding situations encountered in the workplace" (5). The first SJT was recorded in 1958, and since then, the assessment method has been widely used in industrial-organizational psychology. Yet, its use in an applied setting as a selection tool is fairly recent. In 2010, in his thesis, Grim (56) designed an adaptability situational judgement test (ASJT)

designed to be used a valid and reliable selection tool. One of the thirty-six studies pertained to Situational Judgment Test (SJT – see Table 12 and Appendix D Table D5).

Table 12: Summary of the results on the predictive validity of Situational Judgment tests

Authors (year)	Study participants	Predictive validity – Strength of association
Buyse, T. and F. Lievens (2011) (32)	Y1 n=781, Y2 n=489, Y3 411, Y4 n=343, Y5 n=274	Individualism dimension: First-year GPA – *β*=0.18, p>0.05 Second-year GPA – *β*=0.11, p>0.05 Third-year GPA – *β*=0.10, p>0.05 Fourth-year GPA - *β*=0.04, p>0.05 Fifth-year GPA - *β*=0.20, p>0.05 Overall Dental School GPA – *β*=0.13, p>0.05
		***** = p<0.05; ** = p<0.01; * = p<0.001**

Using video-based SJT about interactions with patients, Buyse and Lievens (32) assessed SJT's predictive validity as a selection tool on students' performance throughout their five years of dental school (n=781, dropping to 274 the last year). The authors found no relationship between SJT and GPAs for each year (Y1 to Y5), nor with total GPA, and observed incremental value over cognitive tests only for fifth year (β=.16, R^2 = 0.03 for SJT vs. β =0.04 R^2 = 0.00 for cognitive tests). Also, SJT showed weak convergent validity, as it was not significantly correlated with any other selection tools (cognitive or non-cognitive).

6.3.2.4 Personality and values assessment

Four studies out of thirty-six report findings on either personality or value assessment tools, each assessing a different selection tool: Hosftede cultural values test, Myer-Briggs Type Test, the NEO-PI-R and the Emotional Competence Inventory (see Table 13 and Appendix A Table A6).

Table 13: Summary of the results on the predictive validity of Personality and value tests

Authors (year)	Study participants	Predictive validity – Strength of association
Hosftede's Cultural Dimensions		
Itaya, L. E., D. W. Chambers, et al. (2008) (57)	n=144	Second-year GPA: Individualism dimension: β = -0.20, p=0.05*** Power distance dimension: β = -0.05, p=0.68 Long-term orientation dimension: β = 0.02, p=0.88 Masculinity/ Femininity dimension: not included Tolerance to uncertainty dimension: not included
Myer-Briggs Type Test		
Behar-Horenstein, L. S., C. W. Garvan, et al. (2011) (31)	n=209	NBDE Part II Extraversion/Introversion, range undisclosed, p=0.1098 Intuition/Sensing: not included Feeling/Thinking: range undisclosed, p=0.0133*** Judging/Perceiving: not included
Emotional Competence Inventory – University Version		
Victoroff, K. Z. and R. E. Boyatzis (2013) (36)	n=100	EI- Self-Awareness Didactic GPA – β=0.186,p>0.05 Preclinical GPA- β= -0.204, p>0.05 Third and Fourth-year Clinical GPA –β= 0.133, p>0.05

		EI- Self-Management Didactic GPA- β= 0.133, Preclinical GPA – β= -0.398, p≤0.05*** Third and Fourth-year Clinical GPA – β= 0.490, p≤0.05*** EI-Social Awareness Didactic GPA - β= -0.123, p>0.05 Preclinical GPA - β= - 0.045, p>0.05 Third and Fourth-year Clinical GPA - β= -0.313, p>0.05 EI-Relationship Management Didactic GPA – β= 0.507, p≤0.01* Preclinical GPA - β= 0.002, p>0.05 Third and Fourth-year Clinical GPA – β= 0.027, p>0.05
NEO-PI-R		
Poole, A., V. M. Catano, et al. (2007) (19)	n= 373	Conscientiousness: First-year GPA – r= 0.24, p <0.05*** Second-year clinical GPA – r=0.47, p<0.001* Second-year academic GPA – r=0.32, p<0.05*** Third-year clinical GPA – r = 0.08, p>0.05 Third-year academic GPA – r=0.40, p<0.05*** Fourth-year clinical GPA – r=39, p<0.001** Fourth-year academic GPA – r=0.09, p>0.05 Agreeableness / Extraversion / Neuroticism First-year GPA – r=0.06, p>0.05 Second-year clinical GPA – r=0.12, p>0.05 Second-year academic GPA – r=-0.01, p>0.05 Third-year clinical GPA – r= -0.07, p>0.05 Third-year academic GPA – r=0.12, p>0.05 Fourth-year clinical GPA – r=0.04, p>0.05 Fourth-year academic GPA – r=-0,01, p>0.05 Extraversion First-year GPA – r=-0.03, p>0.05 Second-year clinical GPA – r= -0.09, p>0.05 Second-year academic GPA – r=-0.05, p>0.05 Third-year clinical GPA – r= -0.01, p>0.05 Third-year academic GPA – r=0.08, p>0.05 Fourth-year clinical GPA – r=0.12, p>0.05 Fourth-year academic GPA – r=-0.01, p>0.05 Openness First-year GPA – r=0.01, p>0.05 Second-year clinical GPA – r=-0.13, p>0.05 Second-year academic GPA – r=-0.01, p>0.05 Third-year clinical GPA – r=0.09, p>0.05 Third-year academic GPA – r=0.24, p<0.05*** Fourth-year clinical GPA – r=0.11, p>0.05

	Fourth-year academic GPA – r=-0.05, p>0.05 Neurotism First-year GPA – r=-0.10, p>0.05 Second-year clinical GPA – r= -0.11, p>0.05 Second-year academic GPA – r=-0.01, p>0.05 Third-year clinical GPA – r=0.02, p>0.05 Third-year academic GPA – r=-0.08, p>0.05 Fourth-year clinical GPA – r= -0.18, p>0.05 Fourth-year academic GPA – r= -0.01, p>0.05

Hofstede's Cultural Values

Hosftede's Cultural value index is a validated tool used to assess national cultural values that impact organizational climate. The five sets of values are: power distance, individualism/collectivism, uncertainty/avoidance, masculinity/femininity, and long-term orientation. All of the items are scored 1 to 5. The power distance dimension is the extent to which power (i.e. hierarchical ranking in an organization) is linked to performance. Individualism/collectivism refers to the prioritization of individual vs. collective needs in an organizational context. Uncertainty/avoidance refers to the extent emphasis is placed on rules and regulations vs. informal guidelines. The masculinity/femininity dimension refers to the extent status, roles and power are determined by gender in an organizational context. Finally, long-term orientation refers to an organizational tendency toward short or long-term planning. Itaya et al., Chambers and King (57) tried to determine if cultural norms predicted students' performance through dental school. Using data from the 1994 to 2004 admissions cycles and determining the students' cultural value score through their country of birth, the authors found that Individualism scores have a weak negative correlation with second-year combined GPA, but all other variables were not significantly correlated for all first and second year clinical and academic scores and/or dropped for multicolinearity. We suggest caution with these results, since Hosftede's index was not meant to be used at an individual level, and that taking mean national score of country of birth as an individual personal score negates the influence of personality and of the integration process.

Myer-Briggs Type Indicator (MBTI)

The MBTI is based on Jung's four psychological types (Introversion or Extraversion; Intuition or Sensing; Judging or Perceiving; Thinking or Feeling). These psychological types may have an influence not only on academic performance, since they should influence the way information is processed, but even more so on clinical performance – in dental school and beyond. Behar-Horenstein et al. (31) explored the degree to which MBTI predicts student passage at the NBDE Part I. The authors found no significant relationship among the four psychological types and NBDE Part I, although Thinking or Feeling related to NBDE Part II (p=0.0133, range score undisclosed).

Emotional Competence Inventory

Emotional intelligence refers to the "ability to recognize and regulate emotions in ourselves and in others" (58). This competence is particularly important in the dentist-patient relationship (36), notably in diagnostic and treatment planning and in effective communication with the patient and other collaborators to attain optimal care (59). Victoroff and Boyatzis (36) examined the role of emotional intelligence (EI), assessed by the Emotional Competence Inventory (ECI), on dental student clinical performance. ECI is a 360-degree tool[13] that assesses emotional

[13] By "360 degree assessment tool", the authors mean a whole-life assessment tool of emotional intelligence through multiraters point of view.

competence, which is considered a "learned capacity based on emotional intelligence" (60). The ECI 2.0 assesses eighteen competencies, which are regrouped into four clusters: self-awareness, self-management, social awareness, and relationship management. The self-awareness contains three competencies: emotional awareness, accurate self-assessment, and self-confidence. The self-management cluster contains six competencies: emotional self-control, transparency, adaptability, achievement, initiative, and optimism. The social awareness cluster contains three competencies: empathy, organizational awareness, and service orientation. Finally, the relationship management cluster contains six competencies: developing others, inspirational leadership, change catalyst, influence, conflict management, and teamwork and collaboration. The results show that two of the constructs (EI self-awareness and social awareness) were not correlated with any of the performance indicators (didactic GPA, preclinical GPA, and clinical GPA Y3-Y4), while another (EI relationship management) was only positively correlated to didactic GPA. The last of the four constructs, EI self-management, was found to be negatively related to didactic GPA, but positively related with preclinical GPA and clinical GPA. Furthermore, EI contributed 12.1% to variation on didactic GPA (Y1-Y2), 6.1% to preclinical GPA, and 14.6% on clinical GPA, which suggest that EI could be an interesting addition to cognitive tools in dental admission process, even if more research is needed.

NEO Personality Inventory Revised (NEO-PI-R)

The NEO-PI-R is a 240 items measure of the Big Five Personality Traits: agreeableness, conscientiousness, extraversion, openness to experience, and neuroticism. The NEO-PI-R (UK version, 2013) manual refers to neuroticism as the extent to which individuals might be prone to psychological distress, such as depression, anxiety or vulnerability. Agreeableness refers to the preferred type of interactions preferred by the individual, from altruism/compassion to tough-mindedness. Extraversion refers to the quantity and intensity of energy directed outwards to the social world. Openness to experience refers to the degree to which individuals appreciate and search for new experiences. Finally, conscientiousness refers to the degree of organisation, persistence, control and motivation in goal-motivated behaviour. Our results show that NEO-PI-R seems to have moderate concurrent validity, and moderate to weak predictive validity for two of the indicators (conscientiousness and openness) – see Table 13 and Appendix A Table A6.

Poole et al. (19) used NEO-PI-R to compare candidates that were offered and accepted entry to dental school to others that either were not offered or declined admission. The authors found that dental schools' matriculated applicants have higher personality scores for all factors than non-matriculated applicants. As for predictive validity, three of the traits (agreeableness, extraversion and neuroticism) had no significant relationship with all the performance indicators. On the other hand, conscientiousness correlated with first-year GPA, second-year clinical grades, second-year academic grades, third-year academic grades, and fourth-year clinical grades. Last, openness was weakly correlated with third-year academic grades. All other relationships were found to be not significant ($p>0.05$). NEO-PI-R also shows potential for incremental predictive validity (19), although this needs further assessment.

6.3.3 Scalability potential and hypothetical biases that might impact student diversity

As our results show, little was found regarding the scalability potential of the different tools assessed, even if cost considerations (human, material and financial) remain central in the decision of implementing new selection tools. Moderate to considerable costs associated with the elaboration of the scenarios of two of the newest additions of the admission "toolbox", MMI and SJT, have been cited as potential barriers for their implementation[14], but none of the articles tried to assess these costs, nor their potential cost/efficiency gains of these selection tools versus more traditional measures.

Scalability issues of MMI in a medical context were assessed by Rosenfeld, Reiter, Trinh and Eva (61). The authors found that MMI required greater infrastructure (interview rooms) and preparation than traditional panel-based interviews, but fewer person-hours investment (67 hours per applicant, and 16% as much time). As a result, the MMI interview process was completed in one weekend in 2004, versus two weekends in 2003 when panel-based interviews were used. Still, the costs of implementing MMI can be off-putting. Another study in the medical admission setting (62) offered a low-cost method for enhancing structured interviews' reliability that might be considered a good alternative to MMI. The authors concluded that "replicating a number of brief interviews, each with one rater, is likely to be superior to the often recommended [structured] panel interview approach", and could be a cost-effective choice without sacrificing validity and reliability (62). Still, further research is needed to see if these changes would be sufficient.

