

## Improving Dental Care Recommendation Systems Using Patient and Dentist Profiling

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### Abstract

*Online social networks are emerging in a fast pace as people have started to rely on the information presented on such platforms as a source for many day-to-day activities such as travel, shopping, healthcare, weather and even government services. However, the usage seems to be far less for the healthcare and dental care recommendation sites. This paper investigates whether adding profiling would make a difference in the quality of the recommendation. It analyses dentists' qualities from online dental reviews. The patients are classified based on their dental behavior and type of personality obtained from a popular personality test. A survey on 240 participants confirms that participants with different personality prioritise dentists' qualities differently when selecting their ideal dentist. From this finding, this paper recommends integrating subjective characteristics while profiling both dentists and patients in dental recommendation systems.*

### Keywords

Online social networks, crowdsources, reviews and ratings, subjective characteristics, recommendation systems.

### INTRODUCTION

Information overload in this information age is inevitable with the growing internet users and pervasive technologies. Recommendation systems have been gaining popularity to filter the information for both internet users and business owners in the Internet world (Ricci et al 2011). Collaborative filtering (CF) and content based filtering (CB) are the most popular methods for recommendation systems. Many other types of methods such as item based, knowledge based, trust based and others have been used by automatically combining intelligence with machine learning for the recommendations systems (de Gemmis et al 2011).

Profiling users is the foundation of any recommendation systems. The closer the profiling of the users, the better the recommendation would be in a given context whether it would be for buying items or watching movies or listening to music or seeing a professional. Many machine learning methods (data mining techniques) have been used to mimic the profiles to make the most effective and efficient recommendation system from the online data (Lops et al 2011). Most of them are mastering on methods to automatically learn the profile from the online behaviour such as historical record of buying, online feeds or feedbacks in social media. For example, Amazon.com recommends items similar to the one purchased or searched.

The growth of social networking sites has been a catalyst to new methods and means for filtering information as more data is available within different dynamics of user profiles. Not only historical records but how internet users share information with their friends or review a particular topic and so forth are being used (Castelluccia 2012). Healthcare industries are not immune to the spread of impacts of social media. Making decisions for health treatments have been obstructed by inundated amount of information online (Wiesner and Pfeifer 2014). The impacts are much more substantial due to the sensitivity of health matters and potentially fatal. A special

attention should be given to these alarming concerns when filtering health data for recommendation systems. There are many studies and researches on how the impacts can be minimized for healthcare consumers (de Magalhaes et al 2013, Fernandez-Luque et al 2011 and McKinsey&Company 2011). For example, rules to ensure that diabetic patients are never recommended items with sugar (Lopez-Nores 2011). To the best of our knowledge, existing systems have used profile matching within a stakeholder. For example, matching a profile of a patient with other patients and recommend the same dentist used by matched patients. The problem with this approach is that it is not capturing the holistic view of the patients, and the dentists' own profile is not considered while generating recommendation list.

Our aim is to profile both patients and dentists based on their subjective characteristics and skills which are related to dental treatments. Certain skills have been recognized as imperative, such as caring attitudes, friendly, confidence and communication (Sbaraini et al. 2012). Many researchers in the area of dental care have been exploring other subjective attributes which affects patients during visit to the dental clinic such as dental fear (Armitage & Reidy 2012, Armfied 2010, McNeil et al. 2011 and Rodriguez-Vazquez et al. 2008), and quality of care (Merijohn et al. 2008, Sbaraini et al. 2012 and Yarascavitch et al. 2009). Our approach is to identify the subjective characteristics of dentists preferred by patients from crowdsources such as dental reviews. Both positive and negative online reviews/feedback provides guidance to patients about what other patients thought of particular dentist or dental practice they have visited. On the other hand, the subjective characteristics of the patients or the reviewers of the dental reviews are not yet available and remains a challenge. However, researchers have been working to identify health profiles of patients by analysing tweets (Batoool et al 2012). Perhaps in the future, there will be enough data to be able to analyse from crowdsources to profile patients. In this study, we have incorporated one of the popular personality tests, called DISC (Dominant, Influencer, Steady and Compliant), to profile patients to match with a suitable dentist.

