THE INFLUENCE OF INTERDENTAL SPACING ON PERCEIVED SMILE AESTHETICS

By

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A thesis submitted to the University of Birmingham for the degree of

MASTER OF SCIENCE

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January 2018

ABSTRACT

Introduction

This cross-sectional study aims to assess the influence of varying patterns and size of interdental spacing on perceived smile aesthetics amongst general dentists, orthodontists, lay adults and children.

Methods

A photograph of the ideal smile was digitally manipulated to display varying patterns and sizes of interdental spacing. In total, twenty-five images were shown in a questionnaire format, to forty participants in each group. Each photo was rated on a visual analogue scale (VAS).

Results

The ideal image was preferred to interdental spacing by all groups ($p<0.05$). The images with generalised spacing had the lowest VAS ratings compared to the ideal image and this was statistically and clinically significant ($p<0.00$). The difference in VAS scores between children and professional groups was statistically significant ($p<0.05$), with children being the most critical group. A 0.5mm increase in the size of the space, resulted in a statistically significant reduction in VAS ratings ($p=0.00$).

Conclusion

Interdental spacing is disliked by all groups, and the size and pattern of spacing has an influence on aesthetic perception. Professional groups tolerated interdental spacing more than the lay groups. The large variation in VAS ratings highlights that aesthetics can mean different things to different people

DEDICATION

I dedicate this thesis to my best friend and husband, Kavit. His selfless support, encouragement and patience has been instrumental in this process. I would also like to dedicate it to my parents, Ranjan and Vinod Hindocha, for showing me the importance of hard work and giving me the self-belief to be anything I want to be. I would not be where I am without their love, support, guidance, and inspiration. Finally, to my maternal grandmother, Mrs Vimlaben Ladhani, who passed away during the writing of this thesis, I express heart-felt gratitude for her eternal love and teaching me values of spirituality, kindness and patience that I will carry forward in my lifetime.

ACKNOWLEDGEMENTS

I would like to express my sincere gratitude to the following people

Miss Sheena Kotecha for her boundless enthusiasm, incredible support and guidance throughout the project.

Professor Dietrich for making statistical analysis enjoyable.

Mr. Turner for his ongoing encouragement, statistical support and constructive feedback.

Mr David Spary for his guidance and support.

Mr Miren Patel and Ms Michelle Minott for their support with the digital manipulation of images.

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LIST OF ABBREVIATIONS

AM	Aarti Mehta (Principal Investigator and Author)
ANCOVA	Analysis of covariance
BDS	Bachelors in Dental Surgery
CI	Confidence intervals
DHC	Dental health component
AHC	Aesthetic health component
GDPs	General dental practitioners
GS	Generalised spacing
ICC	Intra Class correlation Coefficient
LD	Lateral diastema
LS	Lateral spacing
IOTN	Index of orthodontic treatment need
MMD	Maxillary midline diastema
NHS	National Health Service
OHRQOL	Oral health-related quality of life
PJT	Peter John Turner (Clinical supervisor)
Post CCST	Post completion of certificate in specialist training
QOL	Quality of life
RBB	Resin bonded bridges
SEC	Socio–economic class
SKO	Sheena Kotecha (Clinical supervisor)
TSD	Tooth size discrepancy
VAS	Visual analogue scale
WHO	World Health Organisation

CHAPTER ONE

LITERATURE REVIEW

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Project title

The influence of varying interdental spacing on perceived smile aesthetics

1. Introduction

Throughout history, the aesthetic impact of interdental spacing has had both positive and negative connotations attributed to individuals. The *'gap-toothed wife of Bath'* was described as having lustful characteristics (Chaucer, 1478), whilst during the Napoleonic era, a midline diastema was associated with the positive characteristic of luck (Nagalakshmi et al., 2014).

Generalised interdental spacing in the maxillary labial segment is a frequently encountered problem (Steigman and Weissberg, 1985). The perceived aesthetic acceptability of various patterns of interdental spacing in the maxillary labial segment amongst professionals and lay people is unknown.

This study aims to determine the aesthetic perception of interdental spacing among orthodontists, general dentists, lay-adults and children.

1.1 Definition of interdental spacing

Interdental spacing or diastemata is defined as "a lack of proximal contact between teeth" (Steigman and Weissberg, 1985). When the spacing is localised between the central incisors it is referred to as a maxillary midline diastema (MMD) (Huang and Creath, 1995).

1.2 The research problem

Johal et al. (2007) demonstrated that interdental spacing in the maxillary labial segment negatively impacts the quality of life of the affected adolescent and their parents. Orthodontic correction of midline diastemas has been shown to improve oral health-related quality of life (Nagalakshmi et al., 2014). The aims of modern orthodontics are to improve occlusal function, dental health and to improve the dento-facial appearance (Roberts-Harry and Sandy, 2003). However, interdental spacing does not feature as an occlusal trait warranting treatment according to the Index of orthodontic treatment need (IOTN).

1.2.1 Significance of the Index of Orthodontic Treatment Need

The IOTN categorises features of malocclusion and their severity, in order to determine eligibility for treatment on the National Health Service (NHS) in the United Kingdom (UK) (Brook and Shaw, 1989). The index is divided into the dental health component (DHC) and aesthetic health component (AHC). At the time of writing, a patient must score a minimum of three on the DHC and six on the AHC in order to qualify for NHS-funded orthodontic treatment. The presence of an 'aesthetic component' demonstrates that the system recognises smile aesthetics as a contributory factor to dental health (See section 1.6).

Shaw (1981) identified that aesthetic concerns are one of the major reasons to seeking orthodontic treatment. Orthodontic correction has been found to enhance self-esteem (Johal et al., 2015) and improve perceptions by others (Shaw and Humphreys, 1982). The IOTN may lack sensitivity with respect to interdental spacing in an ever increasingly aesthetically aware population.

Whilst Hemley (1971) described interdental spacing as an acceptable deviation within a normal occlusion, the fathers of orthodontics viewed interdental spacing as a trait of malocclusion (Angle, 1907; Andrews, 1972). A long held frustration of the orthodontic community (O' Brien, 2014) is that there is a population of patients who are psychosocially affected by interdental spacing (Johal et al., 2007) but who would not be eligible for NHS funded orthodontic correction.

1.3 Prevalence of interdental spacing

‘Developmental spacing’ (Graber, 1971) is seen in the deciduous dentition and a necessary feature for developing a well aligned permanent dentition.

The reported prevalence of interdental spacing ranges from 1.8% (Horowitz and Doyle, 1970) to 50% (Steigman and Weissberg, 1985; Lavelle, 1970). Aetiological factors such as genetics and environment are responsible for some of the variation seen (Huang and Creath, 1995). However, there are a number of study design related factors that responsible for the large variation in reported figures of prevalence including:

- The dimension of the space (in mm) included varied between 0.2 to 2mm.
- The region of the jaws where spacing was measured.
- The age of the cohort.
- Differing exclusion criteria, such as participants in the mixed dentition, with decayed, missing or filled teeth, those with aetiological habits or periodontal disease (Steigman and Weissberg, 1985).

Below is a summary of epidemiological papers, which reported on the prevalence of interdental spacing. Due to large heterogeneity of confounding factors as listed above, direct comparisons of each study cannot be made

Table 1: Prevalence of interdental spacing

Author	Size of Interproximal space	Population size	Age of cohort	Prevalence of diastemata
Mugonzibwa et al. (2008)	Nil minimum threshold. Total spacing was 2mm or more	706	3.5-16y	7.1-59.2%
Steigman and Weissberg (1985)	0.2mm or more	1269	12-18 y	50%
Lavelle (1976)	2mm or more	1000	15-20y	4-7%
Lavelle (1970)	0.5mm or more	656	18-25y	49.8%
Horowitz and Doyle (1970)	2mm or more	321	10-12y	1.8-13.1%

1.3.1 Prevalence of interdental spacing by age group

Large-scale epidemiological studies, as outlined in table 2 below, have found that interdental spacing decreases with age. The largest epidemiological study (N=1269) by Steigman and Weissberg (1985) observed generalised spacing and found that 53.1% of 12-14 year olds in the permanent dentition had spacing and this reduced to 42.7% in 16-18 year olds. This reduction of prevalence of interdental spacing with age is likely to be attributed to the closure of the transitory MMD. Furthermore, mesial drift (Downs, 1938) and unfavourable growth rotations of the mandible with age (Bjork and Skieller, 1972) have also been reported as contributory factors to space closure.

Table 2 below summarises the literature on the prevalence of median diastemas in different age groups.

Table 2: Prevalence of spacing by Age. Table adapted from Huang and Creath (1995).

Study	Prevalence (%)of Spacing by age									
Age	6	7	8	9	10	11	12	13	14	15
Taylor (1939)	97	87.7	-	-	48.7	48.7	-	7	-	-
Weyman (1967)	44.4	52	49.1	45.8	17.7	21.2	-	7.4	5.3	-
Gardiner (1967)	46	48	43	33	10	11	18	12	20	7

1.3.2 Prevalence of interdental spacing by gender

The prevalence of interdental spacing is statistically higher in younger age groups amongst males (Gardiner, 1967; Weyman, 1967). However, gender differences disappear in older age groups (Mugonzibwa et al., 2008; Steigman and Weissberg, 1985). Dental development in males generally occurs later than in females, and this may be the reason for this finding.

Steigman and Weissberg (1985) and Helm (1970) did not find any statistically significant differences between males and females in any age group.

1.3.3 Prevalence of interdental spacing by ethnic group

Horowitz and Doyle (1970) measured spacing of 2mm or more in 718 children; 397 were Afro-Caribbean and 321 were Caucasian (See table 1). The children studied were 10-12 years of age. Whilst only 10% of Caucasian children had two or more spaces in the maxillary labial segment, 26% of the Afro-Caribbean cohort had this feature. Richardson et al. (1973) observed a higher incidence of MMDs in 2,554 Afro-Caribbean children compared with 2,753 Caucasian children, but they did not state if the differences found were statistically significant. Furthermore, this study found a statistical significant difference with the size of MMDs, being larger in the Afro-Caribbean cohort.

Lavelle (1970) also found a higher prevalence of MMDs in West African 15-20 year olds, compared to their age matched Caucasian and Mongoloid (Chinese from Hong Kong and Malaysia) counterparts. However, the differences found between the ethnic groups was not statistically significant. In a younger cohort in the mixed dentition, Mugonzibwa et al. (2008) compared East African subjects with Caucasians in Finland (See table 1). Similar to Lavelle (1970) this study found slightly higher, incidences of spacing in Afro-Caribbeans (9.1-

55.8%) than in Caucasians (7.1-59.2%) but this was not statistically significant.

The studies highlight that ethnic background can affect the overall frequency and size of spacing but the differences found have not always been shown to be statistically significant. A number of studies have led to the belief that the spacing in the maxillary midline is more prevalent and considered to be an ethnic norm for the Afro-Caribbean population (Becker, 1977).

1.3.4 Size and site predilection of interdental spacing

DuBois et al. (1993) examined the magnitude of spaces between teeth using shim stock of varying sizes. He examined 40 patients and measured 1040 interproximal contacts, and found that the midline exhibited the largest space followed by the canine–premolar region. In contrast, Steigman and Weissberg (1985) identified that the canine–premolar region had the largest spaces with a mean of 1mm in size (range 0.2-3mm).

Keene (1963) and Lavelle (1970) identified that the most common site for spacing was in the anterior part of the maxilla, between the lateral incisor teeth and canine teeth and between the canines and premolars.

Steigman and Weissberg (1985) identified more spacing (0.2mm or more) in the maxilla (16.6%) than the mandible (7.9%) irrespective of age, racial background or gender. Lavelle (1970) observed spacing to be consistently more prevalent in the maxilla than the mandible in a 3:1 ratio across three different ethnic groups; Caucasian, Afro-Caribbean and Mongoloids. Whilst there may be variable findings on the site predilection of diastemata, all studies agree that spacing in the maxillary labial segment is more prevalent.

1.4 Aetiology of interdental spacing

Interdental spacing can occur due to environmental and genetic factors. (Becker, 1977; Huang and Creath, 1995; Gass et al., 2003). Osterle and Shelhart (1999) and Huang and Creath (1995) identified the following aetiological factors:

- Physiological: normal growth and development
- A fleshy maxillary labial fraenum
- Developmental defects such as midline clefts
- Dental anomalies (tooth size discrepancies), supernumeraries, hypodontia
- Environmental soft tissue factors: damaging habits, oral musculature imbalances, tongue thrusting, lip sucking
- Environmental hard tissue factors: tooth surface loss, tooth loss due to trauma
- Inflammatory: periodontal disease

Normal development, maxillary labial fraena, and midline clefts are implicated in the aetiology of MMDs, whereas the other factors can contribute to generalised interdental spacing in the anterior maxilla.

1.4.1 Normal growth and development

Pressure from the unerupted lateral incisors and canines leads to the 'ugly duckling stage;' (Broadbent, 1937) which is characterised by distally flared incisors and a transitory MMD. As the lateral incisors and canines erupt, they exert mesial pressure and the MMD naturally disappears. Concomitantly, with continued vertical growth, the low lying maxillary labial fraenum migrates away from the maxillary alveolus helping to facilitate diastema closure (Huang and Creath, 1995).

This naturally occurring physiological process is supported by a reduction in MMDs with age observed within epidemiological studies as described in Table 2. The explanation of persistent MMDs into adult hood, may be attributed to other aetiological factors (Huang and Creath, 1995).

1.4.2 Maxillary Labial Fraenum

The fraenum is a naturally occurring *"*fold of tissue, triangular in shape, extending form the maxillary midline area of the gingivae into the vestibule and mid portion of the upper lip*"* (Edwards, 1977*).* It begins to form three months in utero and *is a "*remnant of the tectolabial band, which connects the tubercle of the upper lip to the palatal papilla*"* (Edwards, 1977). As the maxillary alveolar process fuses in the midline, the tectolabial band separates into the palatine papilla and the maxillary fraenum (Huang and Creath, 1995). In some cases, however, the central incisors erupt a distance apart, and thus do not cause superior migration of the fraenum in these instances.

Bergstrom et al. (1973) identified 40 patients, with a mean age of 8 years, with “fleshy labial fraenae” and performed fraenectomies on half the group. A “fleshy labial fraenum” in this study, was defined as one when pulled would causing blanching of the incisive papilla and displacement of the interdental tissues (Bergstrom et al., 1973). Follow up was carried out at six months, two, five and ten years. The study concluded that those patients who underwent a removal of the frenum had more rapid spontaneous closure of their diastema, thus implicating the fraenum as the aetiological factor. However, there were no significant difference of the size of MMDs between both groups 10 years post surgery (approximately aged 18-19 years of age). This suggests that even in cases where the fraenum was not removed, the diastema closed spontaneously but more slowly. Some authors have suggested that the dimensions of the fraenum has no effect on the presence of MMDs, and that the frenum is merely a trait associated with MMDs (Dewel, 1966; Ceremello, 1933; Taylor, 1939).

More recently, the American academy of Pediatric Dentistry suggested that MMDs greater than two millimetres very rarely fully close, and if associated with a low lying frenal attachment, frenectomy and orthodontic space closure is advocated (American_Academy_of_Paediatric Dentistry, 2015)

1.4.3 Midline Bony Clefts

Midline clefts appear radiographically as a V-shaped notch and occur due to inadequate fusion of the lateral maxillary alveolar and medial nasal processes in utero (Adams, 1954). Higley (1969) postulated that the midline cleft would interrupt the transeptal fibres, causing them to divert superiorly at 90 degrees (Stubley, 1976) thus helping to maintain the MMD.

1.4.4. Supernumerary teeth and obstructions

A supernumerary tooth is defined as a tooth that is "*additional to the normal series"* Garvey et al. (1999) They have a multifactorial (environmental and genetic) aetiology (Fleming et al., 2010) and commonly occur in the anterior maxilla (Scheiner and Sampson, 1997). Supernumeraries have been known to cause MMDs (Ferres-Padro et al., 2009) and inhibit the eruption of central incisor teeth (Foster and Taylor, 1969) A Swedish study found that supernumerary teeth that were referred to a paediatric dental department inhibited eruption of incisors, and caused anterior spacing and rotations in the upper labial segment (Tyrologou et al., 2005).

Supernumeraries are rare in the primary dentition (0.8%) but have been reported to occur in 2.1% in the permanent dentition, although figures vary (Brook, 1974). Supernumerary teeth have a male to female ratio of 2:1 (Brook, 1974).

Supernumeraries can be described by form and location as follows (Cobourne and DiBiase, 2010)

- **Conical**

  Conical supernumeraries are peg shaped teeth that commonly occur in the anterior maxilla

- **Tuberculate**

  Tuberculate supernumeraries are described as barrel shaped or with multiple cusps. These are implicated in the aetiology of 38% of cases with impacted central incisors (Betts and Camilleri, 1999).

- **Odontome**

  These can be subdivided into complex and compound types. Complex odontomes are a disorganised mass of dental hard tissue encased in a follicle, whereas compound odontomes are made up of small denticles with distinct separate layers of enamel and dentine. They can act as an obstruction, although they are rare in the anterior maxilla.

- **Supplemental**

  These occur at the end of a series of teeth with their morphology mimicking the last tooth in that series. Therefore, supplemental teeth are often lateral incisors, second premolars and third molars.