6.3.4 Student diversity

As for potential biases deriving from the selection tools' utilization that might impact student diversity, our results show that cognitive and non-cognitive tools do not seem to disadvantage significantly gender, ethnic/racial or age groups – or when they do, it is only marginally.

6.3.4.1 Gender

Results show that gender seems to be either not significantly or only marginally correlated with selection tool results. Gender was not found to be significantly correlated to Overall Pre-dental GPA and Pre-dental Science GPA (12). Males were found to have slightly higher DAT-AA scores (12, 36), DAT-PA scores (31), DAT-BIO scores (12), DAT-OC (12) and DAT -average weighted scores (15), but gender was found not significantly correlated with all other DAT sub-scores. As for non-cognitive assessment tools, gender was not significantly correlated with semi-structured, MMI and structured interviews performance (33, 37, 42), nor was any relationship found between applicant-interviewer gender concordance and applicant's decision to enrol (63). As for personality and values assessment tools, females tend to have higher scores in agreeableness *(r*= .17[15], p <0.05 n= 359, (19) and neuroticism for the NEO-PI-R test (*r*=.28, p <0.001, n=359, (19), while for the MBTI, females are more likely to have a feeling (56% vs. 26%, p< 0.001, n=209, (31) or judging orientation (82% vs. 68%, p=.0236, n= 209 (31)). For all other items, as EI test, the relationship between gender and selection tools results did not reach significant value.

6.3.4.2 Socioeconomic background

Using a composite socioeconomic background indicator (measured by high school background), Giuiliani and al. (55) observed that a classical and/or scientific high school background correlates positively to performance in dental school (overall dental school GPA), while a vocational (dental mechanical high school) background correlates

[14] Although the drafting of the MMI scenarios requires an intensive amount of resources, once this step is done MMI seems to be more cost effective that traditional interviews.

[15] It is unclear whether the authors meant ρ, and that *r* is a typographical error on their parts, or if they used the wrong statistical test considering their variable's format.

negatively to performance in dental school. No other relationship between dental school or board examination performance and socioeconomic background indicators reached a significance level.

6.3.4.3 Age

Age was found to be not significantly related to all selection tools reviewed, except for the extraversion/introversion item of the MBTI tests, where age was associated with lower extraversion scores (28.8 vs. 29.8, p=0.0005).

6.3.4.4 Geographical origin

None of the studies consulted addressed the issue of geographical diversity (i.e. rural/urban divide), and the potential impact of selections tools on this issue. In the medical context, contradictory results were observed. Raghavan et al. (64) found that applicants from rural high schools obtained significantly lower scores on the MMI compared with applicants from urban high schools (4.4 vs. 4.6), hinting that rural students might be disadvantaged by MMI format interviews. Another study found the opposite results. Wright & Woloschuk (65) examined the progression of rural students through the admission process. They found that, contrary to common belief, rural students were not disadvantaged by the interview process; their under-representation was rather based on the fact that fewer of them applied to medical school. No other selection tools seem to impact on geographical student diversity, in dental or in other high-stakes admission contexts.

6.3.4.5 Ethnic/racial background

Both for cognitive and non-cognitive assessment tools, ethnic and racial status were generally found to be not significantly correlated to selection tool performance.

6.3.4.6 Student Diversity overview

Therefore, our results regarding gender, socioeconomic background, age, geographical origin and ethnic/racial background suggest that the underrepresentation of certain population groups in a dental school's student body does not seem to result from biases linked to the selection tools used during the admission process. When exploring race-neutral alternatives to race-conscious policies, Steinecke, Beaudreau, Bletziger and Terrel (66) proposed three potential avenues to increase diversity while respecting the new US legal context: firstly, implementing a combination of lower thresholds for GPAs and MCAT and non-cognitive assessments tools; secondly, using Goggin's merit-aware index measures, which measures "the extent to which a student's achievement [on traditional performance measures] exceed[s] what could have been reasonably expected given his or her academic background" (p. 120); and thirdly, using a constrained optimization decision analysis to maximize the predictive power of predictor variables. Out of the three avenues, the merit-aware index seems to be most promising. Lopez and al. (15) reported on the University of Minnesota School of Dentistry revised admission process, which includes a measure similar to the merit-aware index that now accounts for 35% of the total admission score. The factors assessed include: extracurricular activities, volunteer and work experience, research and shadowing experiences, first-generation and underrepresented minority status, and personal statements. Merit-aware index-type initiatives are also part of more holistic "whole-file review" admission processes (67), and have shown considerable positive impact on diversity when implemented.

Even when appropriate strategies are implemented to increase diversity, other issues may hinder this process. Price et al. (68) highlighted five main issues that influence admission committees' effectiveness when trying to impact on student diversity: dental school's institutional climate toward diversity; presence of explicit admission committee's mission statement toward diversity; diversity in the composition of the committee itself; leadership and function of the admission committee in supporting and promoting diversity; and finally the presence of evaluation and selection

criteria that not only are not biased but also promote a diversified student body. Yet changes to the admission process alone may not be enough to attain the desired effects (65). Therefore, an increase in geographical diversity of dental students may not be attained by changing the selection tools or admission processes used, but on increasing recruitment efforts in these population sub-groups. Universities wanting to increase student diversity have to address all these issues in parallel with implementing changes in their admission processes to attain significant results. Therefore, other initiatives must be implemented if universities want to achieve greater student diversity. One of these avenues is through the implementation of a pipeline program.

6.3.4.7 Pipeline programs

The Pipeline, Profession, and Practice[16]: Community-based Dental Education program was initiated by the Robert Wood Foundation in 2001, and jointly funded by the latter, the California Endowment grant, and the W.K. Kellogg Foundation. The Pipeline program wishes to address the main oral health problems: access to oral health (accessibility), and the underrepresentation of certain minority groups in dentistry (equity). The main objectives of the Pipeline programs were: "to increase recruitment and retention of students from racial and ethnic groups that are underrepresented in dentistry, [and] to integrate community-based clinical experiences into the dental-school curriculum" (69). The rationale underlying these objectives is as follows. It is believed that practitioners coming from underserved backgrounds will be more effective in communicating with patients from these communities, and therefore will improve adherence to care regimen and access to care. Also, community-based clinical experience should develop in students' greater skills and abilities to interact with diverse patients, while directly increasing access to care for underserved communities. These goals were to be attained through five avenues:

- Underrepresented minority and low-income recruitment;
- Curricular changes;
- Extramural clinical rotation;
- Program evaluation by the National Evaluator Team, and continuous improvement of the programs; and
- Coaching and technical support (for instance through "train the trainees" workshops for admission officers) by the National Program Office's personnel (70).

In total, fifteen US dental schools participated in the first phase of the program (2002-2007), while eight others joined in for the second round of projects (2007-2010), for a total of twenty-three dental schools (71). Preliminary results are presented by project goals.

6.3.4.8 Recruitment of underrepresented minority (URM) students

Thirty-three different strategies were identified to be effective in recruitment of URM students (see Table 14) (72). The strategies most often cited were: recruitment of students in URM's colleges (n=13), presence of a pre-dental club (n=13), presence of a summer program (n=12), and to a lesser extent, presence of a post-baccalaureate program (n=10). The development of a long pipeline program with elementary and high schools and clinics was also perceived as an effective recruitment strategy by ten of the twenty-three respondents (see below for short and long pipeline definitions).

[16] Our goal is not to carry out an integral assessment of the Pipeline program, as this falls outside the scope of this review. Yet we feel that addressing dental schools' concerns over student diversity without at least offering an overview of the Pipeline program would be an inadmissible omission.

Table 14: Strategies identified to be effective in recruiting URM students by administrators (and number of times cited - Andersen et al. 2009, S239) (72)	
Recruitment at URM students' colleges (n=13)	Pre-dental club (n=13)
Summer program (n=12)	Post-baccalaureate program (n=10)
Developing a long pipeline with elementary and high schools and clinics (n=10)	Brochures (n=8)
Pipeline program (n=8)	Partnership with URM dental associations
Increased visibility of URM recruitment programs (n=7)	Scholarships (n= 6)
Regional post-baccalaureate program (n=5)	Changes in admission process (n=5)
Pre-dental advisors (n=5)	Faculty mentors (n=5)
URM student dental associations (n=4)	Partnership with medical school (n=4)
Travel and outreach (n=4)	Partnership with a community health centre (n=3)
Change in faculty attitudes (n=3)	Email advisements (n=3)
Pressure from state legislators (n=2)	Open admissions for out-of-state applicants (n=2)
Hiring a recruiter (n=2)	Pre-dental counsellor seminars (n=2)
Alumni groups (n=2)	Having students on admissions and recruitment committees (n=2)
Regional recruitment conferences and efforts (n=2)	Connecting with minority groups (n=2)
Eliminating institutional barriers (n=1)	Having administrative support for diversity (n=1)
Developing cohorts of URM students (n=1)	Increasing cultural sensitivity in dental school (n=1)
Change in interview process (n=1)	

There are two designs of pipeline programs. The short pipeline program targets students beyond high school, while the long pipeline program targets a wider audience (grades 11-12 until first and second-year of college). Activities in short program pipelines include mentoring programs, summer enrichment programs and pre-dental clubs and associations, all aiming for a more effective recruitment of URM. As a result of these activities, Andersen et al.(73) observed a 500% increase in URM students participating in short pipeline, an increase from n=493 in 2003 to n=2,466 in 2007. Greater URM student involvement was also observed for pre-dental clubs (n=1,345 in 2007), summer enrichment programs (n=396 in 2007), and special mentoring programs (n=311 in 2007). As for the long pipeline programs, which are "designed to ensure a continuous supply of talented URM students as members of the profession"(72), they were found to be controversial, "as outcomes of these programs are often difficult to track, and activities more expensive and distant from the payoff" (72).

The impact of the Pipeline program was also observed in the number of URM applicants and URM enrolees in the participating dental schools. Only for the first phase of the program (2002-2003 to 2006-2007) the number of URM applicants increased in all participating dental schools, for a total of a 180% increase (n=3249 in 2006-2007). This increase was observed for Hispanic students (176%, n=1518 in 2006-2007), for African-American (187%, n=1609 in 2006-2007) and for Native American (153%, n=122 in 2006-2007) (73) .

Other elements to Pipeline programs – Curricular changes

Many revisions occurred in participating dental school curricula, aiming at increasing students' cultural competence (74). Those include the addition of new classes and activities on cultural diversity and competence, the expansion of the cultural content in existing classes, and the revision of the academic program's structure to prepare for earlier rotations of community-service work. Additional emphasis was also placed on the importance of cultural competence in clinical setting throughout the curricula (74).

Other elements to Pipeline programs - Extramural clinical rotation

When launching the Pipeline program, one of the primary objectives of the Robert Wood Johnson Foundation was to have "senior students, as well as general and paediatric dentistry residents, spend an average of sixty days in patient-centred community clinics and practices treating underserved patients, [...] 25% of these being located in rural communities" (73). At the end of the first round of the Pipeline project, all participating dental schools had increased their community involvement. At the beginning of the program (2001-2002), students had participated in an average of 16 days of extramural rotation, compared to an average of 41 days in 2006-2007. A total of 344 community facilities participated in the project, 24% of them (n=98) located in rural communities (75).

Davidson et al. (2009) observed, however, that clinical rotation didn't have the expected effect on students' immediate future practice plans (next five years). At the beginning of their dental school curricula, students were questioned about their intention to provide care for underserved communities in their future practice. The same questions were asked at the end of their clinical rotation. Contrary to the expected outcomes, the authors observed no variation in students' intention to provide care for underserved communities. Financial barriers were most frequently stated as the main reason for this situation (76). Yet, specific characteristics were associated with an increase tendency to plan to provide care for underserved populations, such as being female (Inverted OR 1.21, $p<0.01$), being considered URM (OR = 3.23, $p<0.001$), being of Asian/Island Pacific descent (OR=1.88, $p<0.01$), having low income parents (OR=1.37 $p<0.001$), and (counter intuitively) in having educational debt higher than $168,000 ($r=1.49$ $p<0.001$).

Overall, results of the Pipeline program seem promising, especially if we look at the increase of URM number of applicants. Yet further research is needed to assess these initiatives' mid- and long-term influence in recruitment and retention of URM students, and on underserved population accessibility of dental care.

6.3.5 What can be learned from other disciplines

In the last five years, academics have shown interest in the validity and reliability of assessment tools in high-stakes selection contexts, especially in the medical school admission process. As there seems to be a relative consensus on the value of cognitive and academic tests for dental school selection, this section will concentrate on non-cognitive selection tests, as this is where the debate lies. The results of these studies are presented by discipline (Medicine, Nursing and Veterinary science).