In this paper, we describe our framework for dental care recommendation system showing the importance of profiling of both patients and dentists. It is followed by methods used in this study to capture the subjective characteristics for both dentists and patients. Some results from the methods are discussed here. In quest of finding out the matching rules, an online survey is set up. The process of setting up the survey is discussed in the following section. Some results from the survey focussing on matching rules involving types of personalities and preferred dentists' qualities are discussed. Finally, further direction of this research is presented in the end.

## RECOMMENDATION SYSTEM AND PROFILING

Recommendation systems are able to filter information based on interests and preferences of individuals. Thus, systems are able to support and improve the decisions made by users (Xiao and Benbasat 2013). Popular recommendation methods such as CB or CF use the intelligence based on previous interactions. The engine personalises the user based on past behaviour or interaction by looking at the similarity features of either contents or their user community. In CB, the system learns user preferences and recommends items based on contents similar to the preferences. CB shows more of the same items or services what have been used by the user before. Whereas, CF assumes that users who had similar tastes in the past, will have similar tastes in the future (Jannach and Friedrich 2013). CF recommends item based on similarity of users and rankings in the past. The question is how much information of the user has been collected online. Is that enough to profile the user? When it is about an interaction between two human beings, subjective characteristics of both users involved, has a significant influence on how the interaction transpires. What is good for one person is not necessarily good for the other person while interacting with people. By nature, dental treatments are uncomfortable and painful. Consequently, the patients are fearful to see a dentist (Armitage and Reidy 2012). Trust and familiarity with dental team has been reported as key factors by Dyer et al (2013). Trust was fortified by effective behaviours, communication skills and continuous care by the dentist. Although subjective criteria have not yet been considered for matching a patient with a dentist, the ratings are often based on some criteria related to a level of satisfaction which is resulted from subjective characteristics such as punctuality, helpfulness, level of trust etc (Pradhan et al. 2013). Our prime focus in this research is to match a patient with a dentist based on attitudes and behaviours.

Trust from the patients to the dentists is very important due to the intrusive nature of treatment. One of the most effective sources to gain that trust of a dentist is through understanding subjective characteristics such as behaviour and attitude of a dentist, like experienced, reliable, caring etc. The same applies to patients as well. Figure 1 shows an overview of framework of dental care recommendation system.

The patients select their objective and subjective criteria while searching for the most suitable dentist. Filtering based on the criteria is done but most importantly, profiling based on personality is also recorded. Combination of both criteria (query) and personality types are used to construct a patient profile as shown in the Figure 1. On the other hand, dental crowdsources such as DrOogle, Yelp, Healthgrades are taken as examples of sources of reviews for dentists. The reviews are analysed to create dentists' qualities and eventually profiling dentists.

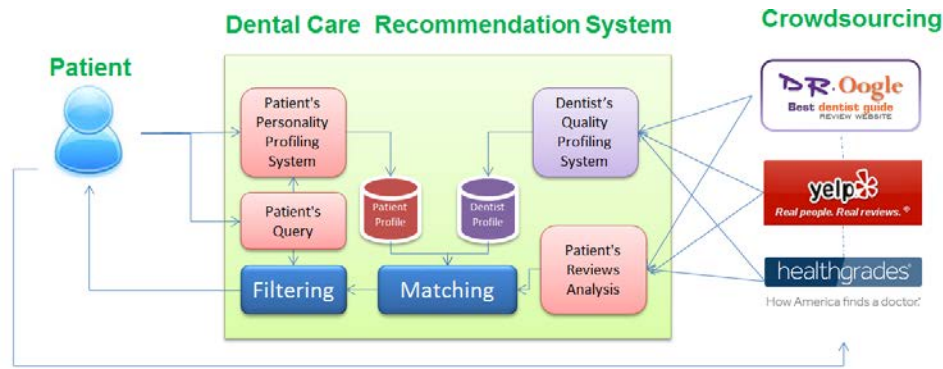


Figure 1: Framework of dental care recommendation system

Based on the profiles of both patients and dentists, matching is carried out to recommend an ideal dentist. The aim of this study is to improve quality of the recommendations by matching the subjective aspect of profiles of both patients and dentists. In this paper, we focus on the methods of profiling and setting up survey to create matching rules with some results. Analysing and finding out types of patients and dentists from subjective characteristics, is a useful process for matching process. If this process can match a patient with a dentist based on their subjective characteristics, it would be considered a quality recommendation. For example, a dental educator stated that qualification and expertise of dentist would be important for D (dominant) type of patients and they would not like socializing as much, whereas, I (influencer) type patient would prefer discussing in a friendly manner (Meyer 2012).