Supernumeraries can be described by location as follows (Cobourne and DiBiase, 2010)

- Mesiodens: Supernumeraries that are present in the midline and are responsible for causing MMDs in 10% of cases (Shah et al., 2008). Mesiodens most commonly take a conical form.
- Paramolars: Supernumeraries that are located in the molar region
- Distomolars: Supernumeraries that are located distal to the third molars

Dentigerous cysts associated with supernumerary teeth, fibromas or other pathologies can cause physical obstruction to the approximation of teeth leading to diastemata (Huang and Creath, 1995). These can be responsible for spacing anywhere in the upper labial segment.

1.4.5 Tooth agenesis

Tooth agenesis is defined as “the developmental absence of one or more teeth, excluding third molars” (Goodman et al., 1994). Tooth agenesis occurs is described as one of the most common congenital dental abnormalities in humans (Altug-Atac and Erdem, 2007; Shapiro and Farringron, 1983) affecting 6.4% of the population with a higher incidence in females (Khalaf et al., 2014). Tooth agenesis affects 3% of all second premolars, 1.6-2% of all maxillary lateral incisors and less than 1% of mandibular incisors (Polder et al., 2004; Grahnen, 1956). Agenesis of maxillary canines or central incisors is extremely rare. Therefore, it is often hypodontia of maxillary lateral incisors that causes spaces in the maxillary labial segment. ‘Gaps’ are a commonly reported concern of individuals with hypodontia (Hobkirk et al., 1994).

The reported prevalence of tooth agenesis varies between ethnic groups. Khalaf et al. (2014) reported an incidence in Africa (13.4%) and the least in Latin America/ Caribbean (4.4%).

A lack of space, physical obstruction, abnormal development of the dental lamina, abnormalities of the epithelium or failure of mesenchyme to be activated, are all thought to play a role in the multifactorial aetiology of this condition (Nunn et al., 2003). Homeobox genes, MSX 1, PAX 9 and AXIN 2 are genes associated with tooth agenesis (Cobourne, 2007) and linked to other dental anomalies such as microdontia (Graber, 1978) and tooth size discrepancy (TSD) which can also cause spacing.

1.4.6 Tooth size discrepancy (TSD)

Tooth size discrepancy is defined as *"*a disproportion among the sizes of individual teeth" (Proffit et al., 2013) and it exists in approximately 5-14% of the population (Othman, 2006). Markovic (1992) found that monozygotic twins had a higher concordance rate than dizygotic twins and concluded that tooth size is genetically determined by MSX 1 and MSX 2 homeobox genes. However, Lundstrom (1984) found that genetics contributed to only 40% of dental anomalies when he studied 50 pairs of monozygotic and dizygotic twins. Overall it is felt that the aetiology of tooth size discrepancy is multifactorial with both genetic and environmental influences, sharing similarities with aetiological factors of tooth agenesis (see section 1.4.5).

Peg shaped maxillary lateral incisor teeth have been cited to be the most common dental abnormality with high heritability and female predilection (Alvesalo and Portin, 1969). Prevalence has been reported to range from 1.3% -1.5% depending on race (Hua et al., 2013). In a study of Dominican Americans, Santoro et al. (2000) found that that the prevalence of TSD is more than twice as likely to occur in the anterior maxillary region than in the mandibular region. Therefore, TSD is an aetiological factor in causing localised or generalised spacing in the maxillary labial segment.

Bolton (1958) determined that in order for good buccal segment interdigitation to result, the overall tooth size ratio between mandibular and maxillary teeth should be 91.3+/- 1.91% overall or 77.2+/-1.65% anteriorly (considering the incisors and canines only). A Bolton's analysis is carried out by dividing the sum of the mesio – distal widths of the mandibular teeth by the sum of the mesio distal widths of the maxillary teeth and multiplying this figure by 100 to obtain a percentage. He based his ratio on 55 cases with excellent, well interdigitated occlusions (44 treated non extraction and 11 untreated). Disharmony between tooth sizes in opposing jaws, such as when microdont lateral incisors are present, will lead to interdental spacing unless the occlusal fit is sacrificed. This is a problem in orthodontics, a speciality which focuses on obtaining optimal occlusal function and aesthetics.

1.4.7 Dento – alveolar disproportion

A discrepancy between tooth and jaw size is known as dento-alveolar disproportion. Interdental spacing can result when normal or large dental bases are accompanied by small or normal-small sized teeth respectively.

In the general population, Cassidy et al. (1998) found that arch width in particular had modest heritability (50%) thus implying that arch size is determined by genetic and environmental factors. Howe et al. (1983) found that dental crowding was more common in those with smaller dental arches, than those with larger teeth. They suggested that the size of the dental base has a larger role to play in determining the presence of spacing.

Faruqui et al. (2012) found that those with spaced dentitions had statistically significantly longer dental bases and that the mesio distal widths of the upper incisors, mandibular canines and premolars were statistically significantly smaller in those with spaced dentitions than those who had well aligned or crowded teeth, thus suggesting the aetiology of spacing is from a combination of tooth and jaw size discrepancy. Puri et al. (2007) also supported the findings that the mesio distal width of mandibular incisors in particular was smaller in those with spaced dentitions than those with crowded teeth. Lundstrom (1955) postulated from his observational study of tooth and jaw size of 227 study models before treatment that tooth size had a greater role to play than jaw size in determining the degree of crowding or spacing.

Dento – alveolar disproportion: tooth size

Dempsey and Townsend (2001) found that tooth size is genetically determined and can vary depending on ethnicity, gender and evolutionary trends.

The term microdontia is used when *"the teeth are small, the crowns are short and normal contact between teeth are frequently missing"* (Boyle, 1955). It can be localised, or more rarely, generalised (Shafer *et al., 1958).* Localised microdontia is most commonly observed in the maxillary lateral incisors (see section 1.4.6).

True generalised microdontia is rare (Bargale and Kiran, 2011). It can be associated with radiation and chemotherapy during development of the dentition (Van der Waal and Van der Kwast 1988). Pituitary dwarfism (Shafer et al., 1958) and Fanconi's Anaemia (Opinya et al., 1988) have been implicated in its aetiology. It can also occur as part of a syndrome, and has been reported to occur with Down syndrome, Gorlin- Chaudhry Moss syndrome, and Type III orofaciadigital syndrome (Bargale and Kiran, 2011).

Dento alveolar disproportion: Jaw size

Interdental spacing may also occur due to skeletal growth abnormalities. Disproportionate growth between the dental bases as seen in class III malocclusions of skeletal aetiology, can result in dento-alveolar compensation resulting in proclination and spacing in the maxillary labial segment. Class III malocclusions occur in 5% of the Caucasian population (Todd and Dodd, 1988).

Similarly, severe class II division 1 malocclusions with mandibular retrognathia can cause the lower lip to be trapped behind the upper incisors, allowing excessive proclination and spacing in the maxillary labial segment. Todd and Dodd (1988) reported the prevalence of class II division I malocclusions to be approximately 20% however this phenomenon of upper labial segment spacing does not occur in all class II division 1 cases.

1.4.8 Environmental

Environmental factors, which may result in interdental spacing, include:

- Soft tissue imbalances
- Diet

Soft tissue imbalances

The teeth are held in a position of equilibrium in the neutral zone between the forces of the tongue and lips. The periodontal ligament helps to counteract the higher forces from the tongue (Proffit et al., 2013). However, situations in which the forces are imbalanced, such as compromised periodontal support, results in proclination and spacing in the upper labial segment. Chasens (1979) coined the term ‘pathological tooth migration’ to describe this phenomenon.

This periodontal destruction is most commonly caused by inflammatory periodontal disease, but can be exacerbated by a deep and traumatic overbite (Abraham and Kamath, 2014).

A tongue thrust habit, macroglossia, lower lip trap, flaccid lips (Lamberton et al., 1980) digit sucking habits or lip incompetence can also lead to proclination and generalised spacing in the upper labial segment (Proffit et al., 2013; Huang and Creath, 1995).

It is theorised that non-nutritive sucking habits persisting for more than 6 hours per day disturb the balance of lip and tongue pressure in neutral zone (Proffit et al., 2013). Bowden (1966) in a longitudinal study found that digit sucking caused proclination and spacing of the maxillary incisors.

Diet

Abrasive diets can cause increased interproximal wear and spacing (Hunt, 1961). Lavelle (1970) compared the complete dentitions of five hundred, 15-20 year old males and females with Anglo Saxon (60), Medieval (70), West African (100) and North American (100) skulls. He found more spacing was evident in the dentitions of the Anglo Saxon and Medieval skulls than the modern cohorts. This reduction in spacing supports the theory of Begg (1954) that modern, softer diets reduce interproximal wear. The softer diet reduces the need for as much masticatory effort as was required in the past (Goose et al., 1956) leading to underdevelopment of the jaws and thus more crowded dentitions and fewer spaces. (Varrela, 2006).

1.5 Treatment options to address interdental spacing

Treatment options for interdental spacing can be broadly divided into:

- Acceptance of the spacing
- Orthodontic space closure
- Composite build ups to augment the size of the teeth
- Redistribution of spacing with or without prosthetic replacement

Multidisciplinary management of cases with extensive spacing or tooth agenesis is recommended (Kokich and Spear, 1997). Depending on the aetiology and extent of spacing present, patients may need an interdisciplinary management approach as recommended by Kokich and Spear (1997).

Acceptance of diastemata is an option that eliminates commitment in terms of time and associated cost. This can be a viable option, as spontaneous reduction in the size of interdental spacing has been found to occur with age (Jonsson and Magnusson, 2010)

Interdental spaces can be closed orthodontically however, if the aetiology is due to a tooth size discrepancy this may compromise the occlusal fit (See section 1.4.6). The most common example of orthodontic space closure is the situation when maxillary lateral incisors are absent and canines are camouflaged to appear as lateral incisors. This minimises the restorative burden for the patient. Rayner et al. (2015) demonstrated that lay people could not distinguish between smiles with lateral incisors, and where the canines had been camouflaged to replace them. Robertsson and Mohlin (2000) showed that patients who had canines camouflaged as lateral incisors, 93% were moderately or very pleased with the overall result. The most satisfied patients were those with bilateral missing maxillary lateral incisors hence indicating that symmetry is a key factor in optimal smile aesthetics (See section 1.9).

Composite build-ups are a common treatment offered in those with microdont lateral incisor teeth, or those with anterior spacing wishing to avoid orthodontic treatment all together. The disadvantage of this option is that it is associated with life-long maintenance. Demirci et al. (2015)

demonstrated 92.8% (3 step) and 93% (2 step), 4 year survival rate of composites used to close residual spaces in the maxillary incisor region and proposed it as an excellent minimally invasive restorative approach to address spacing. In a sample of 30 patients who required 147 direct composite build ups, only 10 restorations failed.

Space redistribution is considered in cases such as hypodontia when full closure may not be achievable. Restorative options to address the resultant spaces include options to enlarge existing teeth (composite build ups, veneers, crowns) or prosthetic teeth in the form of dentures, bridges or implants.

Implants have a 97.6% success rate when replacing a lateral incisor when followed up after 24-39 months (Zarone et al., 2006). They can have excellent aesthetics as the emergence profile can be dictated during placement. Implants are considered the gold standard of prosthetic tooth replacement. Implants require 1.5mm space either side between the implant and adjacent tooth. In cases where this space is unachievable, then resin bonded bridges (RBBs) are a good fixed alternative.

Resin bonded bridges (RBBs) are a cost effective alternative to implants, especially when patients wish to avoid surgery, or in whom surgery is contra indicated. An average survival rate of 7 years and 10 months has been reported (Djemal et al., 1999).

Partial dentures may be an option for those who do not wish to have protracted treatment with orthodontics and can provide a suitable aesthetic replacement for missing teeth. Additionally, they are a good substitute in younger patients awaiting growth completion prior to implant placement.

1.6 Interdental spacing and oral health

There is a school of thought that spacing is detrimental to arch integrity (Steigman and Weissberg, 1985) and thus should be thought of as trait of malocclusion (Andrews, 1972). The evidence on the impact of spacing on oral health is inconclusive. Periodontal health has been found to be worse in those with interdental spacing compared with those with tight contacts (Hellgren, 1956; Gould and Picton, 1966). However, as these were cross – sectional studies, it may be that it was the periodontal deterioration which manifested first and led to the interdental spacing causing pathological spacing, thus highlighting correlation, but not causality between spacing and periodontal disease (Geiger, 2001).

In contrast, other studies have shown plaque levels to be lower in those with spaced dentitions in both adolescent and adult cohorts (Silness and Roynstrand, 1984; Geiger, 2001). Both of these studies indicated that spacing facilitated improved oral hygiene, and fewer restorations and carious lesions were reported in subjects with spacing compared with unspaced dentitions.

Geiger et al. (1974) examined 516 university students and found those with spacing had fewer proximal restorations than normal occlusions without spacing, but found no difference in periodontal health. Geiger et al. (1974) observed university educated students as a convenience population, and thus it could be argued that his cohort was not representative of all socioeconomic classes found in the general population.

In 1948, the World Health Organisation (WHO) defined oral health as a state of "being free from mouth and facial pain, oral and throat cancer, oral infection and sores, periodontal (gum) disease, tooth decay, tooth loss, and other diseases and disorders that limit an individual's capacity in biting, chewing, smiling, speaking, and psychosocial wellbeing (WHO, 1948). The 'psycho-social well- being' component of this statement encompasses feelings of being confident when smiling, social functioning, and the absence of social or cultural disadvantage due to oral health status; not merely the absence of disease (Cunningham et al., 2002).

1.7 Oral Health related quality of life

Quality of life (QoL) is defined as an 'individual's perception of their position in life in the context of their culture and value systems in which they live and in relation to their goals, expectations standards and concerns' (WHO, 1948).

Oral health related quality of life is defined as 'the impact of oral disorders on aspects of everyday life that are important to patients and persons, with those impacts being of sufficient magnitude, whether in terms of severity, frequency or duration to affect an individual's perception of their life overall' (Locker and Allen, 2007).

1.7.1 Malocclusion and quality of life

Havens et al. (2010) found that overall facial harmony and tooth alignment were the two highest ranked features determining attractiveness.

Klages et al. (2004) found that dental aesthetics was directly correlated to oral health-related quality of life (OHRQoL) scores. Children with malocclusions were found to suffer from low self-esteem (O'Brien et al., 2007) and have a higher experience of bullying (Macgregor, 1970). Macgregor’s study specifically investigated those with class II division 1 malocclusion, with an increased overbite and overjet and found that both the children and their parents felt that an improvement in dental appearance would contribute towards improving self- confidence and societal perceptions of the individual (Shaw et al., 1979) Children being bullied reported that changing the appearance of their teeth would be their first priority in order to stop the teasing.

A recent study of cyber bullying related to malocclusion found that bullying of an individual with spacing can lead to psycho-social changes (Chan et al., 2017). A direct quote from a participant’s ‘Tweet’ in this study included the following statement:

“Front teeth gaps aren’t fun because throughout my whole childhood I was bullied about it to the point where I stopped smiling & talking.”

Langlois et al. (2000) found that children and adults with optimal smile aesthetics are judged and treated more positively even by people who already know them.

1.7.2 Interdental spacing and quality of life

Johal et al. (2007) used the child perceptions questionnaire (CPQ) to evaluate OHRQoL in a group of 13-15-year-old subjects with an increased overjet (more than 6mm) and a group with interdental spacing, compared to a control group. Interdental spacing in the upper labial segment had a negative impact on the OHRQoL of children aged between 13 and 15 years of age. Furthermore, they also found that interdental spacing had a negative effect on the parents of these children. Most commonly, parents felt concerned about taking their child into public places. It has been postulated that if the parent and child are both affected then they are both likely to be motivated about seeking treatment and thus treatment is likely to be more successful (Shaw, 1981).

Bernab et al. (2007) interviewed and examined 1,318 adolescents aged 15-16 years of age and identified that anterior dental spacing was the third highest ranked malocclusion trait which impacted on a patient's socio-dental well being. Only overjet and centre line deviation were ranked to have a greater effect than dental spacing. Spacing was reported to have more of an impact on this study than dental irregularity and open bites.

Mokthar et al., (2015) conducted a survey of participants in Saudi Arabia and compared variations in smile aesthetics. They found that the presence of a MMD was associated with a perception of being less intelligent and less likely to find success in social relationships. Nagalakshmi et al. (2014) found that the reported quality of life increased by 50% after the orthodontic closure of a MMD in 40 motivated South Indian patients.

Hypodontia of the anterior teeth often results in anterior spacing. Sixty-six percent of patients with hypodontia described the main feature of their teeth as ‘gappy’ (O'Brien et al., 2007). Hobkirk et al. (1994) investigated the concerns of 451 patients with hypodontia and concluded spacing and aesthetics to be one of the top three concerns for these patients. Wong et al. (2006) interviewed 25 patients who were missing 4 teeth or more, and found that 100% reported that their teeth affected their social well-being, and 55% reported that it affected their emotional well-being.

1.8 Determinants of facial attractiveness

Human neonates as young as one day old are able to inherently show a preference to a beautiful rather than a less attractive face, suggesting an intrinsic likeability associated with beauty (Slater et al., 1998). Unattractive people tend to be liked less, have difficulty forming friendships, are less desirable as ‘dates’, and are viewed to be less trustworthy, less intelligent, perceived to be more aggressive and perceived to lack social skills (Dion, 1973; Walster et al., 1966; Baldwin, 1980; Mathes and Kahn, 1975).