6.3.5.1 Medicine school admission context

Out of the 183 articles consulted for this literature review, 143 pertained to Medical school admission tests or processes.

Interviews

As our results seem to indicate, unstructured and semi-structured interviews were of weak predictive and content validity in dental school admission context. Our findings corroborate those found in the medical context. No relationships were found between unstructured interview scores and cumulative medical school GPA, first-year medical school GPA, school merit ($p>0.05$, n= 513, (77), or licensing exam performance ($p>0.05$, n=441(78). Dahlin et al. (79) also concluded that, although the interview procedure seems to reduce the selection of students with inferior communication skills, it was not able to distinguish the students with superior fourth-year performance (GPA) from the rest of the applicant pool (n=137, $p>0.05$).

As for what was observed in the dental school context, interview format influences widely in its validity and reliability. Axelson et al. (40) performed three univariate G-studies (n=3,043 interview scores) and one multivariate G-study (n=168 re-test interview scores) to assess the reliability of unstructured and structured interviews. The authors concluded that both types of interviews simply didn't assess the same constructs, and that their mutual reliability could be increased by combining both formats.

Although in general studies seem to agree that structured interviews have higher predictive validity than their unstructured counterpart, the structured interviews' reliability and validity still vary widely. Using social network analysis, Dawson et al. (80) investigated the admission criteria that better predict student performance and their engagement in a social learning environment. Their results show that not only interview scores show a weak but significant correlation with first-year overall academic performance ($r = 0.253$, $p < 0.05$, n=132), but that they also correlate to learning community engagement (closeness component: $r = 0.311$, $p < 0.05$, eigenvector scores: $r = 0.152$, $p < 0.05$). Stansfield and Kreite (78) explored the reliability and validity of a structured interview. The authors found that raw interview scores did not predict United States Medical Licensing Examination (USMLE) Step II scores (after controlling for Step I), but that weighting interview ratings by estimated conditional reliability considerably improved its predictive validity (incremental $r^2= 0.121$, $P < 0.01$ for Step II). They also concluded that since raters tended to agree more about the lowest and highest quality applicant interviews, changing from a five to a three point scale may increase an interview's reliability. Still, these relationships stay weak, and account only for a small variation on Step II performance.

Medical school MMI was found to have better validity and reliability than both unstructured and structured interviews. Based on studies published in the medical context, MMI scores were significantly correlated with student academic performance ($r = 0.253$, $p < 0.05$, (80). As with traditional interviews, there seems to be differing expectations and understandings between applicants and examiners of what the MMI is assessing, for example, reasoning skills in areas such as teamwork and empathy vs. communication skills (81). Still, more research is needed to assess the predictive validity and reliability in the dental school admission context, even if MMI remains extremely promising.

Many of the studies also assessed different MMI's formats, to try to come up with a configuration that optimizes its validity and reliability. In light of these results, an effective MMI should have been between seven to ten interview stations (Cronbach $\alpha = 0.55$-0.79; (20, 82, 83). As for time per station, Dodson et al. (84) observed high correlations between 5- and 8-minute scores at single stations and between cumulative 5- and 8-minute scores, and that applicant ranking based on scores awarded after 5 and 8 minutes were almost identical. Therefore, 5 minute MMI stations could be considered, even if the authors concluded that the content of the station may influence the time needed.

Another issue of interviews as assessment tools is linked to truthfulness in applicants' interview answers, as reported by Kelley et al. (85). The authors assessed the validity of asking prospective students about their future career plans. Out of the ninety-five students interviewed, half (n=50) already had an idea about their future field of practice. Still, when asked during the interview if they had an idea of the aspect of medicine they planned to pursue, 34% (17/50) of them were not completely forthcoming and truthful, while only 58% (n=29/50) reported being truthful in their responses. The reason most commonly stated for this untruthfulness were: "My desire goes against the goal of the college of medicine, such as trying to develop physicians who will practice medicine in rural areas" (n=11); "Heard from sources that revealing true desire could possibly hinder my interview" (n=8); "Interviewed by a MD outside of the aspect of medicine I am interested in" (n=8), and "Was not sure how the interviewer would react" (n=7) (85).

These results seem to reinforce the argument that in high stakes situations, applicants have a tendency to give what they feel is the expected response, especially if they feel the real answer would hinder their chances of an admission offer.

Manual Dexterity tests

As with what was observed in the dental school's admission context, most of the studies on manual dexterity tests for medicine pertained to their validity as predictors of academic performance. The results seemed to infer little to no predictive abilities of manual dexterity tests. These findings were similar to those found in the dental admission context. Goldberg et al. (86) carried out a clinical study of manual dexterity assessment, using the Stromberg Dexterity Test (gross motor function of arm and hand coordination), the O'Conner Tweezer Test (fine motor function test where students are required to place 100 small pins in a ordered fashion into a pegboard using forceps), and the MIST-VR[17] laparoscopic simulator (requires virtual movement and placement of a ball into a container using alternated hands) (87). In total, 113 fourth-year medical students at Virginia Commonwealth University School of Medicine participated in the study. Academic performance was operationalized as USMLE Step I and II scores, and medical school class rank. The authors found no relationship between performance time on the three manual tests and medical school performance, except for gross dexterity that was significantly correlated with class rank ($r = -0.20$, $p=0.04$) and USMLE Step I scores ($r = 0.20$, $p=0.04$).

Goldberg et al. (86) also observed that participants who considered themselves to have good manual dexterity participated in more extracurricular activities involving manual dexterity, such as cooking, sports, video games, and playing musical instruments, and seemed to have better dexterity skills than those reporting not being good with their hands. Therefore, an alternate, more reliable way to assess manual dexterity could be through a proxy composite measure of self-assessment weighted by extracurricular activities scoring. This could be done through analysis of applicant's files and of interview answers at low cost.

Personality and value assessment

As for personality and value tests, our previous findings suggest that the validity and reliability of personality and values tests vary widely in the dental school context. These finding were corroborated by those observed in the medical school admission context.

NEO-PI-R

The weak to null validity of most of the NEO-PI-R dimensions observed in the dental school admission context is corroborated by studies in the medical context, although its validity seems to slightly increase throughout medical school (from $r^2 = 0.22$ for the first-year, to r^2 0.56 for the seventh-year, $p<0.05$, $n= 631$) (88). Doherty (89) performed a review of the literature (2000-2009) to try to determine which of the personality dimensions influenced both medical students' and doctors' performance. They found that only one of the dimensions – conscientiousness – seems to be associated in a consistent manner to academic and clinical performance in the literature.

Furthermore, there seems to be debate about the truthfulness of applicants' answers on NEO-PR-I test, and that these considerations relate especially to the dimensions that seem to have the highest predictive validity. Using

[17] Developed by a joint venture between the North England Wolfson Center for Minimally Invasive Therapy and Virtual Presence Ltd., MIST-VR is a part-task virtual reality laparoscopic simulator.
For more information, see 87. Chaudhry A, Sutton C, Wood J, Stone R, McCloy R. Learning rate for laparoscopic surgical skills on MIST VR, a virtual reality simulator: quality of human-computer interface. Annals of the Royal College of Surgeons of England 1999;81(4):281.

scores outside the 95% CI, Griffin and Wilson (90) explored the extent of self-enhancement of medical schools applicants on NEO-PI-R test. The authors found that 62.7% of the applicants' samples were deceptive on at least one of the five personality scales (with 4.8% who had self-enhanced on all five scales). They also found that more candidates (33.7%) were deceptive on conscientiousness than on any other factors (neuroticism 26.7%, extraversion 21.7%, agreeableness 19.3% and openness 14.3%), which ironically was found in our review to be the one factor with the most predictive power. NEO-PI also seems to have weak convergent/divergent validity, as no significant relationship was found between the five personality factors and any of the cognitive and non-cognitive measures used in admission process (GPA, MCAT, interview scores) (91).

Autobiographical essays

None of the studies published between the years 2007-2013 assessed the validity of autobiographical essays in the dental context. Yet, findings in the medical context suggest weak predictive validity and reliability, as high expectancy bias is associated with this type of selection tool[18]. Essay scores were not related to any of the performance measures during medical school or their internship (92, 93). Hanson et al. (94) compared the results of on-site (controlled) and off-site (non-controlled) performance of students' autobiographical submission scores. They found that candidates' mean performance scores were significantly higher when completed off-site, and that off-site scores were non-predictive of scores assigned to onsite autobiographical essay submissions ($r = 0.16$), which seems to indicate that candidates were not writing their essays alone when off-site, and casts doubt on the truthfulness of their answers. These findings were corroborated by White et al. (95), who examined 210 essays and 30 pilots of 2007 medical students of a Canadian medical school (name undisclosed). The authors proposed a theory named "What do they want me to say?" to describe the ways in which applicants modulate their responses to conform to their expectations of the selection process, and revealed tension between "genuine" and perceived "expected responses" by applicants. Also, applicants and raters seem to have different approaches to the essay questions (96), which may explain its lack of validity.

Situational Judgement tests

As our findings suggest, SJT was found to have weak convergent and predictive validity in dental school context. Yet, these findings were based on one study only, and these findings contradict those of a large body of literature on medical selection tools which found the opposite results. In fact, Patterson et al. (5) performed a comprehensive literature review of MEDLINE, PsychINFO, and Web of Science for the years 1990-2010 (n=76 articles). The authors concluded that "situational judgment tests have good levels of reliability, predictive validity and incremental validity for testing a range of professional attributes, such as empathy and integrity, […] and can test a broad range of non-academic constructs depending on the selection context (so can be tailored to context)" (5). The instrument is a cost-efficient methodology compared with high-fidelity assessments of non-academic attributes, such as those used in objective structured clinical examinations. Also, the instrument seems positively received by candidates, who think of it as reliable, fair and adequate.

In addition, three other selections tools and processes pertaining to non-cognitive assessment in medical school admission were reviewed: the Anatomical Self-Efficacy instrument (ASE), the Computer-based Multiple Sample Evaluation of Noncognitive Skills (CMSENS), and Hogan's Development Survey.

[18]In this case, high expectancy bias refers to the tendency to give the expected response to an essay question, instead of being entirely truthful.

Anatomical self-efficacy instrument (ASE)

This tool consisted of 16 anatomical self-efficacy items, based on the college biological literacy self-efficacy instrument for non-majors (97). The purpose of the ASE is to assess the respondent's beliefs in his or her ability to successfully complete a task relating to the anatomy curriculum (for example, dissecting, learning and applying concepts,...). Students' clinical performance was assessed through four laboratory tests, each pertaining to different anatomical regions of the human body (upper and lower limbs, and back, etc.). Results showed that ASE's ratings predicted all four laboratory practical scores ($p<0.05$).

Computer-based Multiple Sample Evaluation of Non-cognitive Skills (CMSENS)

In their study of Michael G. DeGroote School of Medicine applicants (n=82), Dore et al. (98) aimed to assess the psychometric qualities and the reliability of a new assessment test, the CMSENS. The CMSENS's pilot consists of eight 60 seconds video-based vignettes, and of four self-descriptive questions, with a short-answer-response format. All pertain to ethical or groups dynamic challenges that may occur in a medical context. The purpose of this tool is to use the same psychometric principles as the MMI and Objective Structured Clinical Examination OSCE, while increasing its scalability by using a computerized format. The results show high overall generability (both for audio G=0.86 and typewritten version G= 0.72) and interrater reliability (audio r=0.82, typewritten r=0.81). With correction for disattenuation, CMSENS scores also show moderate concurrent validity, being positively correlated to MMI scores (r=0.60, $p<0.05$, n=167) and with the MCAT's verbal reasoning scores (r=0.38, $p<0.05$, n=167).

Hogan's Development Survey (HDS)

Developed in 1997 by Drs Roberts and Hogan of the University of Tulsa, the Hogan's Development Survey (HDS) is an eleven scale measurement tool that assesses harmful behaviours, which are referred as "dark sides personality traits". Hogan's eleven dimensions are clustered in three different groups. Cluster A measures people's ability to "work under pressure, as well as teamwork and interpersonal skills", and includes five personality dimensions: excitable, skeptical, cautious, reserved, and leisurely. Cluster B measures people's attitude about uncertainty and risk taking, and includes four personality dimensions: bold, mischievous, colourful, and imaginative. Cluster C measure people's compliance and attention to details, and includes two personality dimensions: diligent and dutiful. Knights and Kennedy (99) assessed HDSs' predictive validity in an Australian undergraduate medical program. The authors found that HDS was able to detect negative personality characteristics that were not detected by the structured admission interview. Cluster A dimensions (excitable, skeptical, cautious, reserved and leisurely) were renamed "moving away syndrome" and were associated by the authors with DSM-III's borderline personality disorder. Cluster B dimensions (bold, mischievous, colourful, imaginative) were renamed "moving against syndrome" and associated with DSM-III personality disorder of antisocial conflict. The last cluster (dimensions- diligent and dutiful) was renamed "moving toward" people and was associated with DSM-III's dependent and obsessive-compulsive disorder. The authors observed that 0.8% of the respondents reported extreme tendencies on the syndrome scale of "moving away", 10.7% of the respondents reported extreme tendencies on the syndrome scale of "moving against", and 33% reported extreme tendencies in the syndrome scale of "moving toward".