The following sections will detail how and where we can extract the subjective characteristics of both patients and dentists to improve the dental care recommendation systems.

## SUBJECTIVE CHARACTERISTICS IN PROFILING

Subjective characteristics have been included as a latent construct with users' rankings and ratings for products (Luo et al 2008) and rating a service provider or professional is about his/her subjective characteristics. The perception of characteristics is critical while reviewing a professional. This section shows how those subjective characteristics for profiling dentists and patients are extracted. First two components: Dentist's quality and patient's personality profiling system in Figure 1 is detailed here.

### Subjective characteristics of Dentists

Subjective characteristics of dentists are revealed by the patients when they write reviews. The terminologies used by patients to describe their dentists, are subjective characteristics or behaviours of the dentists, and they are referred as dentist's qualities in this paper. Figure 2 below shows how the dentist's qualities are extracted from the dental crowdsources. It is an expansion of the component in the top right corner of Figure 1. The text mining of the dental reviews is done to extract subjective characteristics of dentists.

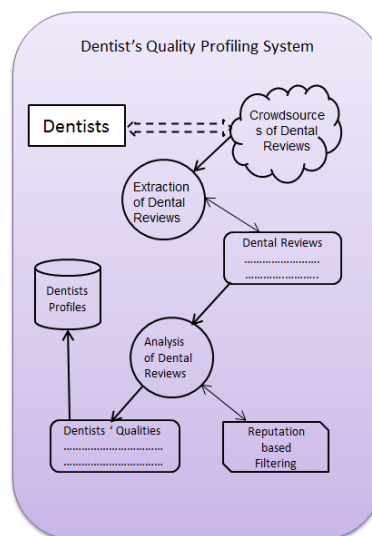


Figure 2: Process to create dentists' profiles

By doing so, 10 dentist’s qualities are selected after reviewing subjective attributes used in dental care literatures. The list is shown in Table 1 below:

Table 1. List of Dentist’s Qualities

Friendly	Caring	Professional	Experienced	Knowledgeable
Explains well	Recommendable	Quality of service	Reliable	Good personality

There are not only synonyms for a word but the word can also be expressed in many different ways. Since different vocabularies are used by different people, a lexicon prepared by ‘National Research Council Emotion Lexicon’ (Mohammad 2011) is used. The list is further filtered to make it relevant with patients’ dental treatments. Some of the examples of the synonyms used for the text mining are listed in the Table 2 below.

Table 2. Examples of synonyms used for text mining

Terms	Synonyms						
Friendly	affable	affectionate	amiable	amicable	attentive	beneficial	cordial ...
Caring	attention	Tend	kind	attend	Careful	bedside manner	gentle...
Professional	competent	efficient	confident	qualified	skillful	expert	skilled ...
Experienced	quick	capable	veteran	seasoned	sophisticated	mature	trained ...
Knowledgeable	brilliant	conscious	discerning	informed	intelligent	insightful	perceptive...
Explains well	brightness	precision	articulate	evidence	certainty	accuracy	directness ...
Recommendable	recommended	referred	suggest	satisfied	send friends		
Quality of Service	follow up	booking	process	easy	good	clean	fantastic
Reliable	trust	honest	authentic	punctual	steady	strong	sincere ...
Good personality	charm	charisma	nature				

Frequencies of the terms used by patients to describe a particular dentist in the reviews are analysed. Based on the number of terms used to describe a dentist, the subjective characteristic of the dentist is determined.