The eyes and mouth have been reported to the be the main focus of the face by earlier studies. (Baldwin, 1980; Lombardi, 1973). This has subsequently supported by the findings of Hickman et al. (2010) who monitored the movements of the eye when observing frontal facial images. Adult subjects in this study showed that the main areas of fixation were eyes, ears, mouth chin. They found that the mouth only received 5.1% of attention. In contrast, Kiekens et al. (2007) found that smile aesthetics accounted for 25-31% of overall attractiveness. Proffit et al. (2013) stated that the smile is the most important aspect of facial animation.

Other studies have not shown a significant difference between perceived smile aesthetics alone or with a background face (Shaw et al., 1985; Shaw, 1981; Chang, 2011). Howells and Shaw (1985) found that the perceived attractiveness of live subjects and dental photographs were comparable. Pictures of smiles were perceived as slightly more attractive than when with the background face but this was not statistically significant. The evidence on the effect of facial attractiveness on overall perceived smile aesthetics is inconclusive.

1.9 Smile aesthetics

Edward Angle, the father of orthodontics perceived the Greek statues of Aphrodite to be a marker of optimal aesthetics, and no doubt this will have influenced his treatment philosophies. Smile aesthetics consists of three main components, lip frame work, gingivae and the dentition itself (Sharma and Sharma, 2012) but the dentition has been reported to have the greatest impact on smile aesthetics overall (Farzanegan et al., 2013).

Machado (2014) outlined ten principles which dentists should try to observe in order to provide the optimal aesthetics for their patients. These principles specifically recommend the closure of all spaces between teeth and the avoidance of black triangles (See table).

Table 3: Principles of smile aesthetics, adapted from Machado (2014)

Component of smile aesthetics	Associated principles of smile aesthetics.
Smile arc and Buccal corridors.	The incisal and occlusal edges of the maxillary teeth must follow the curvature formed by the lower lip on smiling Aim to achieve intermediate buccal corridors for optimum aesthetics.
Maxillary central incisor dimensions	Incisal edges must be symmetrical, height must be 75-85% of the width of the tooth.
Antero-superior teeth ratio	Narrow lateral incisors are to built up for optimal aesthetics
Interdental spaces and black triangles	All diastemata should be closed and black triangles avoided
Gingival exposure on smiling and gingival architecture	Up to 3mm gingival exposure is aesthetically acceptable. The gingival margin of the central incisors should be the same or 0.5mm below the gingival margins of the canines. Gingival architecture should be symmetrical.
Midline deviation	Tooth angulation is more important than centre line deviation in the aesthetic zone
Voluminous lips	Considered beautiful in the modern age

There are several components to the aesthetic smile, however it has been said that these features cumulatively have a visual impact greater than any one component alone (Ong et al., 2006; Lombardi, 1973).

1.10 Aesthetic perception of interdental spacing

Machado et al. (2013) investigated the perception of varying dimensions of interdental spacing mesial and distal to lateral incisors, a common appearance associated with microdont or peg-shaped lateral incisors. The smile without spacing was found to be the most attractive, however lay persons tolerated a 0.5mm space distal to the upper lateral incisors and did not deem it to be unattractive. Overall, a trend was identified common to both groups, that the greater and more mesially located the spacing was, the more unattractive the smile was perceived to be.

Rosa et al. (2013) conducted a similar study that investigated the perception of 12 variations of a digitally created smile. The images were shown to orthodontic patients, orthodontists, general dentists and lay people and included an image with spacing in the maxillary anterior segment. One of the images showed a smile with a MMD combined with spacing mesial to the canines as the lateral incisors were missing. The image with spacing was least tolerated by all groups, more so than images displaying other features of malocclusions. Both Rosa et al. (2013) and Kokich et al. (2006) demonstrated that asymmetric alterations to smiles were significantly more noticeable in all groups.

The majority of studies world-wide have focused on the aesthetic perception of localised spacing either laterally or in the midline. Noureddine et al. (2014) investigated the perception of varying patterns of interdental spacing in the upper labial segment. They asked 105 lay people in France to rate the following four patterns of spacing:

- Midline diastema
- Lombardi - a small midline diastema, and two larger spaces between the central incisors and lateral incisors bilaterally
- Frush and Fisher Diastema – interdental spaces (unequal in size), located between the lateral incisor and canine on one side and the central incisor and lateral incisor on the other side
- Simian diastemas – interdental spaces located in between the lateral incisors and canines bilaterally

They did not ask the observers to rate an image without any interdental spaces, and thus no conclusions can be drawn from this study as to whether these images would have been rated more or less attractive than a smile without spacing. They felt that they established an 'aesthetic hierarchy' of the pattern of spacing. Simian diastemas were found to be the most attractive, followed by Frush and Fisher Diastemas, Lombardi diastemas, and finally median diastemas were rated as the least attractive. Houacine and Awooda (2017) had dissimilar findings, with MMDs rated as more attractive than more generalised spaces.

Noureddine et al. (2014) artificially created the spaces by adjusting the widths of the teeth which has been shown to also influence aesthetic perception (Wolfart et al., 2005) and thus can be considered a cofounding factor.

Aesthetic perception of maxillary midline diastemas

A European study reported that midline diastemas have a very strong influence on overall perceived facial aesthetics, more so than other background features or prominent incisors (Kerosuo et al., 1995). Similar findings have been found in other studies (Witt and Flores-Mir, 2011). Rodrigues et al. (2009) found the MMD was statistically significantly rated less attractive than other deviations from the ideal smile.

Mokhtar et al. (2015) compared various deviations from the 'ideal' smile and how lay people and dental professionals perceived them. Deviations included, a higher smile line (excess gingival show 5mm), deviation of dental midline from the mid-facial axis, a smile with reverse arc and a midline diastema. The study found that the presence of a midline diastema was rated as the most unattractive trait and most in need of correction to improve smile attractiveness by both lay people and dental professionals in Saudi Arabia.

A study on Peruvian students found interdental spacing to be one of the most significant features of a malocclusion to negatively affect self-perceived smile aesthetics (Bernabe et al., 2006).

Parrini et al. (2016) undertook a systematic review of perceptions of smile aesthetics amongst laypersons. They identified only two studies that investigated a threshold level of spacing and found that lay people tolerated a midline diastema of 1.5mm (Kumar et al., 2012) to 2mm (Kokich et al., 2006) within the realms of aesthetic acceptability. Kokich et al. (2006) found that orthodontists were less tolerant and disliked MMDs between 1-1.5mm. This review concluded that lay people would accept a 1.5mm diastema, based on the available literature.

1.11 Smile perception and social and ethnic background, age and gender

Perception of beauty is complex (Lombardi, 1973). Ethnic background, age, gender and socio-economic class (SEC) of the assessor can influence the perception of smile aesthetics (Peck and Peck, 1970)

1.11.1 Smile perception, age and gender.

There is great variation between studies on whether gender affects how critically a smile is perceived. Some studies that have investigated the impact of anterior spacing in comparison to other deviations from the ideal smile showed no statistical significant difference between the genders (Rosa et al., 2013). Kokich et al. (2006) however, noticed that women rated more leniently than men, but this result was not statistically significant. Abu Alhaija et al. (2011) found his cohort of Saudia Arabian women, significantly favoured a midline diastema of up to 3mm more than their male counterparts

Kokich et al. (2006) found that the number of years of dental professional experience had no impact on aesthetic perception when rating digitally altered smiles with various traits of malocclusion. In contrast, Rodrigues et al. (2009) found that younger people rated the image of a 1mm diastema more critically than older participants. However, this study only had 20 participants in total. Noureddine et al. (2014) found similar results with MMD and images with a Lombardi pattern of spacing (a small midline diastema, and two larger spaces between the central incisors and lateral incisors bilaterally) being rated more critically by the younger cohort of lay persons. This, however was not the primary objective of their study and therefore the finding may be underpowered. Pithon et al. (2013) manipulated images with increasing size of black triangles between the maxillary central incisors and asked 150 lay persons to review the images. They found younger cohorts, 15-19 years and 35-44 years, to be more critical than older participants 65-74 years.

Howells and Shaw (1985) recruited 122 participants to rate the aesthetics of 20 dental images, which deviated from the ideal smile, one of which included a midline diastema. They found that overall, younger groups rated the dental image with the MMD more critically than older participants. There were no statistically significant differences between the genders when rating the equivalent facial view.

1.11.2 Smile perception and cultural variation

Culture can affect perceptions of aesthetic beauty (Gonzalez et al., 2010). The MMD in some African communities is so desirable that some will people seek out to have one artificially created, even if it is at the detriment to pulpal health (Arigbede and Adesuwa, 2012; Umanah et al., 2015). Nigerian populations from six different regions were asked to give their perception on photos with a midline diastema. All of them considered the midline diastema to be an aesthetic attribute provided its width was within 2-3mm (Akinboboye et al., 2015). In fact, Akinboboye et al. (2015) alongside Houacine and Awooda (2017) found that those with a MMD themselves rated images with MMD more favourably than those without an MMD. However, this was not the primary objective of either study, and neither study mentioned how many in the cohort had MMDs, therefore there is likely to be insufficient power to definitively draw this conclusion.

Saunders et al. (2011) showed that patient perception of beauty can not be based on their ethnic background alone. This study showed a number of photographs of with various dental anomalies smiles (which included a smile with a midline diastema) to a cohort of elderly Afro-Caribbean subjects who had lived in the USA, and found no differences between their responses and those of a similar Caucasian cohort (York and Holtzman, 1999).

Therefore, whilst cultural variation may influence smile perception, aesthetics is a more multidimensional construct. It is therefore important that a dentist does not assume aesthetic preference based on ethnic background.

1.11.3 Smile perception and social Background

Howells and Shaw (1985) discovered that lay people belonging to a lower socio-economic classes (SECs) were more likely to rate photos of malocclusions more critically. Social class was determined by participant occupation referenced by the author against the United Kingdom Registrar's General Office (Office_of_National_Statistics, 1970). Other studies investigating the aesthetic perception of anterior segment spacing on smile aesthetics did not evaluate the SEC of the layperson.

Rosa et al. (2013) compared deviations of smile aesthetics, and included a digitally manipulated picture with missing lateral incisors and spacing in the anterior maxillary midline and laterally. This study agreed with other studies on aesthetic perception, which have found orthodontists to be more critical about MMDs than lay cohorts (Kokich et al., 2006) with orthodontists being the most critical of this image. Interestingly Rosa et al. (2013) found that orthodontic patients were more critical than lay people and general dentists.

Machado et al. (2013) observed the perception of unilateral spacing around the lateral incisor and also found orthodontists to be significantly more critical than lay people who tolerated a space of 0.5mm distal to the lateral diastema. Both Rosa et al. (2013) and Kokich et al. (2006) demonstrated that asymmetric alterations to smiles were significantly more noticeable in all groups regardless of social or occupational background.

The critical nature of the orthodontist can be observed from studies investigating other deviations from optimal smile aesthetics. Roden-Johnson et al. (2005) observed arch forms and found orthodontists to be more critical than general dental practitioners (GDPs).

Peck and Peck (1970) described this phenomenon as 'selective conditioning; 'the more frequently we observe a facial pattern the more likely we are to perceive it as 'correct'. An orthodontist, one could argue is selectively conditioned to particular smile aesthetics.

1.12 The measurement of aesthetic perception

Parrini et al. (2016) conducted a systematic review of studies that have investigated the perception of smile aesthetics on lay persons. The review identified that the vast majority of studies (34) adopted a visual analogue scale (VAS) to measure perception (Kokich et al., 2006; Rosa et al., 2013; Machado et al., 2013). A small number of studies used a Likert–type scale (n=7), generic point scales (n=16) rank ordering (n=2) and evaluation of minimum and maximum outcomes (n=3).

1.12.1 Description of various scales

- Visual analogue scales - These can be a line of any length (usually 50-100mm) with the terminal ends anchored with descriptors of the extremes of the emotion; very attractive or very unattractive. Kreindler et al. (2003) found no significant differences between a VAS of 4cm or 10cm.
- Likert type scales – This is a line traditionally with five descriptors namely, very attractive, attractive, neutral, unattractive, very unattractive. This is a way of obtaining categorical data and forcing the subject into making a decision to select the descriptor that best describes their feelings of the image. The potential disadvantage is that it may fail to pick up on certain nuances between individuals (Aitken, 1969)
- Generic point scales - Similar to a Likert type scale, but instead of descriptors, there are numbers from 1 to 10 on the line and the person selects the number that best describes their feelings.
- Rank ordering – Ordering the images into order of preference from most to least attractive. This has been used in a smile aesthetics study of patterns of interdental spacing (Noureddine et al., 2014; Houacine and Awooda, 2017) but can become very time consuming in studies with a large number of photographs to compare.

1.12.2 Visual Analogue Scale

Visual analogue scales are reported to be the gold standard in measuring feelings (Cline et al., 1992) or instinct (Wewers and Lowe, 1990; Kremer et al., 1981). These feelings may be difficult to quantify as a category or number as perception is a very complex and personal concept (Lombardi, 1973).

A VAS has been shown to be a valid and reproducible method of measuring dental attractiveness from clinical photographs with retracted cheeks and lips (Howells and Shaw, 1985). Subjects were asked to assess dental photographs and, five weeks later were shown the same 'live' image on subjects. There was no significant difference between the ratings and therefore concluded that two-dimensional dental photographs are an acceptable method, to simulate aesthetic perception in real life.

The VAS has been described as being 'clear and easy to use' (Kerlinger, 1964) and well understood by children and adults alike (Glasgow, 2012). In contrast, Couper (2006) found the VAS can be a difficult concept to comprehend.

Couper (2006) and Thomas (2011) investigated the effects of the midpoint on a VAS and found no statistically significant difference between the ratings, however mean scores were lower on VAS without a midpoint. They found that participants took less time in completing a VAS with a midpoint than without in both studies, thus suggesting the presence of a mid-point made the scale easier to understand. They also found that the time taken to rate reduced as the exercise continued, suggesting that initial time taken to understand a new task improves with repetition of the same task. Wewers and Lowe (1990) advised that a clear and careful description or background training in how to use the VAS must be given to participants in order to ensure valid results. Joyce et al. (1975) reported a VAS labelled at the terminal ends only, was more sensitive than a VAS with intervals such as a midpoint. This finding has been supported by Price et al. (1994) who investigated pain perception and Howells and Shaw (1985) who investigated smile aesthetics using a VAS.

Couper (2006) investigated 1427 participants and found that the mid-point was used in 22.7% of visual analogue scale ratings. This effect, known as ‘central bias tendency’ (Millar et al., 1995). This was also witnessed by Springer (2010) and Parekh et al. (2005) who investigated the effectiveness of emoticon slider technology with respect to smile aesthetics. Maxwell (1978) in his study on the sensitivity and accuracy of the VAS in the classroom showed that not all subjects used the full range of the scale. Phillips et al. (1992) found that 16% of their dental student cohort clustered their scores to being within less than half of the VAS when assessing facial photographs for aesthetics.

Couper (2006) also investigated the effect of numeric cues on a VAS and found this could influence results. Schwarz et al. (1991) also criticised numeric scales as they felt the larger and positive numbers could influence more positive responses. This has been supported by Scott and Huskisson (1977) who found 10 and 15 to be most popular on a 20-point scale.

A number of studies have not found any statistically significant differences between using a VAS and other scales (Cook et al., 2001; Bayer and Thomas, 2004; Couper, 2006). Averbuch and Katzper (2004) found the VAS and 5 point Likert scale equivalent in measuring pain. Although comparable results can be obtained with both scales, however the VAS has the additional advantage of facilitating more complex statistical analysis as it produces a continuous outcome measure, whereas Likert–scale results are discrete which limits statistical analysis.

Due to variations in the use of the scale, and individual interpretation of emotion, the VAS has been criticised for being unable to extrapolate its findings to the general population (Maxwell, 1978). As perception is a multi-faceted construct, Wewers and Lowe (1990) suggest further psychometric properties of the VAS need to be investigated prior to its results being generalisable. Schabel et al. (2009) described the use of the Q – sort method, first described by Stephenson (1953) in an attempt to overcome this, whereby they attempted to compare the reliability of both methods and found the Q-sort method to have an improved intra class correlation (ICC) and therefore better reliability than VAS. This method asked participants to view 48 photographs identify the 2 most and 2 least attractive photos, then identify the 4 most and 4 least attractive photos from the remaining selection, until all photos had been ordered. They were then asked to mark their threshold of attractiveness. This method appears to be more reliable as demonstrated by a significantly higher ICC in the Q-Sort group, but the VAS is more convenient and other studies have shown good ICC when the VAS has been used (Howells and Shaw, 1985).

Left handed participants were reported as significantly under reporting their feelings on a visual analogue scale. This was explained by ‘hemispheric specialisation and activation for a manual response to a visuospatial task’ (McKechnie and Brodie, 2008).

A search of the literature could not find a study, which measured the perceived smile attractiveness of anterior spacing in the UK population. Searches were conducted using Ovid, Pubmed, Embase databases. Search terms included ‘spacing’ or ‘spaced’ or ‘diastema’ or ‘interdental spacing’ or ‘diastemata’ combined with AND ‘smile aesthetics’ or ‘facial aesthetics’.