6.3.5.2 Nursing school admission context

One of the 183 studies reviewed pertains to an admission process in the nursing school context. Underwood and al. (100) assessed the reliability and validity of Elsevier's HESI[19] (A^2) exam on student performance. The A^2 is a cognitive test that consists of three academic categories: English language (reading comprehension, vocabulary & general knowledge, and grammar), basic math skills, and science (biology, chemistry, anatomy & physiology, and physics).

[19] HESI was not defined on Elsevier's website, nor in the article citing this tool.

The sample consisted of 184 nursing students, while performance was monitored in three different courses: NU301 (fundamentals of nursing), NU302 (community health nursing), and NU305 (health and physical assessment). Results show that A^2 is a good predictor of academic performance in nursing school, being related to NU301 (r=0.564, p≤0.01, β = 0.213, p≤0.01, n=184), RU302 (r=0.604, p≤0.01, β = 0.269, p≤0.01, n=184), and RU305 final grades (r=.518, p≤0.01, β = 0.318, p≤0.01, n=184).

6.3.5.3 Veterinary school context

Two studies reviewed pertained to selection tools in the veterinary schools' admission context: one assessed the validity and reliability of MMI, and the other a supervised essay. Hecker and Violato (101) investigated the reliability and concurrent validity of using essays for veterinary medical school admissions. In total, 103 applicants at the University of Calgary's School of Veterinary Medicine were asked to write a 750 word-count, one hour-long supervised essay regarding their interest in veterinary medicine and practice. Results show reliability coefficients of G= 0.52 with two raters. Based on decision study results, increasing the number of raters to three and the number of items to four also is believed to potentially increase the reliability coefficient to G=0.68. Hecker and Violato (83) also investigated the reliability of the MMI process at Calgary's School of Veterinary Medicine. Using generalisation theory, the authors estimated that the MMI had satisfactory reliability (overall G-coefficient=0.79; inter-rater reliability=0.52, and the interstation reliability=0.25), and that systematic error and varying scores of applicants across interviewers and stations accounted for 37.22% of the variation (σ = 2.255). In summary, University of Calgary's MMI seems to be a reliable, although its predictive validity has not been assessed in a veterinary school context.

7 Discussion

After reviewing the literature and evaluating potential assessment tools during the dental school admission process, we found that some DAT components (mainly DAT-AA, DAT-QR and DAT-RC) and Pre-dental Overall and Science GPA scores still represent the best predictors of academic performance of dental students, and seem to have some correlation with clinical and board examination performance as well, even though the strength of these relationships is only weak to moderate. Yet, some questions remain about the concurrent validity of the DAT-PAT, since its results were not compared with those of any other forms of perceptual ability assessment. Our results also suggest that combining cognitive assessment tools together (22), but also with non-cognitive assessment tools (36) considerably increases their predictive validity. The debate still remains regarding which non-cognitive tools to use.

Interviews remain a popular way to assess non-cognitive and personality traits. Our findings show that increasing the structure of the interview, whether it is through a structured or MMI format, drastically increases its reliability and validity. As for comparing MMI and structured interview, our findings seem to indicate that MMI have a slightly higher reliability, although more research is needed to be able to arrive to more definite results.

Manual dexterity test were found to have null to weak predictive validity on student performance. That being said, manual dexterity can perhaps be utilized as an effective screening tool in admissions and has been shown in the past to reduce attrition rates in dental school.

Two of the Emotional Competency Inventory items (relationship management and self-management) were found to be a good predictor of clinical performance. Yet, we feel it is impossible at this point to arrive at a definite conclusion on the basis of a sole study, especially one with such a small sample size (n=100). Therefore, in this case as well, more research is required before we can make a definitive statement about its reliability and predictive validity in the dental school admission context.

As for NEO-PI-R, and autobiographical essays, our findings suggest that they are not reliable for predicting performance, and concerns can be raised regarding their usefulness in a high-stakes context. Finally, in trying to assess non-cognitive abilities, findings concerning the use of Situational Judgement Tests are promising but more research is needed to fully understand their impact in the dental school context.

Many aspects have to be investigated to assess the quality and value of the selection tools. Yet, most of the reviewed articles only focused on predictive and convergent/divergent validity, and to a lesser extent, on concurrent validity. Face, construct and content validities of the selection tools were only assessed in the case of MMI. Concerning the reliability, this aspect was only addressed by a few studies pertaining to manual dexterity tests (tweezers, computer-assisted dental simulation) and structured interviews. Therefore, based on this review, there are still many areas that need to be explored and researched before any well-informed statement upon the validity and reliability of these selection tools can be made. As for other limits of the article reviewed, most of the results were based on correlations and/or descriptive statistics analysis. So it is impossible to infer causality from these tests, highlighting the need for further research in this area as well.

When it comes to achieving greater student diversity, our findings suggest that students of diverse background (rural/minority) are not disadvantaged by the selection tools currently used in dental admission processes. Therefore, other initiatives such as URM recruitment and pipeline-type programs should be implemented if universities want to achieve greater student diversity. Our literature review suggested different possible avenues to achieve this goal.

8 Recommendations

Based on the findings of the literature review and interviews, the working group makes the following recommendations:

1. The current CDA Dental Aptitude Test Sub-Committee should be replaced by a national Admissions Committee jointly administered by the CDA and the ACFD. The membership of the new Admissions Committee should include:
   - admissions officers from each of the 10 dental schools
   - individuals with expertise in admissions and relevant research
   - individuals with expertise in assessing the validity and reliability of admissions tools
   - individuals with expertise in generating items, scenarios and elements of non-cognitive tests (e.g. MMIs and structured interviews)
   - administrative support
2. The mandate of the new national Admissions Committee needs to be broadened to include the following functions:
   - Development of guidelines concerning overall student selection and admissions processes (i.e. beyond simply oversight of the DAT);
   - Development of guidelines on the use of specific tools and processes to ensure they are used appropriately e.g. cut-off scores, use for screening etc.;
   - Training on the use of admissions tools;
   - Development of elements of tests and processes (e.g. questions for structured interviews or scenarios for MMIs); and
   - Oversight of evaluating the validity of admissions tools and processes.
3. The new national Admissions Committee needs to be appropriately funded to enable the performance of the expanded mandate outlined above.
4. All admissions tools that the new national Admissions Committee recommends to the schools for consideration in their admissions processes:
   - must be available in both English and French
   - must be at an appropriate academic level to be able to be administered to all applicants to dental programs in Canada, specifically to have a level playing field for University-based and CEGEP-based applicants
5. Efforts to investigate validation of tests should focus on those showing promise:
   - DAT-AA (Academic Average); DAT-QR (Quantitative Reasoning); DAT-RC (Reading Comprehension)
   - Overall predental GPA; Science GPA
   - MMI; Structured interviews
   - Combinations
6. As the DAT-CD (Manual Dexterity Test) is currently being used by seven of the ten dental schools in Canada, evaluation of the validity and reliability of this admission test component needs to be undertaken, including its most appropriate use.

7. Efforts should be made by dental schools to focus their admissions processes on tools with the strongest evidence to support them, while ceasing the use of approaches that have little evidence to support them and/or with evidence that shows the tools are not effective in the admissions process.
8. Efforts should be focused on the recruitment of appropriate candidates as well as the processes used to select them.

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10 Appendices

Appendix A: Questionnaire sent to all dental schools

Appendix B: Interview guide for dental schools

Appendix C: Interview guide for other dental stakeholders

Appendix D: Tables summarizing validity studies in the literature review

Appendix A

Summary of Admissions Processes in Canada

What Admissions Tools Are Currently Being Used

	Dental school A	
	Used in Admissions	
GPA		
DAT		
Unstructured Interview		
CDA Structured interview		
Structured Interview (Not CDA)		
PBL evaluation		
NEO-PI-R Personality inventory		
Curriculum vitae		
Letters of reference		
Personal statement		

How Admissions Tools are used

	% Weight	Minimum Cut Score
GPA		
DAT		
Academic Average		
Reading Comprehension		
Natural Sciences		
Perceptual Ability		
Manual Dexterity		
Unstructured Interview		
CDA Structured interview		
Structured Interview (Not CDA)		
PBL evaluation		
NEO-PI-R Personality inventory		
Curriculum vitae		
Letters of reference		
Personal statement		

Institution:	
Name:	**Dr.**

Question	**Response**
1. What factors should be evaluated in candidates with a view to admissions to dental school (examples could include cognitive and non-cognitive attributes)?	
2. What instruments and/or techniques should be used to evaluate these attributes?	
3. What other admissions tools would you like to incorporate into your admissions process and why?	
4. Minimum cut scores are used for some admissions components by some schools but there is a great deal of variation in the cut scores chosen (see examples below). Perceptual Ability 10-15 Manual Dexterity 3-15 Should a minimum cut score be recommended for DAT test components?	
5. Do you feel there is value in having a standardized admissions test (DAT or some other standardized test) to all applicants to Canadian Dental Schools?	

All 10 schools use an interview in their admissions process. Structured interviews are used in 9 of the 10 schools. 5 of the 9 schools using a structured interview use the CDA Structured Interview.

6. If the CDA Structured Interview is **NOT** used, what are the reasons?	
7. How should the DAT and its test components be improved?	
8. If you answered YES to Q7, what test components should be included?	
9. What do perceive are inherent flaws in the tools you currently use?	
10. How do deal with the flaws in your admissions process (security, calibration for interviews, etc.)?	
11. Is there a desire to have a national admissions test battery for dental schools to utilize?	
12. If you answered YES to Q11, why is a national admissions test important?	
13. If a new national Admission Committee was established to serve the needs of the 10 Canadian dental schools, what should be included in the terms of reference for this committee?	

14. Are any other admissions tools being used at your dental school that do **NOT** appear on the **Admissions Survey** sheet?	
A follow-up call will be scheduled with at least two of the ad hoc Committee members. Please advise of the best days and times for a conference call to be arranged.	

Appendix B

CDA-ACFD DAT Review Working Group

Interview Questions

January 2013

1. Please provide a rationale for each of the admissions tools used at your institution.

2. What are the reasons for rejecting some admissions tools that your school has considered?

3. What concerns do you have with the admissions tools currently being used at your institution?

4. Are there any factors/constructs/phenomena that you think should be evaluated in dental admissions processes but which are not currently evaluated? And if so, do you have any idea how we could evaluate such factors?

5. Are you aware of any experts in the field of selection/admissions tools that should be consulted in this process?

6. Non-cognitive attributes have been identified as an important component of the admissions process. The CDA Structured Interview was designed to measure those attributes. Should effort be made to improve the CDA structured Interview or should another assessment method be sought?

7. What tests should be included in a national standardized test battery?

8. The CDA has been responsible for the management and administration of the DAT. What suggestions do you have for the structure and function of a Committee charged with this responsibility in the future?

9. What outcomes would you like to see from the ACFD-CDA DAT Working Group?

Appendix C

ACFD-CDA DAT Review Working Group
Interview Questions
ACFD, CDA, CDAC, CDRAF, NDEB

May 2013

1.Does your organization have an interest in admissions policies and procedures used at Canadian dental schools?

2. If the answer is NO, there is no need to go further.

3. If the answer is YES, please explain.

4. What do you know of the various admissions tools and policies used by Canadian dental schools?

5. What concerns do you have with the admissions tools currently being used to admit students to Canadian dental programs?

6. Are there any factors/constructs/phenomena that you think should be evaluated in dental admissions processes but which, as far as you know, are not currently evaluated or are inadequately evaluated? And if so, do you have any idea how we could evaluate such factors?

7. Are you aware of any experts in the field of selection/admissions tools that should be consulted in this process?

8. Non-cognitive attributes have been identified as an important component of the admissions process, including assessment of manual dexterity, perception of spatial relationships, and ethical/professional attitudes. The CDA Structured Interview and the CDA DAT were designed to measure those attributes. Should effort be made to improve the CDA Structured Interview and CDA DAT or should other assessment methods be sought?