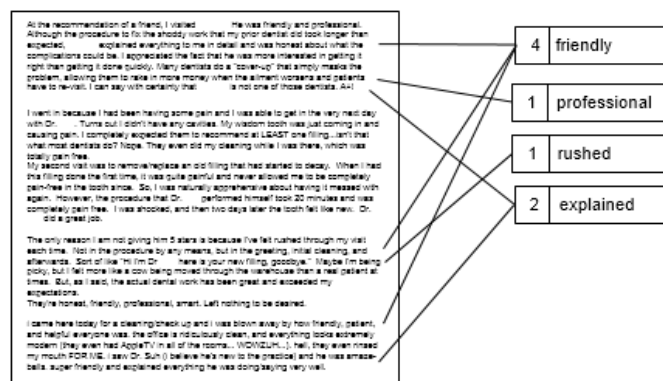


Figure 3: Example of how text mining is done from reviews

Term frequency-inverse document frequency (tf-idf) for text mining (Salton and Buckley 1988) is used. For example, if a word ‘friendly’ is used by many patients to describe a dentist in an average, the dentist’s behaviour can be depicted as ‘friendly’. Similarly, other dentists’ qualities are extracted by analysing the review data. Figure 3 shows an example on how the terms are extracted from 4 random reviews of a dentist. The example shows how the term ‘friendly’ is mentioned 4 times, ‘explained’ is repeated 2 times and ‘professional’ and ‘rushed’ once. The same process is applied for all the reviews of the dentists to describe the dentists’ qualities.

One of the most prevalent challenges in text mining is positive or negative connotation of the terms used. In order to clarify this misconception, a feature is added in the tool. The feature in the tool is to select the range of star ratings, out of 5, while selecting reviews for the specified dentist, as shown in Figure 4. When the rating stars are selected from 3 to 5, the words from the Table 2 have positive meaning to describe their dentists. Similarly, when the rating stars are selected from 1 to 2, the words have negative connotation and hence rated low to the dentist. For example, a simple word ‘good’ may be mentioned with ‘not good’ in the reviews.

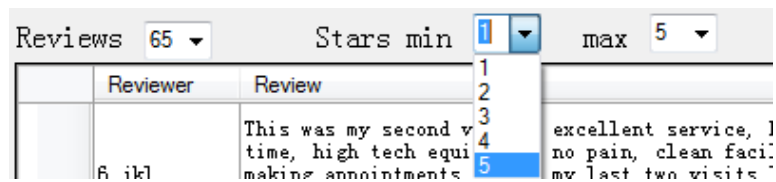


Figure 4: Selection of rating stars.

Another challenge is whether the same dentist has been reviewed and rated consistently across different online reviews platforms. The dental review sites are using various criteria to rate the dentists, however the terms used by reviewers to describe the same dentist in two popular dental reviews sites are consistent. This is verified by analysing the terms used in two of the most popular dental reviews sites: DrOogle and Yelp in the US. These two sites are chosen for this study because the numbers of dental reviews are significant enough to analyse dentists' qualities. A dentist from New York, who has a significant number of reviews in both sites, has been chosen.