1.13 Rationale for Study

There have been studies, which examine the aesthetic perception of localised spacing around the lateral incisor (Machado et al., 2013) and spacing in the midline (Kokich et al., 2006; Kerosuo et al., 1995; Rosa et al., 2013; Abu Alhaija et al., 2011; Kumar et al., 2012; Pithon et al., 2013; Rodrigues et al., 2009). There have been two studies which examined laypersons’ perspectives on different types of spaces that can present anteriorly (Noureddine et al., 2014; Houacine and Awooda, 2017).

The aesthetic perception of different patterns and sizes of interdental spacing in the maxillary labial segment, amongst patient and professional groups is important for the orthodontic profession to understand as orthodontics is concerned with improving smile aesthetics. At the time of writing, such a study has not been carried out before. The findings may help to inform the development of future indices of treatment need.

CHAPTER TWO

METHOD

CHAPTER 2: METHODS

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2.1 Ethical Approval

Ethical approval was obtained from the University of Birmingham's research and ethics committee (ERN_16_0161), London Brent Research Ethics committee (16/LO/1203), Birmingham Community Health Care research and development team, and the NHS Health Research Authority (HRA).

2.2 Objectives

This study aims to understand if there are any differences in aesthetic perception amongst orthodontists, general dentists, children and lay adults between smiles with and without varying patterns and sizes of interdental spacing.

Secondary objectives of this study include understanding if the pattern and size of spacing influences the aesthetic perception of a smile. In addition, we wish to evaluate the impact of any confounding factors such as age, gender, ethnicity and level of dental professional qualification on aesthetic perception of interdental spacing.

2.3 Null Hypothesis

There is no difference in the aesthetic perception of a smile with or without spacing amongst orthodontists, dentists, children and lay adults.

2.4 Study design

The study has been designed as a cross – sectional study. A power calculation (see section 2.7) determined that forty participants would need to be recruited from each group (orthodontists, general dentists, lay people and children).

Participants were invited to join the study and given information verbally by the principal investigator (AM) and in written format (See appendix 1-5). Separate information sheets were designed for adults and children, to ensure participating children were able to fully understand and give assent. Written consent and assent forms were completed by consenting adults and children respectively (see appendix 6-8).

Each subject was given a demographic sheet (see appendix 9-12) and questionnaire (see appendix 13) with a unique code. The demographic sheet requested all participants to document their age, gender and ethnicity. Professional groups were also asked to state their country of primary qualification, their level of qualification and general dentists were asked if they provided orthodontic treatment. The demographic sheet was stored in a locked drawer in a locked clinical supervisor's office and was not accessible to the principal investigator during data analysis.

Data was collected by means of a self-completed paper questionnaire, supervised by AM. Written and verbal instructions were given on how to complete the questionnaire. The main questionnaire was a series of digitally manipulated photographs with a 100mm VAS beneath for the patient to mark their aesthetic perceptions. The first two photographs on the questionnaire were there for practice in order to allow the subjects to become familiar with using the VAS. The VAS had terminal markers of ‘very attractive’ and ‘very unattractive’ and no interval markings**.** The VAS score was measured by the principal investigator (AM) with a digital caliper and was the primary outcome measure of this study.

Ten percent of participants from each observer group were randomly selected using a computerised random number generator and asked to repeat the questionnaire two weeks later. This was to determine intra-rater agreement, and validity of the questionnaire.

Ten percent of completed questionnaires were randomly selected using the same computerised random number generator, and the principal investigator (AM) re-measured the VAS scores in order to determine intra-examiner reliability.

2.5 Participant Group Recruitment

Forty participants were recruited from each group (orthodontists, general dentists, lay people and children). Orthodontists were recruited from the West Midlands Orthodontic Society and consultant orthodontic group meetings. General dentists were recruited at courses for continued professional development in the West Midlands. Children were recruited from the paediatric dental waiting room at Birmingham Dental Hospital. Lay adults were recruited from the Birmingham Business School, University of Birmingham.

2.5.1 Exclusion criteria

- Non-English speaking subjects
- Subjects (child or adult) who did not wish to participate
- Subjects who lacked the capacity to consent. This was assessed by the principal investigator (AM) who is also a healthcare clinician with appropriate training to determine capacity to consent
- Subjects currently undergoing orthodontic treatment

2.6 Images for the questionnaire

The ‘ideal smile’ image (without interdental spacing) was selected from a digital photography library at Birmingham Dental Hospital, where patients had given consent for their images to be used for research and publication purposes. The chosen image was felt to best represent ideal smile aesthetics by the principal investigator (AM) and research supervisors (SK, PJT).

The image was captured by the clinical illustration team at Birmingham Dental Hospital. The image was taken by a trained dental photographer with the use of Cannon 70 D camera with a Cannon EF 100mm f/2.8 macro lens and Cannon MR – 14EX macro ring flash. The aperture was set to f32, shutter speed 1/200. The image of the smile was taken with cheek retractors to show the dentition only, from the frontal view.

The image of the ideal smile was manipulated by a graphic designer using ‘Adobe Photoshop CC®’ software. The manipulation involved four patterns of interdental spacing, which increased by 0.5mm to a maximum of 3mm. The four patterns of spacing were as follows (See appendix 13 and 14):

- Maxillary midline diastema (MMD)
- An asymmetrical localised space mesial to the upper right lateral incisor, (lateral diastema, LD)
- Symmetrical generalised spacing anterior to the maxillary canines with a MMD (generalised spacing, GS)
- Symmetrical generalised spacing anterior to the maxillary canines without a MMD (lateral spacing, LS).

In total this yielded 24 manipulated images. The additional ‘ideal smile’ image was also included for scoring, giving a total of 25 images to be rated by each observer.

2.6.1 Image Management

Images were digitally manipulated using Adobe Photoshop CC ® software. The ‘ideal smile’ image was adjusted in size until the dimensions of the upper right central incisor on the computer screen was the same size as the dimension of the upper right central incisor on the study models. This was necessary to ensure, that the dimensions of the artificially created interdental spaces were the same size and in proportion with what would be seen in real life. Approximately a 0.5mm diastema was 6 pixels in size.

Prior to creating the interdental space, a digital back plate was inserted in order for the ‘inside of the digital mouth’ to be seen through the artificially created interdental spaces. The hue of the gingivae was used as a colour reference for the back plate, and darkened furthermore until it was felt that it represented a real life individual with interdental spacing.

The tooth or teeth selected to be moved were done so using the ‘masking tool.’ These were digitally moved by the appropriate amount. Careful consideration was given to avoid reduction in the size of the dentition as the interdental spaces were artificially created. Therefore, as the size of spacing increased, the width of the smile also increased. In order to keep all other features of the digitally altered image constant, this slight widening of the smile was unavoidable and deemed an acceptable compromise.

As the size of the spacing increased, more of the lower incisor teeth were visible, and these needed to be also digitally manipulated to artificially build up tooth structure, that was not present on the original image.

The images were superimposed in each ‘set’ or pattern of spacing, in order to ensure consistency between the images.

2.6.2 Preparing the images for presentation

Images were printed by the same printer on high quality 100gsm paper. The images were presented to all participants in the same random order. Each photo, including the ideal smile, was assigned a random computer generated number from 1 to 25.

2.7 Sample Size calculation

A power calculation was performed to determine the sample size. Similarly designed studies were reviewed to determine the appropriate standardised difference. Rosa et al. (2013) in a similar study and reported a standard deviation between 10 and 25. Assuming a standard deviation of 16, and a clinically significant difference of 15 between the VAS scores, resulted in a standardised difference of 0.95 (15/16). Parekh et al. (2005) set an arbitrary bench mark of 15% difference in VAS scores as being clinically significant. These studies were used as the basis for obtaining a sample size.

A line drawn on Altman's plot between 0.95 (standard difference) and 0.8 (power of study) resulted in a requirement of 35 participants in each group at the 5% significance level. To account for a potential 10% dropout rate, 40 participants were recruited in each group.

2.8 Data Recording

Data was recorded by the principal investigator, AM on a Microsoft Excel® spread sheet. The principal investigator was blinded and not aware of which participant had completed the questionnaire, as the clinical supervisor (SKO) had assigned each questionnaire with a unique identifier number. Data for VAS scores and participant demographics were recorded on two Microsoft Excel® spreadsheets. The clinical supervisor had separate unique identifier codes for the demographic sheet and questionnaire. These codes were unlocked for statistical analysis.

Each image was measured with a digital caliper and the VAS score recorded for each subject against their unique identifier number. Two weeks later, ten percent of questionnaires were randomly selected and the VAS scores were measured again to determine intra–examiner reliability. Ten percent of subjects were randomly chosen two weeks later to repeat the questionnaire in order to determine intra-rater reliability (See appendix 15).

2.9 Statistical Analysis

Statistical analysis was carried out using Stata-14®. The data met the assumption of normality and the statistical linear regression model used was an analysis of co-variance (ANCOVA), taking into account age, gender and ethnicity as potential confounding factors. Outliers were included within the statistical analysis as it was not believed that they would have a great impact on overall results.

Intra class correlation coefficients were calculated to determine intra-rater and intra- examiner reliability. Descriptive statistics (mean, median, mode, standard deviation) were calculated to further describe the data.

CHAPTER THREE

RESULTS

CHAPTER 3: RESULTS

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3.1 Demographics of participants

All images were assessed by the four observer groups (orthodontists, general dental practitioners (GDPs), lay adults and children) under standardised conditions. In total 161 participants were recruited to this study. The demographics of the subjects are shown in table 4 below.

Table 4: Participant demographics

	Orthodontist	**GDP**	**Adults**	**Children**
N	40	40	41	40
Age *Mean (SD)*	44.5 (10.5)	27.8 (8.0)	20.5 (2.2)	14 (1.6)
Range	29-68	23-57	18-28	12 - 16
≤16	0 (0%)	0 (0%)	0 (0%)	40 (100%)
>16 ≤25	0 (0%)	26 (65%)	39 (95.1%)	0 (0%)
>25 ≤35	10 (25%)	9 (22.5)	2 (5%)	0 (0%)
>35≤ 45	14 (35%)	2 (5%)	0 (0%)	0 (0%)
>45 ≤55	8 (20%)	3 (7.5%)	0 (0%)	0 (0%)
>55	8 (20%)	0 (0%)	0 (0%)	0 (0%)
Gender *Male*	23 (57%)	19 (48%)	17 (41%)	21 (53%)
Female	17 (43%)	21 (53%)	24 (59%)	19 (48%)
Ethnicity *Caucasian*	24 (60%)	15 (37.5%)	25 (61%)	18 (45%)
Asian	12 (30%)	22 (55%)	12 (29.3%)	18 (45%)
Afro-Caribbean	1 (2.5%)	1 (2.5%)	1 (2.4%)	1 (2.5%)
Other	3 (7.5%)	2 (5%)	3 (7.3%)	3 (7.5%)

	Orthodontist	GDP	Adults	Children
Professional Groups Only:				
Qualification (Orthodontist)				
Specialist	12 (30%)	N/a	N/a	N/a
Post CCST	4 (10%)	N/a	N/a	N/a
Consultant	24 (60%)	N/a	N/a	N/a
Qualification (GDPs)				
BDS only	N/a	27 (68%)	N/a	N/a
Other Post Graduate	N/a	13 (33%)	N/a	N/a
Country of primary qualification				
UK	34 (85%)	38 (95%)	N/a	N/a
Ireland	3 (8%)	0 (0%)	N/a	N/a
Europe	1 (3%)	1 (3%)	N/a	N/a
India	1 (3%)	1(3%)	N/a	N/a
South Africa	1 (3%)	0 (0%)	N/a	N/a

3.2 Overall Results

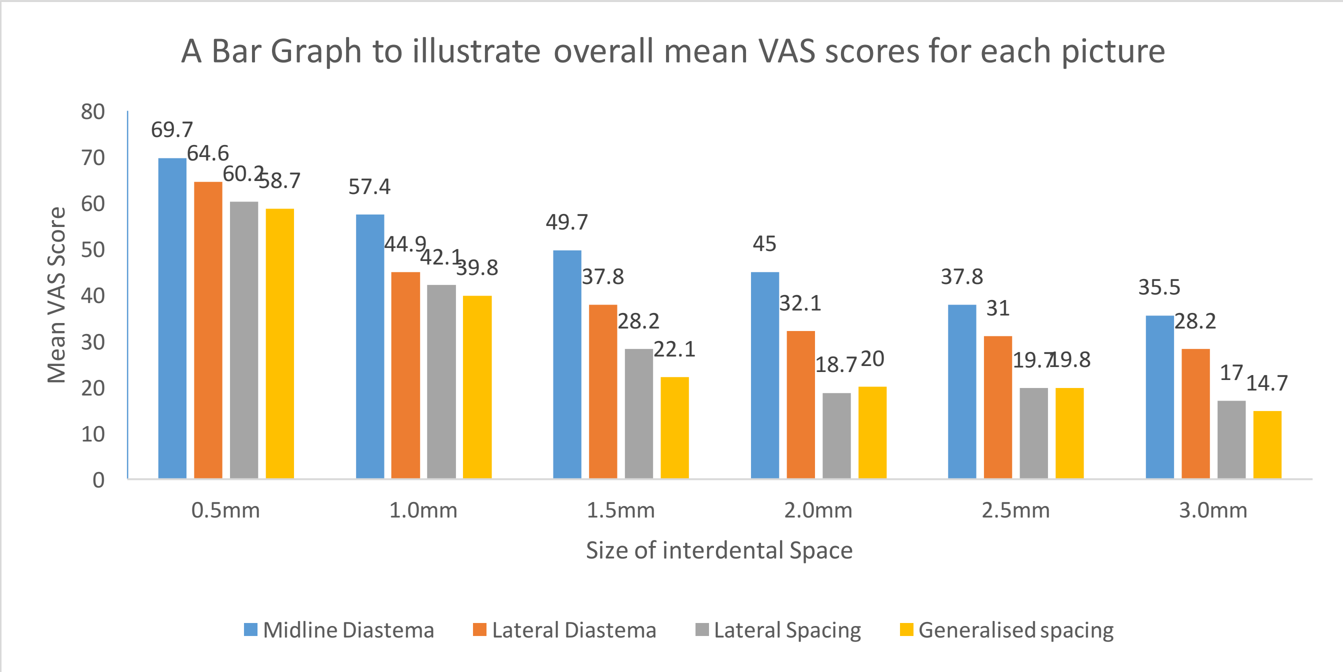
The images shown to participants in the questionnaire exhibited four patterns of spacing as follows:

- Maxillary midline diastema (MMD).
- An asymmetrical localised space mesial to the upper right lateral incisor. These are referred to as 'lateral diastemas' (LD) in the results.
- Symmetrical generalised spacing anterior to the maxillary canines without a MMD These are referred to as 'Lateral spacing' (LS) in the results.
- Symmetrical generalised spacing anterior to the maxillary canines with a MMD. These are referred to as 'Generalised spacing' (GS) in the results. (See appendix 13 and 14).

An image without interdental space was also shown. This image was the 'ideal' image and met the assumptions pertaining to ideal smile aesthetics (see section 1.9).

The mean VAS scores are outlined for the total number participants (n=161) in Table 5 below. The highest overall mean VAS score, and therefore the image rated as most attractive, was the ideal image (without interdental spacing), with a mean VAS of 78.3mm.

Figure 1: Overall Mean VAS scores by type and size of interdental spacing



Overall, a trend is shown that whilst on average, the ideal image is deemed most attractive (mean VAS 78.3), median diastemas and lateral diastemas are better tolerated than other patterns of spacing (GS and LS) irrespective of size. Up to 1.5mm of spacing, the hierarchy of the preferred pattern of spacing in this cohort is median diastemas, followed by lateral diastemas, followed by lateral spacing and generalised spacing is the least tolerated. Once the interdental space is 2.0mm or more, the results for lateral spacing and generalised spacing become comparable, with both patterns still being tolerated less than localised spacing (MMD and LD). The standard deviation ranged from 13.8 to 22.5 indicating that there was a broad range of variability between the results (See table 5 below)

Table 5: Overall mean VAS scores and 1 standard deviation in brackets

Size of space	Midline Diastema (MMD) Mean (SD)	Lateral Diastema (LD) Mean (SD)	Lateral Spacing (LS) Mean (SD)	Generalised spacing (GS) Mean (SD)
0.5mm	69.7 (19.3)	64.6(18.2)	80.2 (21.7)	58.7(21.9)
1.0mm	57.4 (22.5)	44.9 (19.8)	42.1 (21.0)	39.8(20.2)
1.5mm	49.7 (21.3)	37.8(18.0)	28.2(16.9)	22.1 (15.3)
2.0mm	45.0 (20.7)	32.1 (16.9)	18.7 (14.0)	20.0 (14.2)
2.5mm	37.8 (20.3)	31 (16.5)	19.7 (14.6)	19.8 (13.8)
3.0mm	35.5 (18.6)	28.2 (16.2)	17.0 (13.8)	14.7 (13.0)

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3.2.1 Overall distribution of results by pattern of spacing

Figures 2-5 below depict the distribution of VAS scores by pattern of spacing (Q1, median, Q3 and range). The box plots not only highlight a large variation of results, but also show that, for all patterns of spacing shown, the greater the size of the interdental spacing, the less the image was accepted by all participants.