9. The CDA has been responsible for the management and administration of the DAT. What suggestions do you have for the structure and function of a Committee charged with this responsibility in the future?

10. How do you think your organization and/or its members could contribute to the process of admissions to dental programs in Canada?

11. What outcomes would you like to see from the ACFD-CDA DAT Working Group?

ACFD-CDA DAT Review Working Group
Interview Questions
ADA

May 2013

1. What are the most significant concerns regarding the admissions process or admissions tool identified by Admissions officers in US dental schools?

2. Are there any factors/constructs/phenomena that you think should be evaluated in dental admissions processes but which are not currently evaluated? And if so, do you have any idea how we could evaluate such factors?

3. Are you aware of any experts in the field of selection/admissions tools that should be consulted in this process?

4. Non-cognitive attributes have been identified as an important component of the admissions process. What admissions tools are currently being used or are being evaluated to assess non-cognitive attributes?

5. Are Admissions officers in the US schools concerned about assessing manual dexterity in the admissions process?

6. If YES, are there any tests being considered to assess manual dexterity?

TABLE D1: GPA

Authors (year)	Country (University)	Study participants	Validity[20]	Reliability	Potential internal/external biases	Scalability?	Impact on diversity
1. Overall Pre-dental School GPA							
Alzahrani, M. J., E. M. Thomson, et al. (2007) (21)	US (Old Dominion University /Gene W. Hirschfeld School of Dental Hygiene)	1998-2002 admission cycle's matriculated students (n=146 for graduation, n=130 for NBDHE)	**Predictive validity**: NS for graduation within two years of admission and NBDHE scores				
American Dental Association (2012) (22)	US: Multiple Universities/ Dental schools	2009-2010 American dental schools (2009, n=49; 2010,n=47; all students admitted)	**Predictive validity**: moderate positive correlation with first and second-year Biomedical Grade (median *r*=0.32 and 0.35), first and second-year GPA (median *r*=0.33 and 0.37), and weak positive correlation with first and second-year Pre-clinical Dental Techniques grade (median *r*= 0.23 and 0.29)				
Arnold, W. H., P. Gonzalez, et al. (2011)	Germany (University of	1993-2001 admission cycle's	**Predictive validity**: moderate positive correlation with natural				

(23)	Witten /Herdecke)	matriculated students (n=194 for first dental exam, n=193 for national science exam, and n=163 for state board exam)	science examination (r=0.343 r^2 = 0.12, p<0.001), and weak positive correlation with first dental examination and state board examination scores (r= 0.268 and 0.269 respectively, p< 0.001 r^2=0.07) **Convergent/Divergent validity**: significant positive correlation with unstructured interview (R=0.238, p< 0.001)
Curtis, D. A., S. L. Lind, et al. (2007) (25)	US (University of California / School of Dentistry)	2001-2005 graduating classes' normally tracking students (n=49) and underachieving students (n=45)	**Predictive validity**: Normally tracking students: moderate positive correlation with fourth-year GPA (r=0.33 p< 0.05) but non significantly correlated with firs-year GPA Underachieving students: weak positive correlation with first-year GPA (r=0.26 p< 0.05) but non significantly correlated with fourth-year GPA. Multiple regressions: NS for both groups for Y1 and Y4.
Gardner, S. P. and K. F. Roberts-Thomson (2012) (38)	Australia (University of Adelaide)	2003-2009 admission cycle's applicants (n=216)	**(uGPA/STAT) Predictive validity:** Significantly associated with achieving three or more credits in year 1 (RR 0.38 p=0.008 vs. 150 and up), but

			not for year 2 and 3		
Holmes, D. C., J. V. Doering, et al. (2008) (26)	US (University of Iowa / College of Dentistry)	2000-2007 graduate students (n= 574)	**Predictive validity**: moderate positive correlation to Dental school GPA (*r*= 0.529), NBDE Part I and II (*r*= 0.497 and 0.433), and weak positive correlation with Final Clinical grade (*r* = 0.276). **Concurrent validity**: Weak **Convergent/ divergent validity**: strong positive correlation with pre-dental Science (*r*=0.936), and moderate positive correlation with DAT Academic Average, DAT Perceptual Ability, and DAT Total science scores (*r* = 0.252 - 0.400).		
Kim, M. and J. I. Lee (2007) (24)	Korea (Seoul National University)	2005 admission cycle matriculated first semester student (n=90)	**Predictive validity**: positively related to achievement in first semester (β=.242, *p*< 0.01). **Convergent/Divergent validity**: No significant relationship with MEET/DEET, oral exam and interview scores.		
Kingsley, K., J. Sewell, et al. (2007) (12)	US (University of Nevada /School of Dental Medicine)	2002-2004 admission cycle's matriculated	**Predictive validity**: non significantly correlated with NBDE-1 and Dental School GPA		**Ethnic/racial**: Non minority students have significantly higher scores than minority

		students (n=275)		students(3.38 vs. 3.20, *p*= 0.02) **Gender bias**: NS
Lopez, N., K. Self, et al. (2009) (15)	US (University of Minnesota/ School of Dentistry)	2007-2008 admission cycle applicants (n=1838)		**Ethnic/racial**: minority students had lower weighted GPA than non minority students. **Gender**: NS
Rich, A. M., K. M. S. Ayers, et al. (2012) (39)	New Zealand (University of Otago, Faculty of Dentistry)	students admitted into their second year of dental school between 2004-2009 (n=411)	**Predictive validity**: comparing students with pre-dental GPA above and under 82%: NS with graduation with distinction, any subject distinction, any subject prize, or remedial examination request	

2. Pre-dental College Science GPA

Alzahrani, M. J., E. M. Thomson, et al. (2007) (21)	US (Old Dominion University /Gene W. Hirschfeld School of Dental Hygiene)	1998-2002 admission cycle's matriculated students (n=146 for graduation, n=130 for NBDHE)	**Predictive validity**: non significantly related with graduation within two year of admission and NBDHE scores	
American Dental Association (2012) (22)	US: Multiple Universities/ Dental schools	2009-2010 American dental schools (2009,	**Predictive validity**: moderate positive correlation with first and second-year Biomedical grades	

		n=49; 2010,n=47)	(median *r*=0.33 and 0.32), first and second-year GPA (median *r*=0.35 and 0.37) and weak positive correlation with first and second-year Pre-clinical Dental Techniques grades (median *r*= 0.24 and 0.28)
Arnold, W. H., P. Gonzalez, et al. (2011) (23)	Germany (University of Witten /Herdecke)	1993-2001 admission cycle's matriculated students (n=194 for first dental exam, n=193 for national science exam, and n=163 for state board exam)	**Predictive validity**: natural science examination subject grade: moderate positive correlation with biology scores (*r*=0.276, r^2 = 0.07 p=0.008), and chemistry (*r*= 0.623, r^2 = 0.38 p=0.023), but NS with physics scores (p=0.27) **Convergent/Divergent validity**: significant positive correlation with unstructured interview (R=0.238, p< 0.001)
Curtis, D. A., S. L. Lind, et al. (2007) (25)	US (University of California / School of Dentistry)	2001-2005 graduating classes' normally tracking students (n=49) and underachieving students (n=45)	**Predictive validity**: Normally tracking students: weak positive correlation with first and fourth-year GPA (*r*=0.27 and 0.32, p<0.05), Underachieving students: non significantly correlated with first and fourth-year GPA . Multiple regressions: NS for both groups for Y1 and Y4

Holmes, D. C., J. V. Doering, et al. (2008) (26)	US (University of Iowa College of Dentistry)	2000-2007 graduate students (n= 574)	**Predictive validity**: moderately correlated to Dental school GPA (*r*= 0.537) and NBDE Part I and II (*r*= 0.527 and 0.460), and weakly correlate with Final Clinical Grade (*r* = 0.277). **Concurrent validity**: unable to distinguish between those who passed CRDTS EXAM and those who failed. **Convergent / Divergent validity**: strongly correlated with overall pre-dental GPA (*r*=0.936), and moderately correlated with DAT Academic Average, DAT Perceptual Ability, and DAT Total science scores (*r*=0.288 - 0.472).		
Kingsley, K., J. Sewell, et al. (2007) (12)	US (University of Nevada, School of Dental Medicine)	2002-2004 admission cycle's matriculated students (n=275)	**Predictive validity**: non significantly correlated with NBDE-1 and Dental School GPA		**Ethnic/racial**: Non minority have higher scores than minority (3.26 vs. 3.05) **Gender**: NS
Park, S. E., J. D. Da Silva, et al. (2010) (28)	US (Harvard /School of Dental Medicine)	2001-2005 graduate students (n=159)	**Predictive validity** : non significantly correlated with performance in TXAD with Honours (OR 3.9, p=0.10)		

3. GPA-Pathology

Alzahrani, M. J., E. M. Thomson, et al. (2007) (21)	US (Old Dominion University /Gene W. Hirschfeld School of Dental Hygiene)	1998-2002 admission cycle's matriculated students (n=146 for graduation, n=130 for NBDHE)	**Predictive validity**: related with graduation within two years of admission (β=1.0967 , p=0.0008) and NBDHE scores (β =2.98093 p<0.0001)

4. GPA-Microbiology

Alzahrani, M. J., E. M. Thomson, et al. (2007) (21)	US (Old Dominion University /Gene W. Hirschfeld School of Dental Hygiene)	1998-2002 admission cycle's matriculated students (n=146 for graduation, n=130 for NBDHE)	**Predictive validity**: non significantly related with graduation within two years of admission and NBDHE scores

5. GPA-Chemistry

Alzahrani, M. J., E. M. Thomson, et al. (2007) (21)	US (Old Dominion University /Gene W. Hirschfeld School of Dental Hygiene)	1998-2002 admission cycle's matriculated students (n=146 for graduation, n=130 for NBDHE)	**Predictive validity**: non significantly related with graduation within two years of admission and NBDHE scores

6. GPA-Oral Anatomy

Alzahrani, M. J., E. M. Thomson, et al. (2007)	US (Old Dominion University /Gene W.	1998-2002 admission cycle's	**Predictive validity**: non significantly related with

(21)	Hirschfeld School of Dental Hygiene)	matriculated students (n=146 for graduation, n=130 for NBDHE)	graduation within two years of admission but significantly related to NBDHE scores (β=3.31188 p< 0.0001)

7. GPA-Anatomy

Alzahrani, M. J., E. M. Thomson, et al. (2007) (21)	US (Old Dominion University /Gene W. Hirschfeld School of Dental Hygiene)	1998-2002 admission cycle's matriculated students (n=146 for graduation, n=130 for NBDHE)	**Predictive validity**: non significantly related with graduation within two years of admission and NBDHE scores

TABLE D2: DAT

Authors (year)	Country (University)	Study participants	Version	Validity	Reliability	Potential internal/external biases	Scalability?	Impact on diversity
1. DAT- Academic Average (AA)								
Allareddy, V., T. H. Howell, et al. (2012) (30)	US (Harvard/ School of Dental Medicine)	2005-2006 graduate students (n=66)	**US**	**Predictive validity**: non significantly correlated with obtaining Honours mention in first and third-year comprehensive examination, but significantly correlated with obtaining Honours mention in second-year examination (OR 0.08, p=0.06)				
American Dental Association (2012) (22)	US: Multiple Universities/ Dental schools	2009-2010 American dental schools (2009, n=49; 2010,n=47)	**US**	**Predictive validity (all p<0.05)**: moderate positive correlation with first-year Biomedical grades (median *r*=0.32) and first-year GPA (median *r*=0.30), and weak positive correlation with second-year Biomedical grades (median *r*=0.24), second year GPA (median *r*=0.26) and first and second year Pre-clinical Dental Techniques grades (median *r*= 0.17 and 0.15)				
Behar-Horenstein, L. S., C. W. Garvan, et al.	US (University of Florida /School of	2006-2008 graduate students	**US**	**Predictive validity**: Predicts NBDE Part I scores (scope not defined,				**Gender**: males score higher than