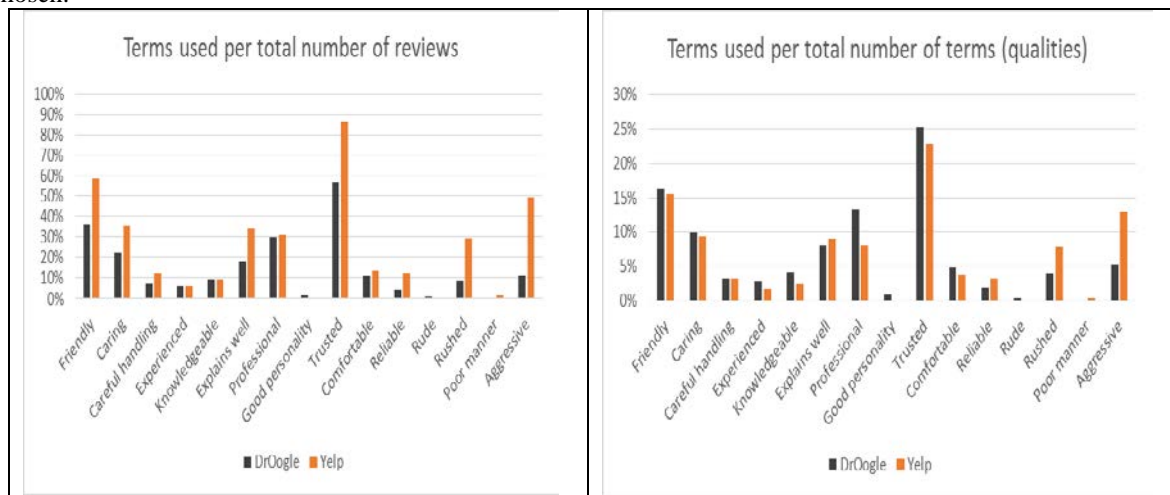


Figure 5: Comparison of terms used (DrOogle vs Yelp) (Y-axis: Percentage of terms used)

There were 556 reviews for this dentist in DrOogle site and 65 reviews in Yelp site. We have used the method, tf-idf to count dentists' qualities used in all those reviews. The result is shown in Figure 5. Number of terms used is shown as percentage based on total number of reviews for the dentist in the first graph. In the second graph, the number of terms is shown as percentage based on total number of terms to describe dentist's qualities, 1,247 and 246 in DrOogle and Yelp respectively. The graphs show that the way patients describe their dentists are similar, although sourced from two different sites (DrOogle and Yelp). In addition, even when actual numbers of reviews are significantly different (556 versus 65) the proportions of actual terms used in the reviews, are almost evenly distributed in both sites. This shows that the dentist's qualities are well recognised and conceded by the patients. This is only for the purpose of the illustration. In order to avoid bias, this experiment for consistent terms to describe dentists, will be carried out for larger number of dentists (data set) in the future.

### Subjective characteristics of Patients

In a dental treatment environment, subjective characteristics of both patients and dentists are crucial for better outcome. With the explosive growth of social media like Facebook and Twitter, some researchers have been analysing postings and tweets to create patient profiles, based on the keywords used. We believe that the subjective characteristics of patients can be extracted in the future. Because of inadequate data in the current scenario, we have selected one of the popular personality tests for profiling patients: DISC, Dominant (D), Influential (I), Steady (S), and Conscientious (C), personality test. This section is an expansion of the component in the top left corner of Figure 1. Behaviour usually is an expression of personality in any given circumstances. Extensive lists of behaviours which qualify into the categories of DISC are available such as ambitious, outspoken and decisive as D, friendly, expressive and people-oriented as I, good listener, consistent and family-oriented as S and organised, perfectionist and detail-oriented as C (DISCInsights 2014). Other personality tests such as Myers-Briggs Type Indicator (MBTI), Personality and Preference Inventory (PAPI) or Big Five Factors, are also available and can be used.

The dental patients for this study are classified based on the DISC personality test. They are categorised into one of the profiles given in the table below.

Table 3. Profiles based on DISC personality test (discprofiles4u 2014)

1	<b>Achiever</b> - is confident of their personal work accomplishments, and may be reluctant to delegate tasks when under stress.	S/D
2	<b>Agent</b> - is easy going, relaxed, and they go with the flow.	S/I
3	<b>Appraiser</b> - is practical, and ensures progressive results by developing a detailed plan of action.	IC
4	<b>Counsellor</b> - embraces others with their warmth, empathy, and understanding.	IS
5	<b>Creative</b> - makes sound decisions yet may lack attention to interpersonal relationships.	DC
6	<b>Developer</b> - is self-reliant individuals who prefer to seek their own creative and individualistic solutions.	D
7	<b>Inspirational</b> - attempts to control their environment and directs the behavior of others toward a predetermined goal.	DI
8	<b>Investigator</b> - calmly and steadily pursues toward a fixed goal.	S/CD
9	<b>Thinker</b> - focuses on achieving complete and total accuracy in everything they do.	C
10	<b>Perfectionist</b> - is precise thinker and employs plans and procedures for both their personal and professional lives.	C/S
11	<b>Persuader</b> - loves working with and through people to accomplish their own objectives.	ID
12	<b>Practitioner</b> - prefers a comfortable and cooperative environment where people are trusting and pleasant.	C/IS
13	<b>Promoter</b> - is more interested in interaction, and less interested in accomplishments.	I
14	<b>Result-oriented</b> - is competitive and likes difficult tasks and high positions.	DI
15	<b>Specialist</b> - is considerate, patient and always stands ready to help others.	S

Figure 6 below shows how patient’s profiles are created by using personality tests.