Figure 2: Box plot to demonstrate the distribution of VAS Scores for midline diastemas

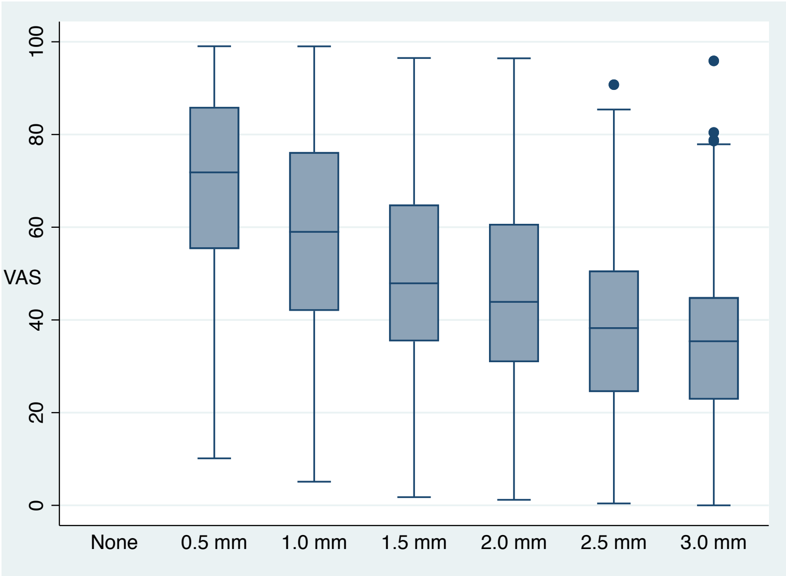


Figure 3: Box plot to demonstrate the distribution of VAS Scores for lateral diastemas

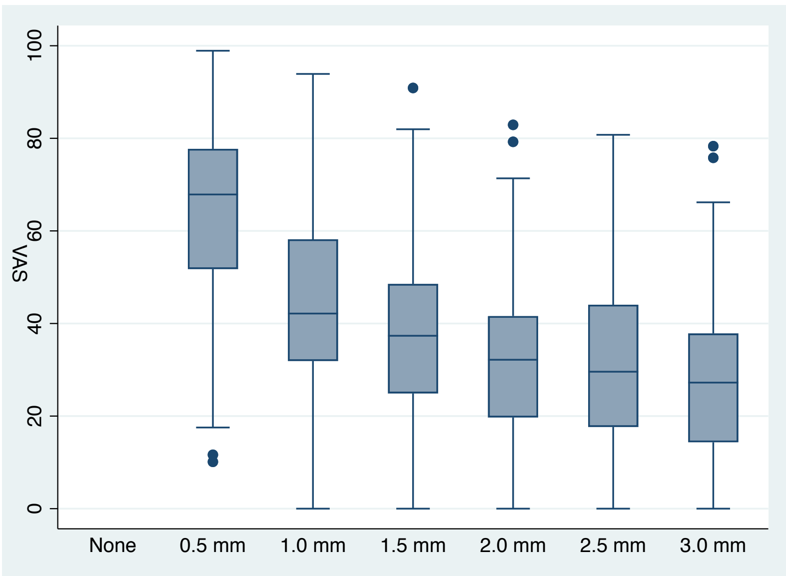


Figure 4: Box plot to demonstrate the distribution of VAS Scores for lateral spacing

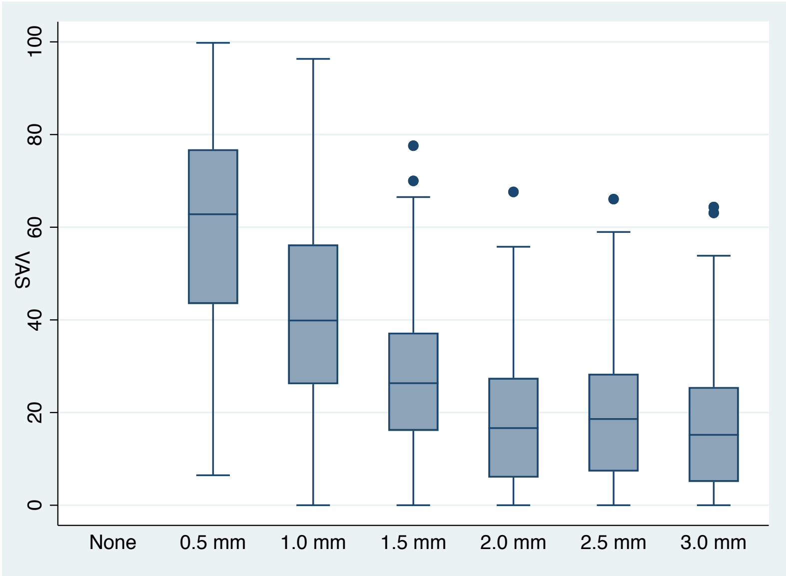
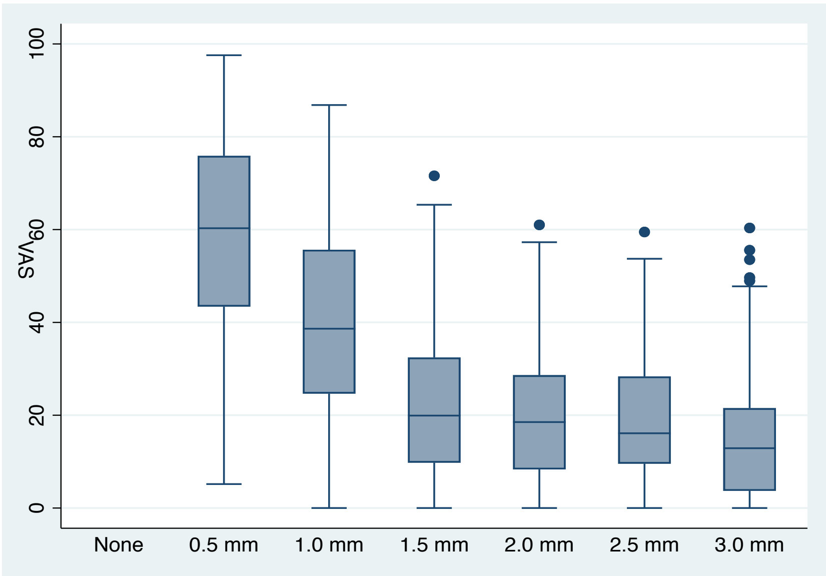


Figure 5: Box plot to demonstrate the distribution of VAS Scores for generalised spacing



3.3 Mean VAS scores by observer group

This section evaluates the preference of the pattern and size of spacing by observer group. The findings are represented with descriptive statistics. Post hoc statistical tests were not employed to determine any significant differences between the preferred pattern of spacing within groups, due to the large variation of VAS scores (See figures 1-5).

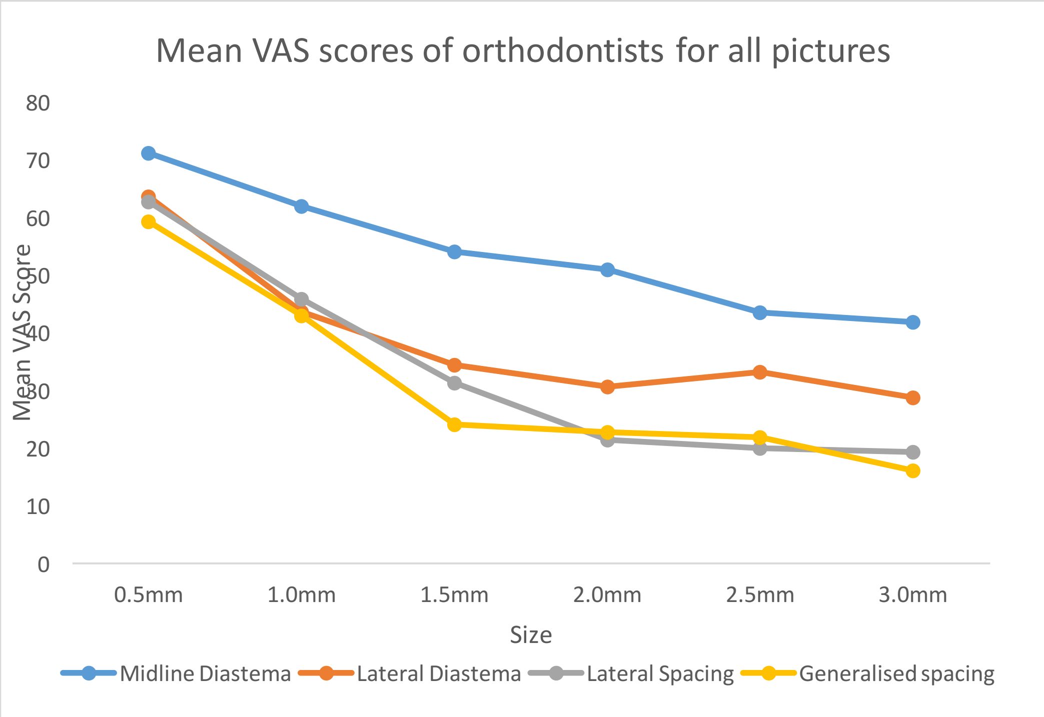
3.3.1 Mean VAS scores of orthodontists

The highest mean score given by orthodontists was for the ideal image 90.5 (+/-10.8).

Table 6: Orthodontist mean VAS scores and standard deviation for all pictures

Size /Type	Midline Diastema	Lateral Diastema	Lateral Spacing	Generalised spacing
0.5mm	71.1 (21.5)	63.6(20.8)	62.7(24.4)	59.3 (24.3)
1.0mm	61.9(25.2)	43.6(18.4)	45.8(22.6)	43.0(23.0)
1.5mm	54.1(23.0)	34.4(13.9)	31.3(17.2)	24.1 (13.0)
2.0mm	50.9 (21.8)	30.6(15.2)	21.4(14.9)	22.8(14.3)
2.5mm	43.5(20.2)	33.2(16.5)	20.0(12.9)	21.9(13.5)
3.0mm	41.9(21.7)	28.8(15.1)	19.3(13.7)	16.1 (11.6)

Figure 6: Mean VAS scores for orthodontists for all pictures



The midline diastema was deemed the most aesthetically acceptable pattern of spacing amongst orthodontists. The mean VAS scores for lateral diastemas, lateral spacing and generalised spacing was similar at 0.5mm and 1.0mm. However, at the 1.5mm size, the hierarchy of the tolerated pattern of spacing became evident and is in keeping with the overall results (see figure 1). At 1.5mm, midline diastemas were most preferred, followed by lateral diastema, lateral spacing and finally, generalised spacing was the least accepted. At 2.0mm, the results for lateral and generalised spacing became comparable. Irrespective of the size of interdental spacing, the localised spaces (MMD and LD) were more aesthetically tolerated than the more generalised patterns of spacing (LS and GS).

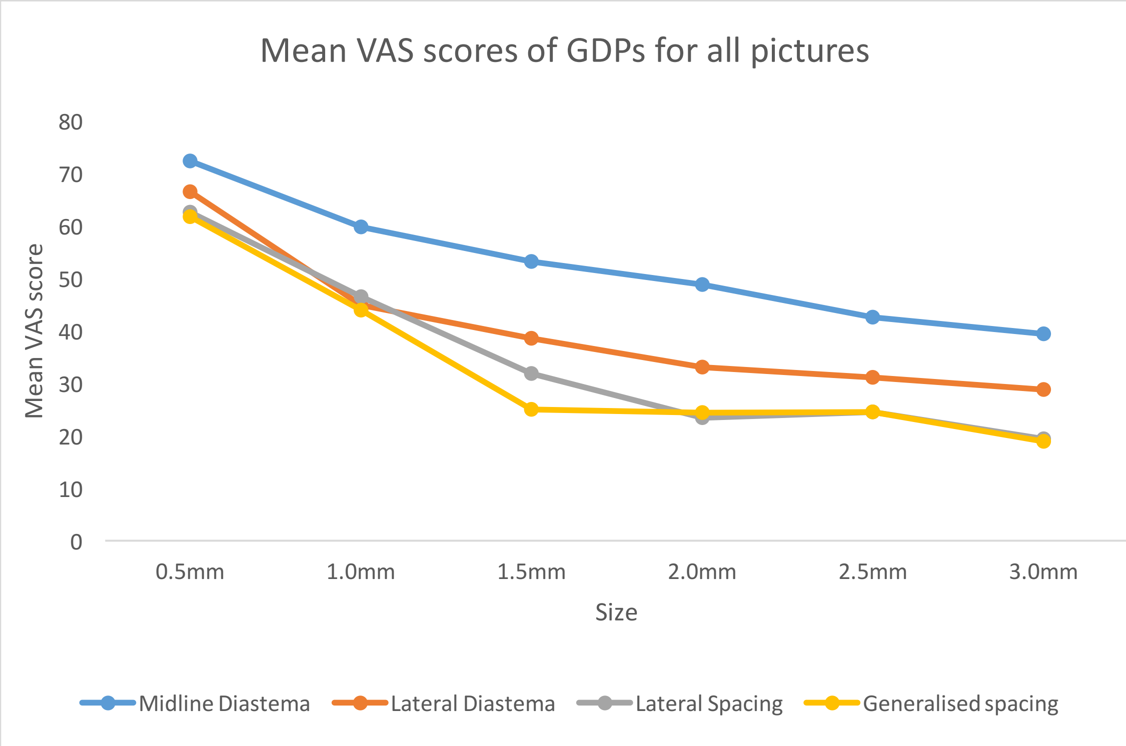
3.3.2 Mean VAS scores of general dentists

The highest mean score given by general dentists was attributed to the ideal image 83.6 (+/- 13.0).

Table 7: The mean VAS scores of general dentists and standard deviation for all pictures

Size /Type	Midline Diastema	Lateral Diastema	Lateral Spacing	Generalised spacing
0.5mm	72.4 (16.1)	66.6 (14.6)	62.7 (21.0)	61.8 (18.9)
1.0mm	59.8 (20.1)	45.0(19.5)	46.5 (20.3)	44.0 (18.0)
1.5mm	53.3 (18.7)	38.6(18.4)	31.9 (18.8)	25.1 (16.4)
2.0mm	48.9 (20.8)	33.1(16.9)	23.5 (15.2)	24.5 (15.7)
2.5mm	42.6 (20.2)	31.2 (16.8)	24.6 (15.7)	24.6 (15.8)
3.0mm	39.4 (18.0)	28.8 (17.6)	19.5 (14.8)	18.9 (16.7)

Figure 7: Mean VAS scores for general dentists for all pictures



Midline diastemas were deemed more attractive than any other type of spacing, irrespective of the size of the interdental space. The results for lateral diastemas, lateral and generalised spacing were comparable, until 1.5mm whereby lateral diastemas were considered to be more attractive than lateral and generalised spacing, in this order. Between 2-3mm the results for lateral and generalised spacing were almost indistinguishable amongst general dentists. The trend shown for general dentists, appears to be very similar to that exhibited by orthodontist. Irrespective of the size of interdental spacing, the localised spaces (MMD and LD) appear to be more aesthetically tolerated than the more generalised patterns of spacing (LS and GS).

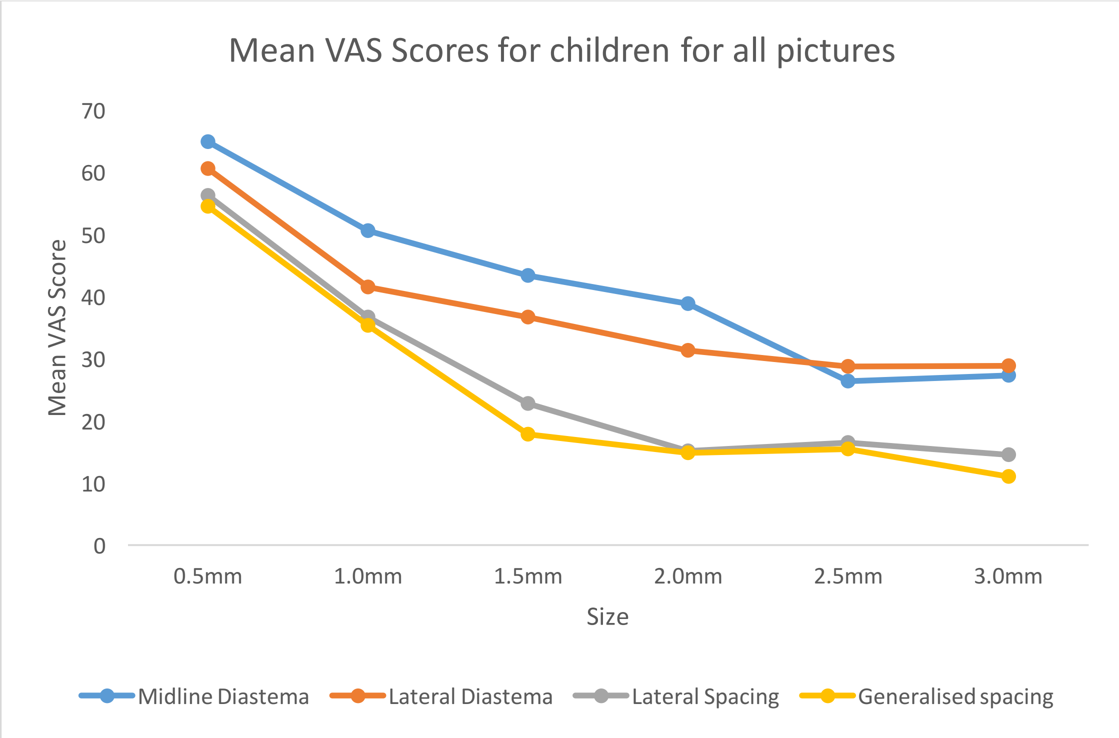
3.3.3 Mean VAS scores of children

The mean VAS score for the ideal image for children was 64.7mm with a standard deviation of 29.3mm. The highest score given by this cohort was not for the ideal image, but for the image with 0.5mm MMD (64.9mm). This difference of 0.2mm between the ideal image and the 0.5mm is not clinically significant and therefore children rated the ideal image as one of the most attractive. The mean VAS scores and standard deviations for the remaining images were as follows.