(2011) (31)	Dentistry)	(n=209)		p<0.001) but not Part II	females (19.9 vs. 19.4 p=0.084
Curtis, D. A., S. L. Lind, et al. (2007) (25)	US (University of California / School of Dentistry)	2001-2005 graduating classes' normally tracking students (n=49) and underachieving students (n=45)	**US**	**Predictive validity**: Normally tracking students: moderate positive correlation with first-year GPA (*r*=0.36 p<0.05) and weak positive correlation with fourth-year GPA (*r*=0.28 p<0.05), Underachieving students: non significantly correlated with first and fourth-year GPA Multiple regressions: NS for both groups for Y1 and Y4	
Holmes, D. C., J. V. Doering, et al. (2008) (26)	US (University of Iowa / College of Dentistry)	2000-2007 graduate students (n= 574)	**US**	**Predictive validity**: moderate positive correlation to Dental school GPA (*r* = 0.494), and NBDE Part I and II (*r*= 0.610 and 0.524), and weakly correlated to Final Clinical Grade (*r* = 0.204) **Concurrent validity**: NS **Convergent/ divergent validity**: Strong positive correlation to DAT Total Science scores (*r*= 0.899) and moderately correlated to DAT Perceptual Ability scores (*r*= 0.504)	
Kingsley, K., J. Sewell, et	US (University of Nevada /School	2002-2004 admission cycle's	**US**	**Predictive validity**: non significantly correlated with	**Ethnic/racial**: NS

al. (2007) (12)	of Dental Medicine)	matriculated students (n=275)		NBDE-1 scores and Dental School GPA		**Gender**: NS
Poole, A., V. M. Catano, et al. (2007) (19)	Canada (Four Dental schools names undisclosed)	Year undisclosed - dental school students, Y1 to Y4 (n=373 Y1, n= 237 Y2, n=176 Y3, and n=161 Y4)	**Canadian**	**Predictive validity**: modest positive correlated with first-year GPA (r=0.46 p<0.01), Y2 clinical (r=0.23 p<0.05) and Y2 academic GPA (r=0.52 p<0.01), but non significantly correlated with Y3 clinical or academic GPA and Y4 academic and clinical GPA- corrected for range restriction and measurement error **Concurrent validity**: matriculated participants have a higher DAT scores than applicant pool (17.36 SD 2.64 vs. 19.15 SD 2.42) **Convergent /Divergent validity**: moderate positive correlation with DAT reading comprehension (r=0.63 p<0.01) and perceptual ability (r=0.41 p<0.01), and weak positive correlation with academic average (r=0.14 p<0.05)		
Victoroff, K. Z. and R. E. Boyatzis (2013) (36)	US (Case Western Reserve University / School of Dental Medicine)	Year undisclosed - third and fourth-year students (n=100)	**US**	**Predictive validity**: positively correlated with Didactic GPA (Model 1 β= 0.424 p≤ 0.001; Model II β= 0.442 p≤ 0.001), and negatively correlated with		**Gender**: NS **Age:** NS

				Preclinical GPA Model 1 NS; Model II β= - 0.342 p≤ 0.001; Model III β= - 0.336, p≤ 0.001), but non significantly correlated with clinical GPA (all 3 models: Y3-Y4) **Convergent/Divergent validity**: moderate positive correlation with DAT-PAT (*r*=0.266)	
2. DAT- Perceptual Ability Test (PAT)					
Allareddy, V., T. H. Howell, et al. (2012) (30)	US (Harvard/ School of Dental Medicine)	2005-2006 graduate students (n=66)	**US**	**Predictive validity**: NS with obtaining Honours in first, second and third comprehensive examination	
American Dental Association (2012) (22)	US: Multiple Universities/ Dental schools	2009-2010 American dental schools (2009, n=49; 2010,n=47)	**US**	**Predictive validity (all p<0.05)**: weak positive correlation with first and second year Biomedical Grades (r= 0.27 and 0.21), First year and second year GPA (r=0.24 and 0.19) and first and second year pre-clinical dental techniques grades (r= 0.12 and 0.12	
Behar-Horenstein, L. S., C. W. Garvan, et al.	US (University of Florida /School of	2006-2008 graduate students	**US**	**Predictive validity**: NS for NBDE Part I, but almost significantly	**Gender**: males score higher than females (18.4 vs.

(2011) (31)	Dentistry)	(n=209)		predicts Part II (p=0.08)	17.5 p=0.004
Curtis, D. A., S. L. Lind, et al. (2007) (25)	US (University of California / School of Dentistry)	2001-2005 graduating classes' normally tracking students (n=49) and underachieving students (n=45)	**US**	**Predictive validity**: Multiple regressions and correlations: NS for both normally tracking students and underachieving students Y1 and Y4	
Holmes, D. C., J. V. Doering, et al. (2008) (26)	US (University of Iowa / College of Dentistry)	2000-2007 graduate students (n= 574)	**US**	**Predictive validity**: (all p<0.05) Moderate positive correlation with NBDE Part I (r=0.363), part II (r= 0.344), Dental school GPA (r=0.370) and final clinical grade(r=0.259)	
Kim, M. and J. I. Lee (2007) (24)	Korea (Seoul National University)	2005 admission cycle matriculated first semester student (n=90)	**MEET/DEET**	**Predictive validity**: NS related to achievement in first semester **Convergent/Divergent validity**: No significant relationship with GPA, oral exam and interview scores.	
Kingsley, K., J. Sewell, et al. (2007) (12)	US (University of Nevada /School of Dental Medicine)	2002-2004 admission cycle's matriculated students (n=275)	**US**	**Predictive validity**: non significantly correlated with NBDE-1 and Dental School GPA	**Ethnic/racial**: NS **Gender**: NS
Lundergan, W. P., E. J. Soderstrom, et al.	US (University of the Pacific Arthur	Year undisclosed - randomly selected	**US**	**Predictive validity (all p<0.05)**: weak positive correlation with	

(2007) (35)	A. Dugoni School of Dentistry)	first-year students in their first quarter (n=51)		first-year Laboratory and Study skills (r=.271), and moderate positive correlation with Operative Dentistry (r=.308), Fixed Prosthodontics (r=.318), Dental Anatomy (.447) and clinical GPA (r=.423)
Park, S. E., J. D. Da Silva, et al. (2010) (28)	US (Harvard /School of Dental Medicine)	2001-2005 graduate students (n=159)	**US**	**Predictive validity:** non significantly correlated with performance in TXAD with Honours (OR 1.1, p=0.13)
Poole, A., V. M. Catano, et al. (2007) (19)	Canada (Four Dental schools names undisclosed)	Year undisclosed - dental school students, Y1 to Y4 (Y1 n=373, Y2 n=237, Y3 n=176, Y4 n=161)	**Canadian**	**Predictive validity**: weak positive correlation with Y1 GPA (*r*=.21, p<0.05) and Y2 clinical (*r*=.27, p<0.05) NS for Y2 academic GPA, Y3 clinical and academic GPA and Y4 academic and clinical GPA - corrected for range restriction and measurement error **Concurrent validity**: matriculated participants have a higher DAT scores than applicant pool (17.80 SD 2.62 vs. 17.05 SD 2.66) **Convergent /Divergent validity**: weak correlation with DAT reading comprehension(*r*=.13 p< 0.05), and moderate correlation with academic average (*r*=.44 p<

				0.01)	
Urbankova, A. and S. P. Engebretson (2011a) (44)	US (Stony Brook School of Dental Medicine)	2012 admission cycle's matriculated first-year dental students (n=39)	**US**	**Predictive validity**: the students who scored lower (both for below 18 and below 19) scored significantly lower on Exam I (r^2 = 0.13, p=0.02)	
Victoroff, K. Z. and R. E. Boyatzis (2013) (36)	US (Case Western Reserve University / School of Dental Medicine)	Year undisclosed - third and fourth-year students (n=100)	**US**	**Predictive validity**: NS with Didactic GPA and clinical GPA but positively related with Preclinical GPA (Model 1 β= 0.388; Model II β= 0.73 p≤ 0.001; Model III β= 0.360, p≤ 0.001), **Convergent/Divergent validity**: moderate positive correlation with DAT-AA (*r*=0.266)	**Gender**: NS **Age:** NS

3. DAT- Survey of Natural Science / Total Science (TS)

Allareddy, V., T. H. Howell, et al. (2012) (30)	US (Harvard/ School of Dental Medicine)	2005-2006 graduate students (n=66)	**US**	**Predictive validity**: non significantly correlated with obtaining Honours mention in first and third comprehensive examination, but significantly correlated with obtaining Honours mention second-year examination (OR 14.17 p=0.01)	
American Dental	US: Multiple	2009-2010	**US**	**Predictive validity (all p<0.05)**:	

Association (2012) (22)	Universities/ Dental schools	American dental schools (2009, n=49; 2010,n=47)		weak positive correlation with first and second-year Biomedical grades (*r*=0.28 and 0.20), first and second-year GPA (*r*=0.26 and 0.21) and first and second-year Pre-clinical Dental Techniques grades (*r*= 0.16 and 0.15)	
Behar-Horenstein, L. S., C. W. Garvan, et al. (2011) (31)	US (University of Florida /School of Dentistry)	2006-2008 graduate students (n=209)	**US**		**Gender**: males have almost significant higher scores than females (9.6 vs. 18.9, p=0.115)
Holmes, D. C., J. V. Doering, et al. (2008) (26)	US (University of Iowa / College of Dentistry)	2000-2007 graduate students (n= 574)	**US**	**Predictive validity**: moderate positive correlation with dental school GPA (*r* = 0.449), and NBDE Part I and II (*r*= 0.582 and 0.469), and weak positive correlation with Final Clinical Grade (*r* = 0.152) **Concurrent validity**: NS **Convergent/ divergent validity**: Strong positive correlation with DAT Academic Average (*r*= 0.899) and moderate positive correlation with DAT Perceptual Ability (*r*= 0.470).	

4. DAT Quantitative Analysis (QR)					
Allareddy, V., T. H. Howell, et al. (2012) (30)	US (Harvard/ School of Dental Medicine)	2005-2006 graduate students (n=66)	**US**	**Predictive validity**: non significantly correlated with obtaining Honours mention in first and third comprehensive examination, but significantly correlated with obtaining Honours mention second year examination (OR 2.48 p=0.03)	
American Dental Association (2012) (22)	US: Multiple Universities/ Dental schools	2009-2010 American dental schools (2009, n=49; 2010,n=47)	**US**	**Predictive validity (all p<0.05)**: moderate positive correlation with first-year Biomedical grades (*r*=0.36), first-year GPA (*r*=0.34), and weak correlation with second-year Biomedical Grades (*r*=0.27), second-year GPA (*r*=0.29), first and second-year Pre-clinical Dental Techniques grades (*r*= 0.20 and 0.16)	
Behar-Horenstein, L. S., C. W. Garvan, et al. (2011) (31)	US (University of Florida /School of Dentistry)	2006-2008 graduate students (n=209)	**US**	**Predictive validity**: non significantly related with NBDE Part I and Part II	**Gender**: NS
Kingsley, K., J. Sewell, et al. (2007) (12)	US (University of Nevada, School of Dental Medicine)	2002-2004 admission cycle's matriculated students (n=275)	**US**	**Predictive validity**: non significantly correlated with NBDE-1 and Dental School GPA	**Ethnic/racial**: Non minority have higher scores than minority (3.26 vs.