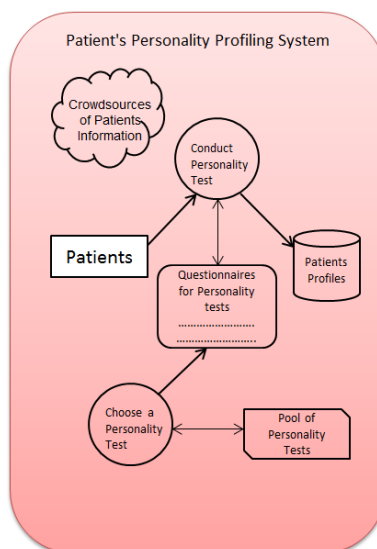


Figure 6: Process to create patients’ profiles

For this study, DISC personality test has been further analysed to help people understand the strengths and challenges of each behaviour style by DISC Classic 2.0 (discprofiles4u 2014). It has simplified the types of personalities from the DISC test in 15 various types of people as shown in Table 3 above. It is basically 15 combinations from D, I, S and C. For example, pure D is Developer, pure S is Specialist, combination of S and I, is Agent and so on. Table 3 details the combinations of D, I, S, and C and their description of personality types with one word. It simplifies the DISC personality test for users to understand.

## SURVEY SET UP

We have set up patients’ survey to construct matching rules between subjective characteristics of patients and dentists. The objective of this survey is to capture information about dental care from patients’ perspectives to improve quality of recommendation. We regard the interaction between patients and dentists in the treatment are more significant that need to be analysed when recommending the dentists to others.

With the rise of dental tourism (Cowie 2014), we have also discerned the situation while an individual has to see a dentist overseas where s/he does not know anyone and have to rely on recommendation system to make decision. A set of questionnaires are prepared to capture related information about dental care. It is aimed to get

participants from different countries in the world. The online survey is designed using a survey tool 'Lime Survey' which is provided by the university e-research team. The link is advertised while participating in two international conferences PACIS (Pacific Asia Conference on Information Systems) 2014, Chengdu in June and IFIPTM (International Conference on Trust Management) 2014, Singapore in July. The link is also distributed through Facebook and LinkedIn and requested to pass on to other peers and friends. This method certainly creates a limitation on reaching to the broad community and hence the limit on representation of overall population for the research. The sample population of this survey is not randomly chosen but through the connections of researchers and participants of the International conferences. However we believe that there would be ample of data to analyse what type of dentist is preferred by certain type of personalities.

The online survey has 31 questions divided into 3 sections: the first section captures basic demographic information such as age group, sex and country of residence and highest level of education. The second section captures their dental care profile by asking questions such as how often they visit their dentist, how they choose their dentist, the number of dentists they have had, describe ideal dentist for them etc. In the final section, we have specifically asked to choose the best way to describe themselves from the list in Table 3, followed by 12 questionnaires to determine their personality. The 12 questionnaires are inherited from disc personality test site. Thus, the participants' personality will be determined, and will also be able to check what they describe themselves as and what they really are in the near future.

One of the major questions in the survey is, 'For your ideal dentist, choose the most important qualities you prefer them to have'. The list is provided from the Table 1 with likert scale from 0 - 10. The participants are asked to choose these qualities for their current dentists as well. These questions will help to formulate matching rules between dentist's qualities and patient's personalities after initial filtering of objective criteria such as location, speciality and availability.

Some of the results from the survey are provided in the next section.

## RESULTS AND DISCUSSION

There are so far 240 participants to the survey. Out of which 87 are invalid due to incomplete submission. 153 submissions are valid. Majority of participants 98, are from Australia, followed by 16 from United States, 8 from India, 7 from China and others. At this preliminary stage, only two questions are analysed to see what matching rules can be set up from this survey.