Table 8: Mean VAS scores of the child cohort

Size /Type	Midline Diastema	Lateral Diastema	Lateral Spacing	Generalised spacing
0.5mm	64.9 (21.5)	60.6 (21.4)	56.3 (23.4)	54.5 (23.9)
1.0mm	50.6 (23.0)	41.5 (21.3)	36.7 (22.1)	35.3 (20.4)
1.5mm	43.4 (20.9)	36.7 (20.1)	22.8 (15.7)	17.8 (16.7)
2.0mm	38.9 (20.0)	31.3 (19.3)	15.2 (13.2)	14.9 (13.6)
2.5mm	26.4 (17.7)	28.8 (16.4)	16.5 (14.3)	15.5 (12.6)
3.0mm	27.3 (15.6)	28.9 (16.9)	14.6 (14.5)	11.1 (11.1)

Figure 8: Mean VAS scores for children for all pictures



Children preferred the midline diastema followed by lateral diastema, lateral spacing and generalised spacing, in this order until 2mm. However, at 2.5-3mm size of spacing, the lateral diastema was rated as more attractive on the VAS than midline diastema. There is a large variability in the results as shown by the standard deviations in table 8. Similarly, to the professional cohorts, the more localised patterns of spacing (LD and MMD) appear to be perceived as more aesthetic than the more generalised patterns of spacing (LS and GS), irrespective of size of the interdental space.

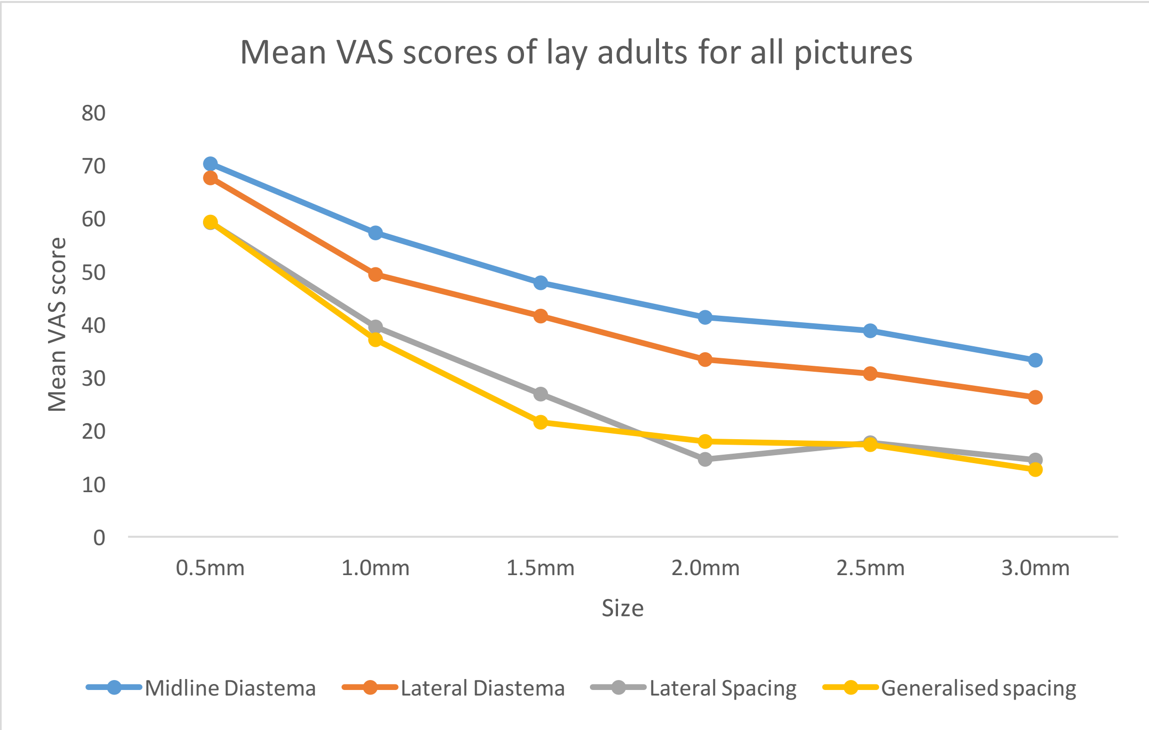
3.3.4 Mean VAS scores of lay adults

The mean and highest VAS score given by lay adults was for the ideal image for lay adults was 74.6mm with a standard deviation of 18.6mm.

Table 9: Mean VAS scores of the lay-adult cohort

Size /Type	Midline Diastema	Lateral Diastema	Lateral Spacing	Generalised spacing
0.5mm	70.2 (17.6)	67.6 (15.0)	59.1(17.6)	59.2 (19.9)
1.0mm	57.2(20.6)	49.4 (20.0)	39.5 (17.7)	37.1 (18.7)
1.5mm	47.8 (21.3)	41.6 (18.5)	26.8 (14.5)	21.5 (14.4)
2.0mm	41.3(18.4)	33.3 (16.3)	14.6 (10.8)	18.0 (11.5)
2.5mm	38.8 (19.2)	30.7 (16.7)	17.7 (14.4)	17.3 (11.9)
3.0mm	33.2 (15.4)	26.3(15.8)	14.4 (11.5)	12.6 (10.9)

Figure 9: Mean VAS scores for lay adults for all pictures

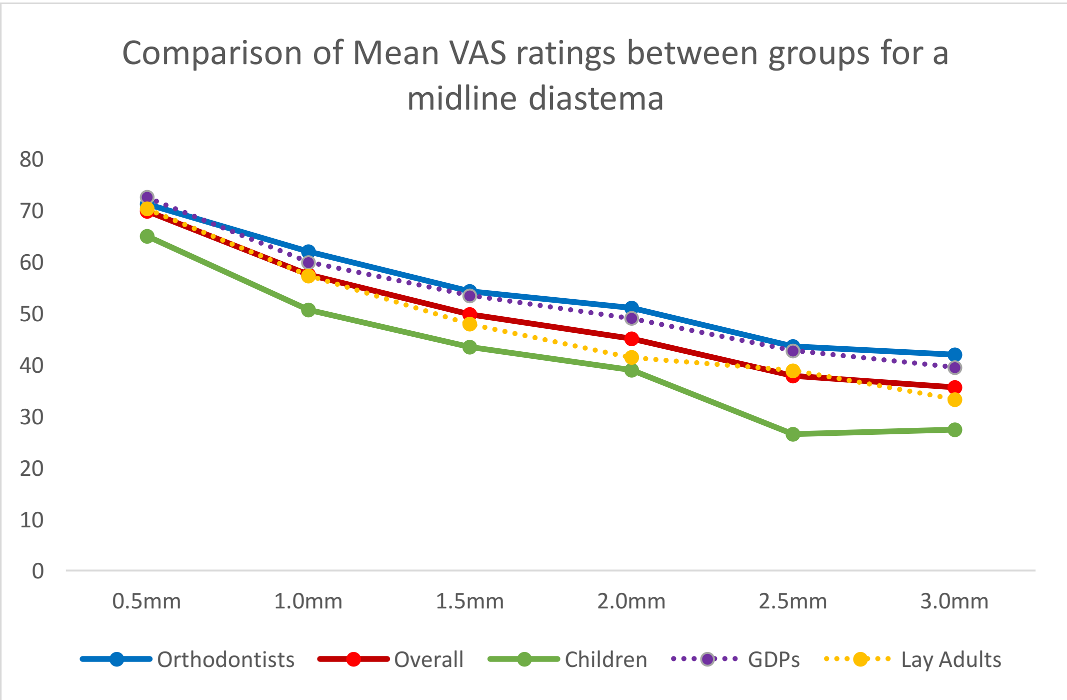


Lay adults preferred the ideal image, followed by midline diastemas, lateral diastemas, lateral spacing and lastly generalised spacing in this order up to a 1.5mm. This aesthetic hierarchy of spacing pattern is similar to the findings of all of the other cohorts. At 2-2.5mm generalised spacing was deemed more attractive than lateral spacing, and at 2.5-3mm, both GS and LS were comparable in their VAS scores. Similar to the other cohorts, the localised spacing (MMD and LD) is perceived to be more aesthetic than the more generalised patterns of spacing (LS and GS) irrespective of size of the interdental space.

3.4 Comparison of mean VAS scores between observer groups by pattern of spacing

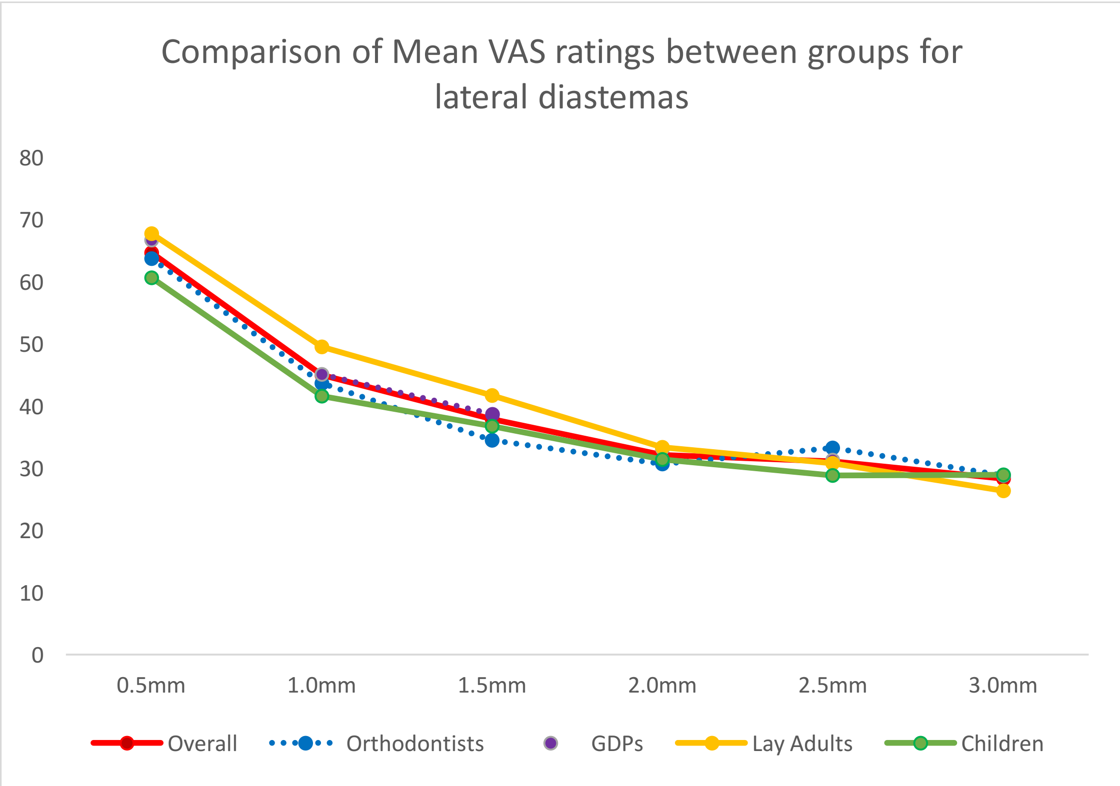
Overall the general trend highlights that the larger the size of the interdental space, the lower the mean VAS score given by all observer groups (see figure 2-5). Figures 10-13 below compare the mean ratings given by each group for each pattern of spacing. Overall an aesthetic hierarchy of the preferred pattern of interdental spacing has shown that localised spaces (MMDs and LDs) are preferable to generalised spaces (LS and GS) irrespective of the size of the interdental space (See section 3.2 and 3.3).

Figure 10: Midline diastema: comparison of the mean VAS scores between groups



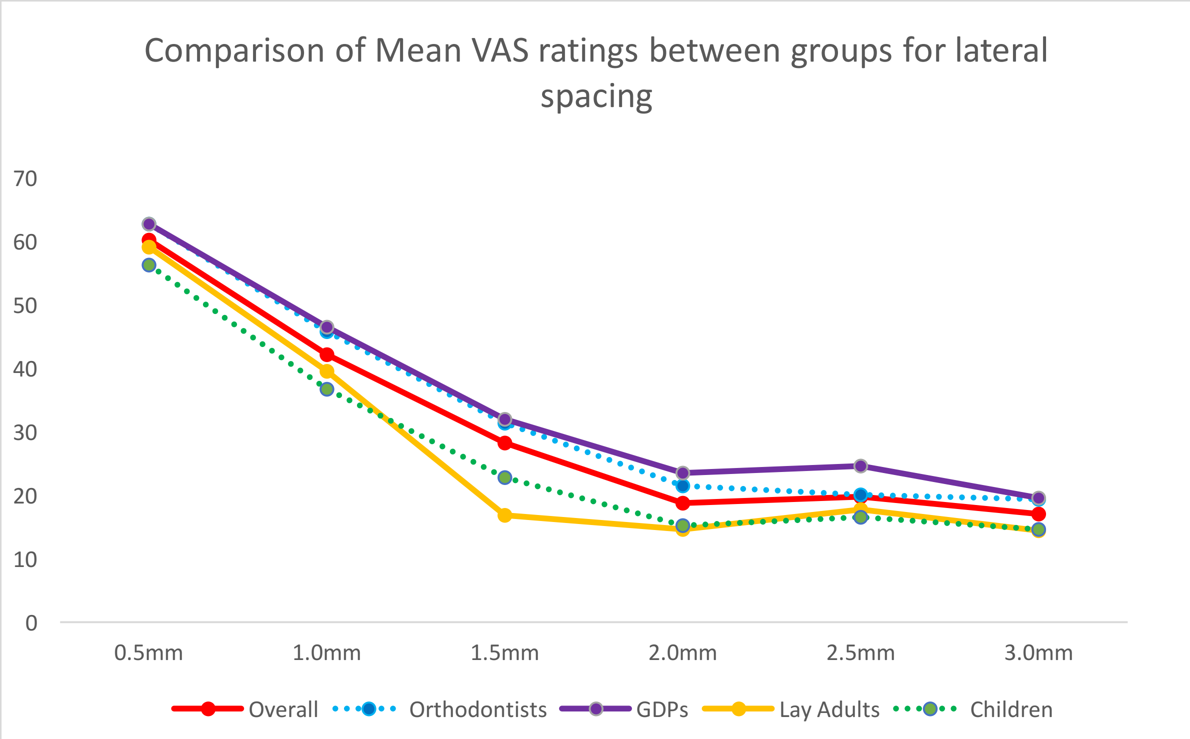
Orthodontists rated the midline diastema pictures most favourably of all groups, whereas children were the most critical in their perception of midline diastemas. However, children were most critical overall.

Figure 11: Lateral diastema: comparison of Mean VAS scores by size for all groups



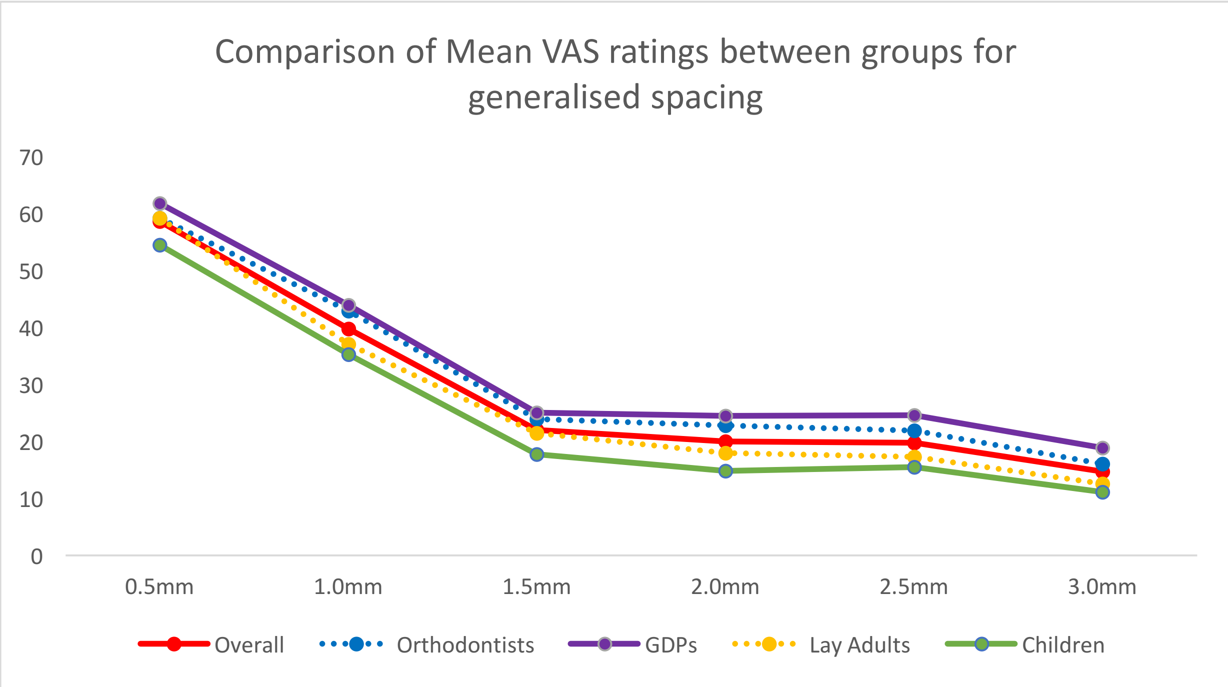
Lay adults rated this image most favourably, whereas children and orthodontists rated this image as least attractive. At the 2mm threshold, most ratings across all groups were similar for this image.