				3.05) **Gender**: NS	

5. DAT Reading Comprehension (RC)

Allareddy, V., T. H. Howell, et al. (2012) (30)	US (Harvard/ School of Dental Medicine)	2005-2006 graduate students (n=66)	**US**	**Predictive validity**: non significantly correlated with obtaining Honours mention in first and second-year comprehensive examination, but significantly correlated with obtaining Honours mention third-year examination (OR 1.81 p=0.01)	
American Dental Association (2012) (22)	US: Multiple Universities/ Dental schools	2009-2010 American dental schools (2009, n=49; 2010,n=47)	**US**	**Predictive validity (all p<0.05)**: weak positive correlation with first and second year Biomedical Grades (0.18 and 0.12), First year and second year GPA (0.22 and 0.22) and first and second year pre-clinical dental techniques grades (0.27 and 0.27)	
Behar-Horenstein, L. S., C. W. Garvan, et al. (2011) (31)	US (University of Florida /School of Dentistry)	2006-2008 graduate students (n=209)	**US**	**Predictive validity**: non significantly related with NBDE Part I but positive relationship with Part II (p=0.023 range undisclosed)	**Gender**: NS
Buyse, T. and F. Lievens	Belgium (two	1997-2009	**Belgium**	**Content validity:** high -	

(2011) (32)	Flemish school - names undisclosed)	admission cycle matriculated applicants (Y1 n=781, Y2n=489, y3 n=343, Y4 n=274)	**Silent reading protocol**	specifically developed medical content article (10p) with 30 multiple-choice (4) questions **Predictive validity**: non significantly correlated with any GPA scores (year 1-5 and overall GPA) **Convergent/Divergent validity**: non significantly correlated with cognitive portion of admission exam and SJT	
Foley, J. I. and K. Hijazi (2013) (33)	UK (University of Aberdeen Dental School and Hospital)	2008-2011 admission cycle's matriculated students (n=75)	**Silent reading protocol**	**Predictive validity**: NS correlated with CAS Scores	
Kingsley, K., J. Sewell, et al. (2007) (12)	US (University of Nevada, School of Dental Medicine)	2002-2004 admission cycle's matriculated students (n=275)	**US**	**Predictive validity**: modest positive correlation with NBDE and dental school GPA for the first cohort only (r=0.318 and 0.332 $p<0.05$) For all participants: linear regression – only related to NBDE-I (β= 0.310, p=.041), the rest: NS	**Ethnic/racial**: NS **Gender**: NS
Poole, A., V. M. Catano, et al. (2007) (19)	Canada (Four Dental schools names undisclosed)	Year undisclosed - dental school students, Y1 to Y4 (Y1 n=373, Y2 n=237, Y3 n=176,	**Canadian**	**Predictive validity**: modest positive correlated with first-year GPA (r=0.25 $p<0.05$) but non significantly correlated with Y2 clinical and academic GPA, Y3 academic and clinical GPA and Y4	

		and Y4 n=161)		academic and clinical GPA- corrected for range restriction and measurement error **Concurrent validity**: matriculated participants have a higher DAT scores than applicant pool (18.01 SD 3.00 vs. 19.66 SD 2.86) **Convergent /Divergent validity**: moderate positive correlation with academic average (*r*=0.57 p <0.01)	

6. DAT-Biology (BIO)

American Dental Association (2012) (22)	US: Multiple Universities/ Dental schools	2009-2010 American dental schools (2009, n=49; 2010,n=47)	**US**	**Predictive validity (p<0.05)**: weak positive correlation with first and second-year Biomedical Grades (*r*=0.19 and 0.14), first and second-year GPA (*r*=0.19 and 0.13) and first and second year pre-clinical dental techniques grades (*r*= 0.10 and 0.11)	
Behar-Horenstein, L. S., C. W. Garvan, et al. (2011) (31)	US (University of Florida /School of Dentistry)	2006-2008 graduate students (n=209)	**US**	**Predictive validity**: significantly correlated with NBDE Part I (p=0.0182) and part II (p=0.0092)	**Gender**: NS
Kim, M. and J. I. Lee (2007) (24)	Korea (Seoul National	2005 admission cycle matriculated first semester	**Korean: MEET/DEET-**	**Predictive validity**: Positively correlated to achievement in first semester (β =.317, p< 0.05)	

	University)	student (n=90)	**Part I**	**Convergent/Divergent validity**: high positive correlation with Part I (*r*=.603, p< 0.01), and modest correlation with perceptual ability scores (*r*=.208, p< 0.05) and oral exam scores (*r*=.222, p< 0.05)	
Kingsley, K., J. Sewell, et al. (2007) (12)	US (University of Nevada, School of Dental Medicine)	2002-2004 admission cycle's matriculated students (n=275)	**US**	**Predictive validity**: for the first cohort only: modest positive correlation with NBDE and dental school GPA (*r*=0.383 and 0.310). Linear regression for NBDE-I (B= 1.043, p=.012); All participants: Pearson's NBDE R=0.304; Correlation DS-GPA NS. Linear regression NBDE-I (B= 0.585, p=.001)	**Ethnic/racial**: NS **Gender**: Males have slightly higher scores than females (17.20 vs. 17.92)
7. DAT- Organic Chemistry (OC)					
American Dental Association (2012) (22)	US: Multiple Universities/ Dental schools	2009-2010 American dental schools (2009, n=49; 2010,n=47)	**US**	**Predictive validity (p<0.05)**: weak positive correlation with first and second-year Biomedical Grades (*r*=0.23 and 0.21), first and second-year GPA (*r*=0.23 and 0.24) and first and second year pre-clinical dental techniques grades (*r*= 0.09 and 0.14)	

Behar-Horenstein, L. S., C. W. Garvan, et al. (2011) (31)	US (University of Florida /School of Dentistry)	2006-2008 graduate students (n=209)	**US**	**Predictive validity**: non significantly correlated with NBDE Part I and Part II		**Gender**: NS
Kim, M. and J. I. Lee (2007) (24)	Korea (Seoul National University)	2005 admission cycle matriculated applicants who completed their first semester (n=90)	**Korean: MEET/DEET-Part II**	**Predictive validity**: Positively correlated to achievement in first semester (β =.229, p <0.05) **Convergent/Divergent validity**: high positive correlation with Part I (*r*=.603, p< 0.01), and modest correlation with perceptual ability scores (*r*=.208, p< 0.05) and oral exam scores (*r*=.222, p< 0.05)		
Kingsley, K., J. Sewell, et al. (2007) (12)	US (University of Nevada, School of Dental Medicine)	2002-2004 admission cycle's matriculated students (n=275)	**US**	**Predictive validity**: non significantly correlated/ related with NBDE and dental school GPA		**Ethnic/racial**: NS **Gender**: Males have slightly higher scores than females (18.34 vs. 17.35)

8. DAT-General Chemistry (GC)

American Dental Association (2012) (22)	US: Multiple Universities/ Dental schools	2009-2010 American dental schools (2009, n=49; 2010,n=47)	**US**	**Predictive validity (all p<0.05)**: weak positive correlation with first and second-year Biomedical Grades (*r*=0.12 and 0.16), first and second-year GPA (*r*=0.15 and 0.18) and first and second year pre-clinical dental techniques		

				grades (*r*= 0.10 and 0.09)	
Behar-Horenstein, L. S., C. W. Garvan, et al. (2011) (31)	US (University of Florida /School of Dentistry)	2006-2008 graduate students (n=209)	**US**	**Predictive validity**: non significantly correlated with NBDE Part I and Part II	**Gender**: NS
9. DAT-Average Weighted Score					
American Dental Association (2012) (22)	US: Multiple Universities/ Dental schools	2009-2010 American dental schools (2009, n=49; 2010,n=47)	**US**	**Predictive validity (all p<0.05)**: weak positive correlation with first and second-year Biomedical Grades (*r*=0.19 and 0.14), first and second-year GPA (*r*=0.19 and 0.17) and first and second year pre-clinical dental techniques grades (*r*= 0.16 and 0.17)	
Lopez, N., K. Self, et al. (2009) (15)	US (University of Minnesota/ School of Dentistry)	2007-2008 admission cycle's applicants (n=1838)	**US**		**Ethnic/racial:** minority students had lower weighted GPA than non minority students **Gender:** males have higher scores than females

10. **DAT Overall Test Scores**				
Beier, U. S., I. Kapferer, et al. (2010) (54)	Austria (Innsbruck Medical University)	2001-2005 admission cycle's matriculated applicants (n=97)	**Austrian – total DAT theory scores**	**Predictive validity:** Graduation on time: Yes 217.62 SD 21.95 vs. 206.16 SD 23.13, Tstat 3.151 p=0.002
Beier, U. S., I. Kapferer, et al. (2010) (54)	Austria (Innsbruck Medical University)	2001-2005 admission cycle's matriculated applicants (n=97)	**Austrian – total DAT theory and practical scores**	**Predictive validity:** Graduation on time: Yes 417.66 SD 45.99 vs. 384.92 SD 51.68, Tstat 3.151 p=0.002
Beier, U. S., I. Kapferer, et al. (2012) (54)	Austria (Innsbruck Medical University /Dental School	2001-2006 admission cycle's matriculated applicants (n=122)	**Austrian**	**Predictive validity:** significantly related to average on final exam grades (β = -.220, p=0.017)
Park, S. E., J. D. Da Silva, et al. (2010) (28)	US (Harvard /School of Dental Medicine)	2001-2005 graduate students (n=159)	**US**	**Predictive validity:** correlated with performance in TXAD with Honours (OR 1.1, p=0.13)
11. **Other cognitive selection tools**				
Gardner, S. P. and K. F. Roberts-Thomson (2012) (38)	Australia (University of Adelaide)	2003-2009 admission cycle's applicants (n=216)	**UMAT**	**Predictive validity:** Significantly correlated with achieving three or more credits in year 1, but only for UMAT scores 100-129 (RR 0.59 p=0.046 vs. 150 and up), but NS for year 2 and 3 (all scores)

Rich, A. M., K. M. S. Ayers, et al. (2012) (39)	New Zealand (University of Otago, Faculty of Dentistry)	Students admitted into their second year of dental school between 2004-2009 (n=411)	**UMAT**	**Predictive validity**: a larger proportion of students who had median or above scores in section 2 graduated with credit or distinction than below median (85.2% vs. 50% p<0.001); a larger proportion of below median students required remedial examination than median and above (16 vs. 3.5% p<0.05)
Gardner, S. P. and K. F. Roberts-Thomson (2012) (38)	Australia (University of Adelaide)	2003-2009 admission cycle's applicants (n=216)	**TER**	**Predictive validity:** significantly correlated with achieving three or more credits in year 1, for TER 80-89.99 (RR 0.46 p=0.030 vs. 150 and up), TER 75-79.99 (RR 0.43 p=0,0016 vs. 150 and up), and for TER <75 (RR 0.11 p= 0.006 vs. 150 and up), but NS for year 2 and 3

TABLE D3: INTERVIEW FORMATS

Authors (year)	Country (University)	Study participants	Validity	Reliability	Potential internal/external biases	Scalability?	Impact on diversity
1. Unstructured /Semi-structured interview							
Kim, M. and J. I. Lee (2007) (24)	Korea (Seoul National University)	2005 admission cycle matriculated first semester student (n=90)	**Predictive validity**: negatively correlated to achievement in first semester (β=.272, p< 0.01) **Convergent/Divergent validity**: moderate positive correlation with oral exam scores (*r*=.622, p<0.01)				
2. Structured interview							
Bender, D. J., D. T. Burk, et al. (2007) (63)	US (Tufts University, School of Dental Medicine	2001-2005 admission cycle's applicants (n=1,192)					**Gender**: no relationship btw applicant-interviewer gender concordance and applicant's decision to enrol.
Kay, E., J. Bennett, et al. (2010) (37)	UK (Exeter and Plymouth University/Peninsula College of Medicine and Dentistry)	2007 matriculated applicants (n=62)	**Convergent/Divergent validity**: correlations between interview scores and traditional aptitude test (GAMSAT, Year one progress test scores and Year-one test scores in life sciences) were weak and failed to reach statistical		Testing effects: Low Experimenter expectation Bias: Low	Yes	**Gender or socioeconomic background**: NS except for one question that displayed visually detectable differential item functioning

			significance.	between subgroups
Gardner, S. P. and K. F. Roberts-Thomson (2012) (38)	Australia (University of Adelaide)	2003-2009 admission cycle's matriculated applicants (n=216)	**Predictive validity**: non significantly correlated with achieving three or more credits in year 1, and 2, and 3	
Poole, A. et al. (2007) (19)	Canada (four dental schools names undisclosed)	Year undisclosed - dental school students, Y1 to Y4 (Y1 n=373, Y2 n=237, Y3 n=176, Y4 n=161)	**CDA interview -Predictive validity**: moderate positive correlation with Y3 clinical (*r*=.31 p<0.05) and Y4 clinical (*r*=.44 p<0.001) - corrected for range restriction and measurement error. **Concurrent validity**: Matriculated participants scored higher than applicant pool (57.20 SD 5.94 vs. 51.73 SD 9.14) **Convergent /Divergent validity**: NS correlated with the DAT AA, RC and PAT, but positively correlated with two of the personality factors of the NEO-PI-R: extraversion (r= .27 p<0.01), and openness to experience (r= .21 p<0.01)	
Rich, A. M., K. M. S. Ayers, et al. (2012) (39)	New Zealand (University of Otago, Faculty of Dentistry)	2004-2009 admission cycle's matriculated applicants admitted in their second year of dental school	**Predictive validity**: NS for predicting top half of the class in year 2 and 5, graduation with credit or distinction, any subject distinction, any subject prize or remedial examination required **Concurrent validity**: Weak	

		(n=411)	**Convergent/ divergent validity**: strong positive correlation with pre-dental Science (*r*=0.936 p<0.05), and moderate positive correlation with DAT Academic Average, DAT Perceptual Ability, and DAT Total science scores (*r* = 0.252 - 0.400 p<0.05).	