Figure 7: Number of participants and their personalities

Out of 153 valid participants, Figure 7 shows the actual number of participants from 15 different personality types listed in the Table 3, for example, 23 Achievers, 16 Perfectionists, 14 Agents etc. Each of these participants chose their preferred dentist's qualities. The distribution of dentist's qualities chosen from these participants is shown in Table 4 below.

The dentist's qualities are selected by each participant in the likert scale from 0 to 10 but mainly between 7 and 10. The participants chose various likert scales on level of preferences for dentist's qualities as shown in the Table 4 and Figure 8 below.

Table 4. Distribution of Preferred dentists' qualities

Dentists Qualities	Std. Dev.	Average	Minimum	Q1 - 1st Quartile	Q2 - Median	Q3 - 3rd Quartile	Maximum
<b>Friendly</b>	2.16	7.53	1	7	8	9	10
<b>Caring</b>	2.05	7.62	0	7	8	9	10
<b>Professional</b>	1.64	8.85	2	8	10	10	10
<b>Experienced</b>	1.47	8.99	2	8	10	10	10
<b>Knowledgeable</b>	1.16	9.04	5	8	9	10	10
<b>Explains well</b>	1.93	8.17	2	7	8	10	10
<b>Recommendable</b>	2.55	7.18	0	6	8	10	10
<b>Quality of service</b>	1.34	8.83	5	8	9	10	10
<b>Reliable</b>	1.57	8.68	1	8	9	10	10
<b>Good personality</b>	2.3	7.12	1	6	7	9	10

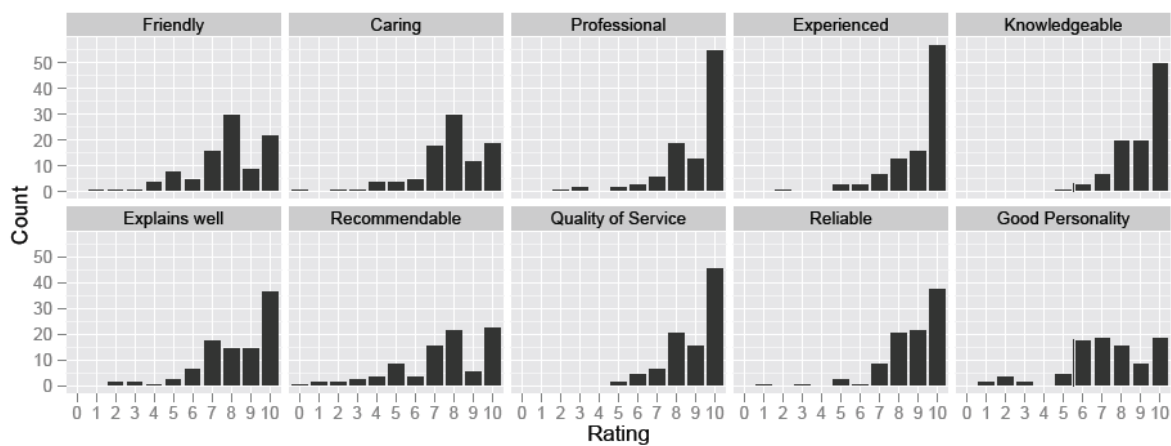


Figure 8: Distribution of dentists' qualities chosen by participants

Various types of participants based on personality and behaviour from Table 3, have chosen different level of preferences for dentists' qualities. There are 15 types of patients but we have drawn radar graphs for 4 types of personalities and shown in Figure 9 below.