Figure 12: Lateral spacing: comparison of Mean VAS scores for all groups and overall trend.



General dentists gave the highest VAS ratings of all groups for laterally spaced images, with lay adults and children giving the lowest scores. There is a marked reduction in aesthetic acceptability of lateral spacing between 1 and 1.5mm amongst lay adults.

Figure 13: Generalised spacing: comparison of Mean VAS scores for all groups and overall trend.



General dentists and orthodontists were more accepting of generalised spacing than children and lay adults, irrespective of size of spacing.

3.5 Primary Objectives

The primary objective of this study was to understand whether the presence of spacing had an impact on smile aesthetics. Furthermore, the study aimed to evaluate if the pattern and size of spacing influenced the attractiveness of a smile and to assess if the observer group had an impact on aesthetic perception of interdental spacing.

3.5.1 Influence of the pattern of spacing on aesthetic perception

Table 10 highlights that the ideal image was rated, on average as more aesthetic than all other images that exhibited spacing. This difference was statistically significant. Overall, midline diastemas (irrespective of size) were rated as less attractive than the ideal image, and this was statistically significant at the 5% level (p=0.013). The VAS scores for all other types of spacing (lateral diastema, lateral and generalised spacing) were lower than the ideal image and these results were highly statistically significant at the 1% level (p=0.000). Furthermore, the difference between the VAS scores of the ideal image and more widespread spacing (LS and GS) were clinically significant. On average, the mean VAS score for LS and GS was, 15mm below the mean VAS score for the ideal image.

Table 10: Statistical analysis of VAS ratings by type of spacing

	Regression Co-efficient	**95% Confidence Intervals**	**95% Confidence Intervals**	**p>[z]**
No Spacing (Base)	0			
Midline Diastema MMD	-3.18	-5.68	-0.68	0.013*
Lateral Diastema LD	-12.58	-15.08	-10.08	0.000*
Lateral Spacing LS	-21.38	-23.89	-18.87	0.000*
Generalised Spacing GS	-23.16	-25.65	-20.65	0.000*

***Statistically significant results**

3.5.2 Impact of observer group on aesthetic perception

Children rated most critically, followed by lay adults however the difference between them was not statistically significant ($p=0.38$). On average, orthodontists perceived all of the images shown as more attractive than the child cohort and the differences between their VAS scores was found to be statistically significant ($p<0.05$). In this study, general dentists were the most tolerant of spacing. The difference between the dentist and child cohort was highly statistically significant ($p<0.01$), with dentists on average rating each image 8.38mm higher on the VAS than children (See table 11). Therefore, overall the professional groups rated the images more leniently than the children's group at 5% significance level.

Table 11: Statistical analysis of VAS ratings by observer group

	Regression Co-efficient	95% Confidence Intervals	95% Confidence Intervals	P>[z]
Children (Base)	**0**			
Orthodontists	**6.1**	**0.71**	**11.5**	**0.027***
Dentists	**8.38**	**3.01**	**13.76**	**0.002***
Adults	**2.41**	**7.78**	**2.96**	**0.379**

Whilst the differences were statistically significant, none of the scores had greater than a 15mm difference therefore showing that the differences between the groups was not clinically significant. Further post hoc statistical testing to observe differences between observer groups for specific patterns and sizes of spaces was not possible due to the large variability between the results, as demonstrated in figures 2-5. As a result, the findings from post hoc testing would be unlikely to be true and occur by random chance.

3.5.3 Influence of size of spacing on aesthetic perception

Size had an effect whereby for every incremental (0.5mm) increase in size irrespective of the type of spacing, on average, across all groups, the VAS scores reduced by 7.84mm. Size had a statistically significant affect on aesthetic perception ($p=0.00$, 95% CI -7.68 to -7.17). For every 1mm increase in the size of the interdental space, there was a clinically significant reduction in VAS scores and aesthetic preference.

3.6 Secondary Objectives

Secondary aims of the study were to investigate any potential influence of confounding factors such as age, gender, ethnicity, level of qualification and on perceptions of a smile with interdental spacing.

3.6.1 Influence of participant gender on aesthetic perception.

Overall the groups were fairly evenly distributed with respect to gender (see table 4) and no statistically significant differences were found between genders (p=0.57).

3.6.2 Influence of ethnic background on aesthetic perception

Caucasians were the most lenient, and Asian participants were more critical, with the latter group rating images 6.83 mm (CI: -10.88, -2.78) less per picture (p=0.001). The 'other' groups of ethnicities combined (mixed Caucasian, Afro-Caribbean and 'other') also rated more critically (-7.39mm) than Caucasians (CI: -13.93 to -0.85), and this was significant at the 5% level (P=0.027), however this had wider confidence intervals than the Asian group and thus the 'other' ethnic group displayed greater variability in their responses. There were no clinically significant differences between ethnic groups. It must be noted that this was secondary objective, and these results are likely to be underpowered. There were 86 Caucasians, 64 Asians and 15 participants in the 'other category' (See table 4).

Table 12: Statistical analysis of VAS ratings by observer ethnicity

	Regression Co-efficient	95% Confidence Intervals	95% Confidence Intervals	P>[z]
Caucasian (Base)	0			
Asian	-6.83	-10.88	-2.78	0.001*
Other Ethnicities	-7.39	-13.93	-0.85	0.027*

***Statistically significant results**

3.6.3 Influence of level of professional qualification on aesthetic perception

Consultants were the most critical of all the professional groups. The less orthodontic training or postgraduate qualifications a dentist had, the more lenient they were with their scores (Table 13). This was a secondary outcome and therefore the statistical analysis is likely to be underpowered.

Table 13: Influence of professional qualification on VAS rating

	Regression Co-efficient	**95% Confidence Intervals**	**95% Confidence Intervals**	**P>[z]**
Orthodontic Consultant (base)	0			
Senior Orthodontic Registrar	7.76	-7.17	22.69	0.308
Orthodontic Specialist	8.8	0.3	17.3	0.043*
General Dentist	14.46	3.02	25.9	0.013*
General Dentist with postgraduate qualification	12.22	2.21	22.23	0.017*

***Statistically significant results**

Post CCSTs were more lenient than consultants (7.76, CI: -7.17 to 22.69) however this was not statistically significant (p=0.308). Specialist orthodontist scores were more lenient than Post CCSTs. On average specialists were 8.8mm more lenient in their scoring (CI, 0.3 – 17.3) but this difference is not clinically significant. Similarly, GDPs with (P=0.013) and without (p=0.017) postgraduate qualifications also rated their images sufficiently differently to orthodontic consultants and Post CCSTs, however whilst he difference in scores was sufficient to be deemed statistically it was not clinically significant.

3.6.4 Influence of country of primary qualification on professional groups

Table 4 highlights the distribution of countries of primary qualification. Eighty-five percent of orthodontists and 95% of general dentists qualified in the UK. The country of primary qualification had no effect on professional rating.

Table 14: Probability of the VAS rating being different to the majority of professionals who qualified in the UK

Country of Primary Qualification	p Value
Ireland	0.67
Europe	0.21
India	0.7
South Africa	0.24

3.6.5 Influence of the age of the professional on aesthetic perception

The age of the professional appeared to be correlated with a lower VAS rating. Professionals aged more than 45 years, rated the images significantly more leniently than the younger cohort of lay adults and children. Generally, the older the professional, the more lenient their scores were, with the greatest difference being between the youngest and oldest professional cohort, however this difference was not clinically significant. We did not carry out statistical tests to compare if any statistically significant existed between the various professional age groups. This is because these are secondary outcomes, and there was insufficient power to carry out these tests.

Table 15: Impact of the professional's age on VAS scores

	Regression Co-efficient	95% Confidence Intervals	95% Confidence Intervals	p>[z]
>12<25 (Base)	0			
>25<35	2.65	-6.38	11.68	0.57
>35<45	9.83	-3.57	23.21	0.15
>45<55	14.62	0.51	28.72	0.042*
>55	15.44	1.38	29.49	0.031

***Statistically significant results**

3.7 Intra –examiner reliability

Ten percent of the questionnaires were randomly selected and measured again by the principal investigator (AM) with a digital caliper to the nearest 0.01mm. There was good intra examiner agreement with an Intra Class Coefficient of 0.99.

3.8 Intra-observer reliability

The intra rater correlation coefficient was highly variable and ranged from 0.13 to 0.76 (Appendix 16). This demonstrated that the same individual did not rate the images similarly after a two week break. Section 3.2.1 also demonstrates the large variability between individuals in the same group. Therefore, not only is variation in aesthetic perception high within the same observer group, but also within the same individual after a time delay. Approximately half of the intra class correlation coefficients (ICCs) were less than 0.5 indicating poor intra observer agreement, and approximately half are between 0.5 and 0.75 indicating moderate reliability.

CHAPTER FOUR

DISCUSSION AND CONCLUSION

CHAPTER 4: DISCUSSION AND CONCLUSIONS

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4.1 Image Management and presentation

Howells and Shaw (1985) concluded that two dimensional photographs were a valid means to represent the malocclusion as seen three dimensionally. This study showed that a panel of calibrated observers had a high intra rater agreement for VAS scores when they rated two intra oral images (frontal and lateral), and later when they rated the same live subject with lips, cheeks retracted and the extra oral features masked out. It must be noted that Howells and Shaw (1985) used photographs of live subjects, whereas the images in the present study were frontal intra oral photographs that had been digitally manipulated (in Adobe Photoshop, San Jose, California ®) similar to other studies that have aimed to measure aesthetic perception (Machado et al., 2013; Kokich et al., 2006; Noureddine et al., 2014; Rodrigues et al., 2009).

The images were presented in the same random sequence in every questionnaire. Rodrigues et al. (2009) conducted smaller (n=20), but similarly designed study and found that the sequence of the images presented, did not influence VAS scores.

4.1.1 Digital Manipulation

Digital manipulation of a two-dimensional frontal intra-oral photograph to represent incrementally larger patterns of interdental spacing was undertaken by a graphic designer. A frontal view with the lips and cheeks retracted was chosen to reduce the impact of the lips of the smile getting wider as the size and location of spacing increased. The investigator

(AM) wished for the observer to focus on the interdental spacing, and to not be distracted by side effects from digital manipulation. Barber et al. (2015) also expressed difficulties with image manipulation during their study which assessed aesthetic impact of opening or closing lateral incisor spacing.

Digital manipulation allows for a full range of malocclusions to be presented, whereas it may not always be possible to find photographs of live subjects exhibiting the desired pattern and magnitude of interdental spacing. Digital manipulation is considered to be advantageous over photographs of live subjects due to the ability to modify only the feature being investigated, ensuring that all other variables such as tooth size, shape and colour are kept constant. Although, there were challenges in obtaining realistic images, it was felt this was more realistic image to rate than a digitally created smile as per the study by Rosa et al. (2013).

4.1.2 Type of Image

The frontal view image was chosen in order to demonstrate bilateral as well as unilateral spacing. Frontal view images are comparable with other similar studies (Kokich et al., 2006; Rodrigues et al., 2009; Rosenstiel and Rashid, 2002; Abu Alhaija et al., 2011). Machado et al. (2013) chose to use oblique views in their study of unilateral spacing around the maxillary lateral incisor. They felt that this view, more so than a frontal image better represented the image seen in real–life scenarios. However, a frontal view was necessary in this study in order to be able to compare the perceived aesthetic differences between unilateral and bilateral spaces.

The images were intentionally shown without the distracting features of the background. Flores-Mir et al. (2005) and Havens et al. (2010) found that the impact of the malocclusion was lessened, when viewed with the background face. In contrast Johnston et al. (1999) identified that the background face can have a deleterious impact on aesthetic perception of a smile associated with midline discrepancy. Rodrigues et al. (2009) investigated the aesthetic perception of a number of malocclusions, in association with the background face, and found it had no impact with respect to midline diastemas.

Previous similar studies investigating the aesthetic perception of interdental spacing have used close up lower third facial views of the smile to include the lips (Kokich et al., 2006; Abu Alhaija et al., 2011; Machado et al., 2013; Rosa et al., 2013), however this study used frontal image, with the lips retracted due to the limitations posed by digital manipulation. Flores-Mir et al. (2005) identified that dental views were rated significantly more critically than lower facial third or extra oral views by a young Peruvian lay cohort. Retracted smiles were selected so that greater attention could be given to the feature of malocclusion being investigated, without drawing attention to the widening lips of the smile as the spaces increased Howells and Shaw (1985).

4.2 Repeatability and reproducibility

4.2.1. Intra-examiner reliability

The intra examiner reliability was almost perfect (0.99). This demonstrated that the VAS measurements undertaken by the principal investigator (AM) was highly reproducible and reliable.

4.2.2. Intra-rater reliability

Four participants from each group (10%) were randomly selected and asked to complete the questionnaire again two weeks after it was initially completed. This was in order to determine the repeatability and validity of the questionnaire. The intra class correlation coefficient (ICC) exhibited large variation (0.13 to 0.76), with the mean ICC being 0.46. The mean value is described as fair intra rater agreement (Cicchetti (1994). There appeared to be greater intra observer agreement when the frequency of spaces increased, as well as the size of spacing. Excellent ICC was present for 1.5, 2.0 and 3.0mm of lateral spacing photos and photos which included 1.5 to 2.5mm of generalised spacing. Conversely, poor intra observer reliability was shown for other images (See appendix 16).

Intra rater reliability has shown mixed results when the VAS has been used in other studies to measure aesthetic perception. Other similarly designed studies have obtained excellent intra rater reliability scores when asking participants to rate again one and five weeks later (Flores-Mir et al., 2005; Howells and Shaw, 1985). Whilst Sriphadungporn and Chamnannidiadha (2017) and Parekh et al. (2005) also obtained excellent agreement, they obtained this by repeating the images within the same questionnaire. Kokich et al. (2006), the most similarly designed study, did not report on intra rater reliability. Barber et al. (2015) identified poor ICCs and attributed this to observer fatigue.

The GDP and layperson cohorts all repeated their questionnaire after two weeks, however two orthodontists and three children completed their second questionnaire more than two weeks after the first questionnaire due to busy work schedules and the inability to return to the hospital within two weeks respectively.

The repeated questionnaires of the child cohort were done at the next appointment which was on average 6 weeks later for most subjects, with the exception of one individual who was able to complete it within the two-week time frame. The investigator (AM) felt it was more important for the child questionnaire to be completed for the second time with the investigator present, rather than at home where conditions or lighting may vary or perhaps the child may lack focus or want to seek clarification again. Therefore, whilst every effort was made for questionnaires to be returned in the two-week time frame, this was not always the case due to practical reasons. This may account for the large difference in ICC, however Howells and Shaw (1985) asked raters to rate the images again after 5 weeks, and still found a moderately high agreement within the same examiner. It must be noted however, that Howells and Shaw (1985) calibrated their panel by asking them to rate 250 images on a VAS before- hand and did not include a child cohort.

Oliveira et al. (2015) compared the effectiveness of VAS and Q-Sort for rating aesthetics of smile attractiveness and found similar ICC (0.42 GDP, 0.4 Ortho and 0.37 lay) to our study. They felt that both methods were reliable, but the Q-sort demonstrated more consistency of results between observers, and therefore a more accurate representation of aesthetic perception. Barber et al. (2015) repeated four images on the same questionnaire to obtain intra examiner reliability and still obtained poor ICC scores (0.5). Despite Howells and Shaw (1985) describing the VAS as a reproducible and reliable method, these studies show the contrary.

Barber et al. (2015) discussed that the mean raw VAS score used to compare the score at T1, and T2 was the incorrect statistic, because it did not take into account individual personality (Briggs and Cheek, 1986). Cronbach (1957) identified that “personality is correlational” and therefore, the difference in VAS scores between photos with same pattern of spacing but with a 0.5mm incremental increase in size of space, would be a better comparison T1 and T2, and likely to result in a stronger correlation. Barber et al. (2015) tested this, and found it resulted in an ICC within the ideal range.

The low ICC scores found in this study is likely to be attributed to a combination of factors including the time lag between rating the questionnaire, observer fatigue, as well as potential inherent problems within the VAS.

4.3 Limitations of the Visual Analogue Scale

As discussed above, a number of similarly designed studies used a VAS to rate aesthetic perception. The VAS has been described as being quick, reliable, cheap, easy to understand and a reproducible scale that is valid for measuring aesthetic perception (Howells and Shaw, 1985; Oliveira et al., 2015; Glasgow, 2012). In contrast others have reported that the VAS was a difficult concept to grasp by adults (Couper, 2006) and adolescents (de Oliveira et al., 2012).

Aitken (1969) cautioned that the VAS may mean “different things to different people”. As a result, people may utilise parts of the scale differently (Schabel et al., 2009; Barber et al., 2015). This is evident in the present study as there was a large variability of results amongst individuals in all four groups.