3. Multiple Mini Interviews

Foley, J. I. and K. Hijazi (2013) (33)	UK (University of Aberdeen Dental School and Hospital)	2008-2011 admission cycle's matriculated applicants (n=75)	**Construct validity**: CAS scores significantly positively correlated to teamwork (*r*=0.097 p=0.024), communication skills (*r*=0.151 p=0.035), work experience (*r*=0.189 p=0.001), and manual dexterity (*r*=0.126 p=0.003); NS for commitment to Aberdeen, core qualities and article review	**Ethnic/racial**: Non minority students have significantly higher CAS scores than minority students (3.38 vs. 3.20, *p*= 0.02) **Gender bias**: NS
McAndrew, R. and J. Ellis (2012) (102)	UK (Cardiff University)	2011 admission cycle applicants (n=190) and interviewers (n=38)	**Face validity (applicants)** 64,8% (n=114) considered them to be better than conventional interviews, 10,2% (n=18) worse, and 25% (n=44) ambivalent. Main critics: lack of control/flexibility, anxiety and nervousness when bad performance; impossible to prepare for in advance; difficulty	

			to understand what is being assessed **Face validity (examiners)** 89,4% (n=34) better than conventional interview, 5,3% (n=2) did not answer. Main critic: assessors' fatigue throughout the day, especially when station is predictable	
Roberts, C., N. Zoanetti, et al. (2009) (43)	Australia (University of Sydney / Faculties of Medicine and Dentistry)	2005 interviewers (n=207), candidates (n=686)	**Content validity:** overall infit = 1.03, SD 0.19, range 0.63-1.27; high reliability to assess the level of difficulty of items; high outfit statistics = good fit to the IRT model	

TABLE D4: MANUAL DEXTERITY TESTS

Authors (year)	Country (University)	Study participants	Validity	Reliability	Potential internal/external biases	Scalability?	Impact on diversity
1. Dental laboratory test							
Al-Johany, S., M. AlShaafi, et al. (2011) (53)	Saudi Arabia (King Saud University/ College of Dentistry)	2009 admission cycle matriculated students in their second year (n=71)	**Predictive validity**: non significantly related to dental skills				
2. Handwriting test							
Al-Johany, S., M. AlShaafi, et al. (2011) (53)	Saudi Arabia (King Saud University/ College of Dentistry)	2009 admission cycle matriculated students in their second year (n=71)	**Predictive validity**: 80% who had excellent writing skills had excellent dental skills, and 20% good dental skills. Students with excellent and good drawing or writing skills had good dental skills (6 to10/10)				
3. Drawing test							
Al-Johany, S., M. AlShaafi, et al. (2011) (53)	Saudi Arabia (King Saud University/ College of Dentistry)	2009 admission cycle matriculated students in their second year (n=71)	**Predictive validity**: 69.6% of students (n=16) who had excellent drawing skills had excellent dental skills (8 to 10/10). Only one student with excellent drawing skills had poor dental skills (0 to 2/10).				

4. Composite manual dexterity test

Beier, U.S., I. Kapferer, et al. (2010) (54)	Austria (Innsbruck Medical University)	2001-2005 admission cycle matriculated applicants (n=97)	**Predictive validity:** NS with first-year performance and graduation on time			
Giuliani, M., C. Lajolo, et al. (2007) (55)	Italy (University of Rome)	Five years dental school applicants– years undisclosed (n=433)	**Predictive validity**: non significantly correlated with academic performance in dental school (average of all exams during the five years of dental school); Borderline significant differentiation between admitted and not admitted (p=0.0648)			**Gender:** NS **Socioeconomic background** (measured by high school background): classical and scientific high school correlate positively, dental mechanical negatively
Foley, J. I. and K. Hijazi (2013) (33)	UK (University of Aberdeen Dental School and Hospital)	2008-2011 admission cycle's matriculated applicants (n=75)	**Predictive validity**: Weak positive correlation with CAS Scores (*r*=0.126, p=0.003)			

5. Tweezers Dexterity Test

Lundergan, W. P., E. J. Soderstrom, et al. (2007) (35)	US (University of the Pacific Arthur A. Dugoni School of Dentistry)	Year undisclosed - randomly selected first-year students in their first quarter (n=51)	**Predictive validity (all p<0.05):** Test #32022: moderate positive correlation with first year Operative Dentistry (r=.431), Fixed prosthodontics (r=.397), and weak positive correlation with Dental Anatomy (r=.285) and clinical GPA (r=.279). Test #18: moderate positive correlation with Fixed	**Intra-rater/Test-retest reliability**: Test #18: strong positive correlation (*r*=0.7925) but lower than what was reported by The Johnson O'Connor Research Foundation (*r*=0.91) **Inter-rater reliability**: high correlation for both Test #18	**Testing effects**: low	**Age**: NS Gender: NS

			Prosthodontics (r=.335), Endodontic (r=.329), and weak positive correlation with clinical GPA (r=.260) and graduation rank (r=.242). Adjusting for PAT: Test #32022 adds predictive value to: Operative Dentistry (r=.386) and fixed prosthodontics (r=.348). Test #18 adds predictive value to fixed prosthodontics (r=.339), endodontic (r=.326), and clinical GPA (r=.266). **Convergent/ Divergent validity**: Test #18 and #32022: moderate positive correlation (r=0.318, p<0.05). Test #32022: weak positive correlation with the DAT-PAT (r=0.245, p<0.05), but #18 is NS	and #32022 (r=0.9977 and 0.9999) -assessed on 11 of the 51 students	

6. Haptics

Urbankova, A. and S. P. Engebretson (2011a) (44)	US (Stony Brook School of Dental Medicine)	2012 admission cycle's matriculated first-year dental students (n=39)	**Predictive validity**: line exercise: NS; circle tests: two moderate positive correlation with Exam I scores (Time left and Accuracy left, respectively r =0.38, p< 0.10; and r=0.43, p< 0.05). Mirror test - all four were moderately correlated with Exam I (r^2 = 0.30 – 0.33), Total score: all moderately correlated time left completed total, accuracy left completed total, and time and accuracy		High

			completed total (r= 0.34 – 0.37, p<0.05) **Convergent/Divergent validity**: circle test -one moderate positive correlation with DAT-PAT scores (Time left completed (r^2 = 0.34 p< 0.10), mirror test - one was weakly correlated with DAT-PAT scores (Accuracy left: r^2 = 0.27, p< 0.01)			

7. Computer-assisted dental simulation

Urbankova, A. and S. P. Engebretson (2011b) (52)	US (Stony Brook School of Dental Medicine)	2012 admission cycle's matriculated first-year dental students (n=38)	**Predictive validity:** Students who passed the CDS had significantly higher mean Exam I scores (73.4 vs. 68.3, two sided Students p< 0.0001) and mean Exam II scores (but NS). Students who passed CDS test were 30.9 times more likely to pass Exam I (two-sided Fisher's exact p=0.0002). Exam I; 72% sensitivity and 92% specificity (positive predictive value 95%, negative 63%). Exam II: 1.7 times more likely, but NS (p=0.35)	**Inter-rater reliability**: Correlation coefficients between the two raters btw .69 and .90	**Potential internal bias** due to the possibility of different level of motivation between students chosen to participate and those not chosen	Low

TABLE C5: PERSONALITY TESTS

Authors (year)	Country (University)	Study participants	Validity	Reliability	Potential internal/external biases	Scalability?	Impact on diversity
1. Hosftede Cultural values							
Itaya, L. E., D. W. Chambers, et al. (2008) (57)	US (Pacific Arthur A. Dugoni School of Dentistry)	1994-2004 admission cycles' foreign trained students in their graduating class (n=144)	**Content validity:** high at national level, low at individual level **Predictive validity**: Individualism weak negative relation with second-year combined GPA (*β*=-.20, p=0.05), all other NS for all first and second year clinical and academic scores and/or dropped for multicolinearity				**Gender**: NS
2. Myer-Briggs Type Test							
Behar-Horenstein, L. S., C. W. Garvan, et al. (2011) (31)	US (University of Florida School of Dentistry)	2006-2008 graduate students (n=209)	**Predictive validity:** feeling/thinking related to NBDE Part II (p=0.0133, range score undisclosed), all other NS. Variables not included in Part I regression Model				**Gender**: Females are more lightly to have a feeling (56% vs. 26% p< 0.001) or judging orientation (82% vs. 68%p=.0236) **Race/ ethnicity**: NS **Age:** related to extraversion and introversion (28,8 vs. 29,8 p=0.0095)

3. Emotional Competence Inventory – University Version				
Victoroff, K. Z. and R. E. Boyatzis (2013) (36)	US (Case Western Reserve University School of Dental Medicine)	Year undisclosed-third and fourth year students (n=100)	**Predictive validity**: EI self-awareness and social awareness are NS correlated with didactic GPA, preclinical GPA, and clinical GPA (Y3-Y4). EI self-management is negatively correlated to didactic GPA (β=-0.398 p ≤0.05) and preclinical GPA (β=0.430 p≤ 0.05) and clinical GPA (β=0.490, p≤ 0.05). EI relationship management correlated with didactic GPA (β=0.507 p ≤0.01) but NS with preclinical GPA and clinical GPA. EI contributed 12,1% to variation on didactic GPA (Y1-Y2), 6,1% to preclinical GPA, and 14,6% on clinical GPA.	
4. NEO-PI-R test				
Poole, A., V. M. Catano, et al. (2007) (19)	Canada (Four Dental schools names undisclosed)	Year undisclosed - dental school students, Y1 to Y4 (n=373)	**Predictive validity:** Consciousness correlated with Y1 GPA (r=.24, p <0.05), Y2 clinical (r=.47, p <0.01), Y2 academic grades (r=.32, p <0.05), Y3 clinical (NS), Y3 academic grades(r=.40, p <0.01), Y4 clinical (r=.39, p <0.01), Y4 academic (NS); agreeableness and extraversion and neuroticism NS with all predictors. Openness with Y1 GPA (NS), Y2 clinical (NS), Y2	**Gender:** females tend to have higher scores in agreeableness ((r= .17, p <0.05) and neuroticism (r=.28, p <0.001), NS for others; Age: negatively correlated with extraversion (r=-.22,p <0.05), NS for others

	academic (NS), Y3 clinical (NS), Y3 academic (r=.24, p <0.05), Y4 clinical (NS), Y4 academic (NS). **Concurrent validity:** Applicant pool have higher personality scores for neuroticism (78,45 SD 22.87 vs. 60.01 SD 18.49), but lower scores for extraversion (126.11 SD 17.03, vs. 133.25 SD 17.24), openness to experience (121,20 SD 17.44 vs. 127.15 SD 16.85), agreeableness (127.87 SD 19.18 vs. 137.88 SD 16.88) and conscientiousness (130.66 SD 19.37 vs. 147.22 SD 18.24) **Convergent/ Divergent validity**: neuroticism- NS with interview and DAT; extraversion correlated with Interview (r=- .26, p <0.01), DAT perceptual ability test (r=-.15, p <0.05), openness to experience - with interview (r=.19, p <0.01), DAT Academic Average (r=.15, p <0.05), agreeableness and conscientiousness NS with all. Correlations BTW personality factors: neuroticism correlated with extraversion (r=-.22, p <0.05), agreeableness (-.29, p <0.01) NS with others; extraversion correlated with neuroticism (-.25, p <0.01), openness to experience (.35, p <0.01), consciousness (.16, p <0.05) NS for others. Openness	

	to experience: extraversion (.40, p <0.01), and agreeableness (.19, p <0.05), NS with others. Agreeableness is correlated with neuroticism (-.34, p <0.05), extraversion (.18, p <0.05), openness to experience (.29, p <0.01) and conscientiousness (.32, p <0.01). Conscientiousness correlated with neuroticism (-.41, p <0.01), extraversion (.26, p <0.01), openness to experience (.20, p <0.01) and agreeableness (.41, p <0.01)	

TABLE D6: SITUATIONAL JUDGMENT TEST

Authors (year)	Country (University)	Study participants	Validity	Reliability	Potential internal/external biases	Scalability?	Impact on diversity
Buyse, T. and F. Lievens (2011) (32)	Belgium (two Flemish school - names undisclosed)	1997-2009 admission cycle matriculated applicants (Y1 n=781, Y2 n=489, Y3 411, Y4 n=343, Y5 n=274)	**Content validity:** high - vignettes tested for realism by two professors **Predictive validity**: Non correlated with GPA (Y1-4 and overall GPA); Incremental value only for fifth year (B=.16, R^2 = 0.03 p <0.01) **Convergent/Divergent validity**: non significantly correlated with cognitive portion of admission test and silent reading protocol				