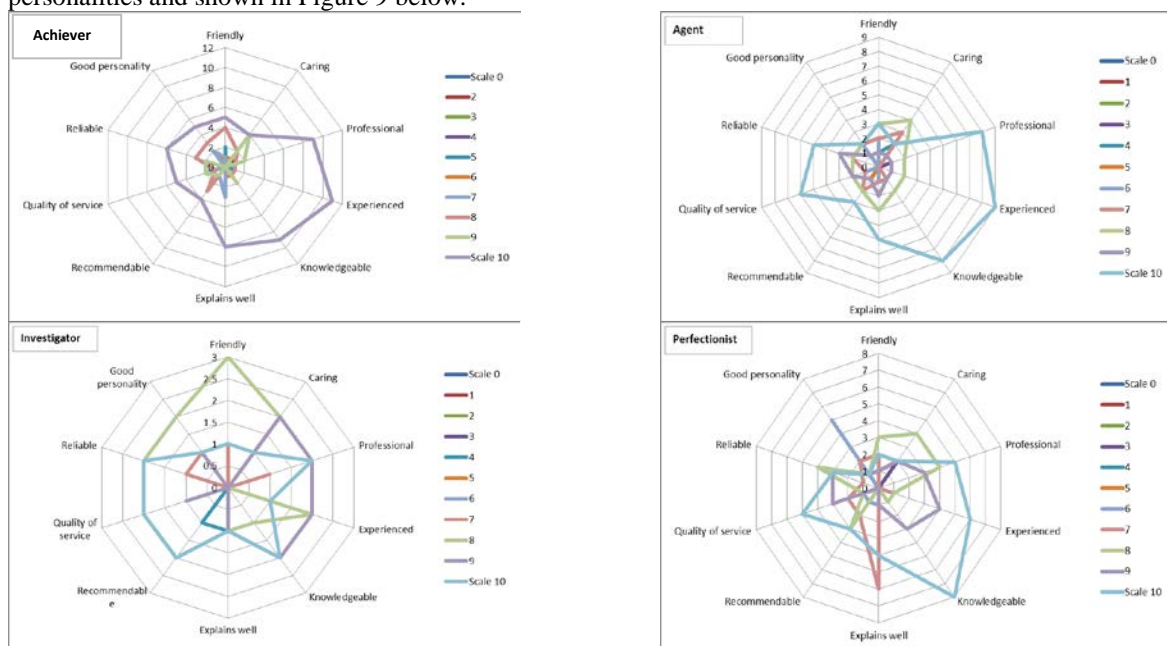


Figure 9: Cross tabulation of dentists' qualities chosen by each type of participants



As mentioned earlier, we will also verify personalities of the participants by analysing their answers to the specific questions to work out their personalities. Any discrepancies will be recorded and the matching rules based on their personalities will be constructed. These rules can be verified by recruiting random samples of patients in the future. Types of patients would be first determined through a set of questionnaires and they would be sent for dental treatment with certain type of dentists. We aim to carry out this experiment in the future to validate the matching rules devised from this patients' survey. Further qualitative study of patients-dentists relationships would be organised. The matching rules between subjective characteristics of both patients and dentists would be confirmed and used as a back engine for the dental care recommendation system.

## CONCLUSION AND FUTURE WORK

This paper highlights that there is a qualitative dimension to the matching of patients and dentists and it is an important aspect to take into account to get quality recommendations. Since the trend nowadays is to use social networking sites to exchange information with peers as well as provide feedback online, the profiling of major stakeholders may be done from the information publicly available. In this study, dentist profiling is done from dental reviews readily available from dental reviews sites. Amongst many dental reviews sites, we have chosen top two sites: DrOogle and Yelp in the US to carry out our experiment of extracting dentist's qualities. At this stage, dental reviews seem to be popular only in the US and these sites have enough number of reviews for analysing dentist's qualities. It is anticipated that other countries would follow the trend in the future.

For the profiling of patients, there is limited information about people's individual qualities available online. Therefore, we have chosen a popular personality test (DISC personality) for profiling patients in this study. There is no explicit reason for choosing this test but other types of personality test also can be integrated if required. We even anticipate that specific personality test for health treatment could emerge in the future. Due to the explosive growth in posting and sharing information in online social networks, people may be more inclined to use the healthcare recommendation sites over the coming years.

Understanding and matching patient-dentist profiles is critical to improve the quality of the match. This paper has provided a fundamental step towards that goal. Further detailed analysis of the survey data will be done in order to create matching rules for each type of personality and integrate them in our framework for dental care recommendation system.

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