The clinical application of the findings from this study was to identify whether child and adult patients tolerated spacing differently to professional groups. Therefore, perhaps more appropriate anchors for the VAS could have been ‘I would be happy if my mouth looked like this’ and ‘I would not be happy if my mouth looked like this.’ Alternatively, the images of the ideal smile could have been placed at the right hand side, and the most unaesthetic smile in that sequence of photos, on the left hand side of the scale. This may have given observers more of a reference when scoring on the VAS. This may have been a more suitable strategy to overcome the individual variation of VAS interpretation, as seen in this study and improve intra rater reliability. These techniques have been utilised in facial aesthetic studies (Honn et al., 2008).

Standardisation of VAS scores has been described by subtracting the actual score from the mean score given by the individual. However, due to the random sequencing of a high number of different patterns of spacing shown, standardisation of scores was not considered to be appropriate. Furthermore, due to the high variability of scores, other variable factors may be of influence such as subject personality, understanding of the VAS, and observer fatigue. Due to the large variability of our results (see figures 2-5), it was felt that post hoc tests would be inappropriate to draw further conclusions from the data.

Therefore, although the VAS may appear to be a convenient method of assessing aesthetic perception on a superficial level, the statistical analyses can be quite complex.

Oliveira et al. (2015), Schabel et al. (2009) and Barber et al. (2015) discuss the alternative to a VAS which is the use of a ‘forced choice’ or Q–sort method, whereby the rater identifies the most attractive and least attractive, and continues to do so, eventually putting the photos in order from most to last attractive. This method, whilst demonstrating greater intra rater agreement (Schabel et al., 2009), takes up more time and resources than the VAS alone, and Oliveira et al. (2015) found the results of both tests to be comparable. Q-sort methods are best utilised when there are a small number of photographs to arrange (Baron, 1996) and they have been effectively used by Noureddine et al. (2014) and

Houacine and Awooda (2017) to demonstrate an aesthetic hierarchy of patterns of interdental spacing amongst French and Sudanese lay persons respectively.

4.4 Sample size calculation

Kiekens et al. (2007) found that a panel size of seven was suitable to obtain reliable results on studies using a VAS and aesthetic perception. However, this study looked at two groups only (lay people and orthodontists) and was based on overall facial attractiveness. Howells and Shaw (1985) found that a sample size of two could give acceptable and reliable results on studies based on perceived smile aesthetics for dental attractiveness. However, they compared two highly calibrated professionals' ratings. Nevertheless, they felt that their study could be improved further by increasing the panel size as there were differences between the ratings of both panel members, which they felt only reduced when the overall means of each rating were compared.

Parekh et al. (2005) set an arbitrary 15% change in VAS as being clinically significant. In previous pain (Powell et al., 2001) and sleep quality studies (Zisapel and Nir, 2003), a 9-13mm difference in VAS was identified as being clinically different. Similarly, Rosa et al. (2013) reported a standard deviation between 10 and 25. Assuming a standard deviation of 16, and a clinically significant difference of 15 between the VAS scores, resulted in a standardised difference of 0.95 (15/16). These studies were used as the basis for obtaining a sample size.

4.5 Summary of results and how they compare to the literature

4.5.1 Aesthetic perception of smiles with and without interdental spacing.

The ideal image was perceived as more attractive, than all patterns of interdental spacing by all observers. The differences in VAS scores were statistically significant for all patterns of spacing but was clinically significant only for the more generalised spaces (LS and GS).

An aesthetic hierarchy was identified with midline diastemas being preferred more than lateral diastemas. Lateral diastemata was preferred more than lateral spacing and generalised spacing was the least favoured image (see table 10).

Therefore, the null hypothesis, that there was no difference in how unspaced and spaced images were perceived, was rejected.

At the time of writing, the aesthetic perception of these different patterns of interdental spacing using a VAS has not been carried out. Therefore, it is not possible to make direct comparisons with other studies. However, Noureddine et al. (2014) and Houacine and Awooda (2017) investigated the aesthetic hierarchy of different patterns of spacing (See section 1.12) using the Q-sort method. Our study was in agreement with (Houacine and Awooda, 2017)'s findings and demonstrated that MMDs were preferred to GS as would have been expected Noureddine et al. (2014) however, found the opposite was true in their cohort of French lay adults.

Machado et al. (2013) investigated the aesthetic perception of localised spacing around the lateral incisor, a clinical presentation commonly observed with microdont lateral incisors. Rosa et al. (2013) and Rayner et al. (2015) investigated aesthetic perceptions of, clinical presentations of interdental spacing seen when maxillary lateral incisors are absent. Other studies have observed the influence of midline diastemas amongst other features of malocclusion on smile aesthetics (Kokich et al., 2006; Abu Alhaija et al., 2011; Kerosuo et al., 1995; Rodrigues et al., 2009; Soh et al., 2006). All studies are in agreement with the results of the present study, that spacing is a disliked feature.

It is surprising to observe in this study that asymmetric lateral diastemas were preferred to symmetrical generalised spaces (LS and GS). This is in contrast with the findings of Kokich et al. (2006), that concluded asymmetric deviations from smile aesthetics were least favoured.

On average, midline diastemas were rated 3mm lower on the VAS than the ideal image. This was statistically but not clinically significant ($p<0.013$, CI -6 to 1). Lateral diastemas were rated 13mm lower on the VAS than the ideal image. This was highly statistically significant, but not clinically significant ($p<0.000$, CI -15 to -10). Lateral spacing was rated 21mm lower on the VAS than the ideal image. This was highly statistically significant and clinically significant ($p<0.000$, CI -24 to -19). Generalised spacing was rated 23mm lower on the VAS than the ideal image. Table 10 highlights that this was highly statistically significant and clinically significant ($p<0.000$, CI -26 to -21).

4.5.2 The influence of observer group on the aesthetic perception of interdental spacing.

Lay groups (children and adults) were more critical than professional groups. Children were the most critical group overall, followed by the lay adult group, however the differences between their scores was not statistically significant $p=0.38$). Orthodontists and GDPs rated the images more favourably. None of these findings however, were sufficiently different to show a clinically significant result.

Adults rated 2.4mm more leniently on the VAS than children. This was not statistically significant at the 5% level ($p= 0.38$, CI -3 to +8). Orthodontists rated 6.1mm more leniently on the VAS than children but this was not clinically significant at the 5% level ($p=0.027$, CI 1 to 11). GDPs rated 8.4mm more leniently on the VAS than children. This showed a high statistically significant difference at the 5% level, but was not clinically significant (p=0.002, CI 3 to 14).

Therefore, children and lay adults, in this study, are more critical towards interdental spacing than dental professionals. This difference was found to be statistically significant.

This result is surprising as orthodontists, focus on delivering optimal smile aesthetics for their patients. It would therefore be expected that this cohort would be less tolerant than the lay cohorts.

Many other studies on aesthetic perception of interdental spacing (Kokich et al., 2006; Abu Alhaija et al., 2011) and overall smile aesthetics (Rayner et al., 2015; Pinho et al., 2007) support this view. Interestingly, Abu Alhaija et al. (2011) found a Jordaninan cohort of orthodontists to be more critical for the 1mm MMD, these differences between groups disappeared when rating MMDs up to 4mm.

Rosa et al. (2013) found no statistically significant differences between professional and lay groups when rating an image with spaces in the maxillary labial segment due to hypodontia of lateral incisors. Parekh et al. (2005) also observed no differences in aesthetic perception between lay groups and orthodontists in a study observing aesthetic perception of smile arcs and buccal corridors.

The results of this study are similar to Zang et al. (2011) who identified that lay people were more critical than professional groups when assessing buccal corridor space. Young people have being shown to be less tolerant of black triangles than an older lay cohort (Sriphadungporn and Chamnannidiadha, 2017; Pithon et al., 2013). This is supported by Flores-Mir et al. (2005) who found young people to be more critical of dental views. All previous studies mentioned, displayed a smile with the lip curtain or a full extra oral view.

The lay adult and child cohort represented likely patients that would be seen in the orthodontic clinic, however it must be noted that Rosa et al. (2013) found that orthodontic patients were more critical than lay people when rating aesthetic acceptability of digitally manipulated malocclusions in a similarly designed study. Whilst an attempt was made to avoid this bias by approaching paediatric and non-orthodontic patients, it could be argued that the likelihood of children aged 12-16 years in the paediatric dental waiting room, not having or wanting any experience of orthodontic treatment would have been low, and this may have been a possible confounding factor affecting the results. This may be a reason why the child cohort was found to be the most critical group in this study.

Furthermore, whilst every attempt was made to ensure the child subject in the dental hospital was made aware that their participation or answers would be anonymised and would not impact on their treatment, this may have influenced their responses. Whilst Schabel et al. (2009) did not find any statistical differences between orthodontists and the parents of orthodontic patients, they also found that orthodontists were less critical than their patients. This may show a similar effect, demonstrating the mindset of individuals seeking treatment, rating more critically, by virtue of being in a hospital environment.

Furthermore, the average age of the child cohort was 14years (+/-1.6). Therefore, the child participant, as well as their peers will have developed beyond the transitory MMD (See section 1.4.1 and table 2) and thus may not be accustomed to seeing interdental spacing amongst their peer group. This does not however, explain why the lay adults rated the images more critically than the professional cohorts.

The lay adult participants were also young and aged 20.5 years (+/-2.2) on average. We live in an increasingly aesthetically aware society, influenced by social media, and this may be a contributing factor as to why we found the lay cohorts to be more critical than professional groups.

Therefore, perhaps the children being more critical is a true finding, or the influence of the hospital environment, not being accustomed to seeing retracted images may have had a greater influence on the children and lay group scoring. It would be interesting to repeat this study without these possible confounding factors and compare the results.

4.5.3 The influence of size of the interdental spacing on the aesthetic perception of the smile

On average for every 0.5mm incremental increase in space shown, regardless of the pattern of spacing shown, the VAS score reduced across all groups by 7.84mm. This was highly statistically significant ($p<0.001$) but not clinically significant. These results show that a 1mm difference in the size of the interdental space was clinically significant

(>15mm) in reducing aesthetic acceptability. Therefore, larger interdental spaces negatively influence aesthetic perception.

Kokich et al. (2006) identified that the larger the size of spacing, the less it was tolerated. However, Abu Alhaija et al. (2011) found that a MMDs of up to 3mm was tolerated in females. This is in contrast to our study whereby 3mm MMD was the least tolerated of all MMDs, and no differences within gender were found.

4.5.4 The Influence of gender on aesthetic perception

Observer gender did not influence aesthetic perception of interdental spacing (confidence intervals: -3 to +5 P=0.57). This finding is in line with other similarly designed studies on aesthetic perception (Parekh et al., 2005; Rodrigues et al., 2009; Kokich et al., 2006).

4.5.5 Influence of orthodontic professional qualification on aesthetic perception of interdental spacing

This was a secondary outcome measure, and this study was not powered sufficiently to draw any generalisable conclusions from our findings, therefore these results need to be interpreted with caution. The trend within our small subsamples of professional groups showed that consultant orthodontists and Post CCSTs were more critical than specialist orthodontists.

4.5.6 Ethnic background and aesthetic perception

The findings regarding the influence of ethnic background on aesthetic perception were secondary outcome measures, and the study was not powered to identify differences between ethnic groups, therefore the results of this study should be interpreted with caution. The ethnic groups were broadly categorised into ‘Caucasian (n=82)’, ‘other(n=15),’ and ‘Asian (n=64).’ Asians were found to be the most critical, compared to the most lenient group who were Caucasians (p=0.000). This is in contrast to Gonzalez et al. (2010) and Umanah et al. (2015) showed south Indians and Afro-Caribbean’s respectively to have a preference towards a midline diastemas.

4.5.7 Age of the dental professional and aesthetic perception

As a secondary outcome measure, professionals are more critical than their older counterparts when rating images with interdental spacing. However, this study was not specifically designed to investigate this therefore the results are not generalisable, however it is an interesting finding and in keeping with the authors views that we live in an ever increasing aesthetically aware population, where social media has greater influence at a younger age and therefore may be influencing younger orthodontists much earlier than their more experienced counterparts.

The eldest cohort of professionals, aged greater than 55 years of age (n=8, all were orthodontists,) rated the images 15mm more leniently than the youngest dental professionals (n=45, 10 orthodontists, 35 GDPs). This was statistically significant (p=0.031) and clinically significant, with 95% confidence intervals ranging from -1 to +29. The second eldest cohort aged above 45 years, but less than 55 years of age (n=11; 8 orthodontists and 3 GDPs), also showed a statistically significant difference in rating the images more leniently than the youngest professional cohort, by 14.6mm on the VAS (p=0.042, CI 0.5 to 29). This result was borderline clinically significant.

4.6 Limitations of the Study

- The use of the VAS resulted in a large variation of responses and therefore statistical analysis of interactions between groups was limited.
- Digital manipulation was challenging and involved the smile widening which may have influenced overall results.
- The impact of being in the hospital environment may have led to responder bias.
- The practice questions could have included retracted dental views rather than images with the lip curtain. Additionally, a larger number of practice images may have better calibrated participants, not only to the VAS but to the style of photographs being used. This may have led to greater intra and inter rater reliability. The VAS may have been difficult to understand amongst younger groups.

- It was not always possible to obtain the repeated questionnaires two-weeks later.
- Students of business studies were identified as convenience sample, to represent lay adults. This cohort was specifically chosen as a search of the University and colleges admissions service database highlighted that business studies had good diversity in gender, ethnicity and socio economic background (UCAS, 2015). Similar studies (Machado et al., 2013; Rosa et al., 2013; Kokich et al., 2006) recruited professionals in the lay adult cohort and thus our results are comparable with these studies. However, this project aimed to capture perceptions of adults in the general population, and only 41.4% of the population have a higher education (ONS, 2015). Therefore, this sample cannot be representative of the total population.
- Akinboboye et al. (2015) and Abu Alhaija et al. (2011) found that those with an MMD themselves rated pictures with interdental spacing more favourably. This study did not identify how many of its participants exhibited an MMD themselves.
- McKechnie and Brodie (2008) identified that left-handed individuals results skewed towards the more negative (left) side of the scale. This study did not report on the dominant hand of each observer. This may have been a possible factor influencing the results.
- All images could have been displayed (per pattern of spacing) on the same page with reference to the 'ideal' image as the gold

standard. Additionally, the anchors of the VAS could be modified to have the most attractive and least attractive photo at each end of the scale as a reference.

4.7 Conclusions

Labial segment interdental spacing is disliked by all groups, and the size and pattern of spacing has an influence on aesthetic perception. The larger the size, and the more generalised the spacing, the less the malocclusion is perceived to be attractive. Median diastemas are most accepted followed by lateral diastemas, lateral spacing and finally generalised spacing is disliked the most. There was no difference in rating between males and females, and Asians were found to be more critical than their Caucasian counterparts, although due to small sample size, these results have to be interpreted with caution. Older clinicians (aged above 45 years) rated the images significantly more critically than younger dental professionals. Children and lay adults rated the images of interdental spacing more critically than orthodontists and general dentists. General dentists rated the images most leniently.

There was large variability amongst the scores, and thus the clinical implications of this study are that spacing is disliked by lay groups, however the extent of dislike is dependent on the individuals. Clinicians, must be aware that the patient themselves may have a lower threshold to accept spacing than themselves.

The generalisability of the results of this study are limited, and the results should be viewed with caution due to the poor intra rater reliability, and large individual variation. Peck and Peck (1970) described the phenomenon of selective conditioning, and perhaps may offer an alternative explanation to the result that children were the most critical cohort. Children are unaccustomed to viewing intra oral frontal images, and this may account for the critical nature of their scoring.

This research supports the long held maxim that beauty is a multi-dimensional concept, and it lies in the eye of the beholder (Hungerford, 1890)

4.8 Suggestions for Further Research

- The same study could be broken down into four separate studies, investigating the aesthetic perception of a single pattern of spacing. The VAS could have been used alongside the Q-sort method if fewer images were used. A shorter questionnaire, may also result in less observer fatigue. This may have also improved the intra rater reliability, reduced variability in results and enabled further post hoc testing to determine threshold levels of aesthetic acceptability of various patterns of spaces.
- Child subjects who are not patients in the hospital could give different results and this could be investigated comparing responses from children both in and outside healthcare environments.

- Lay adult subjects more representative of the generalised population may give have a different aesthetic perception than students of the University of Birmingham business school.
- The study could be developed to ascertain how much calibration is required to obtain good ICC scores.
- Observe if the smile perception of lower facial third view of a smile with interdental spacing is different to an intra oral dental view with the same pattern and type of spacing.
- Compare aesthetic perception of interdental spacing between digitally manipulated smiles show in three dimensions, a video of the smile in function whilst speaking, and how they compare to two dimensional photographs.

This is the first study of its kind and could be developed with improvements suggested. It could be repeated on a larger scale to obtain sufficient statistical power to overcome the variability of results, and observe differences between ethnicities and professional background.

To date, there has only been one study which observed the oral health-related quality of life of those with interdental spacing (Johal et al., 2007). Further studies similar to this one, may help to support any future changes in the IOTN.

CHAPTER FIVE

APPENDICES AND REFERENCES

CHAPTER 5: APPENDICES AND REFERENCES

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Appendix 4 – Information sheet for child participants, page 1

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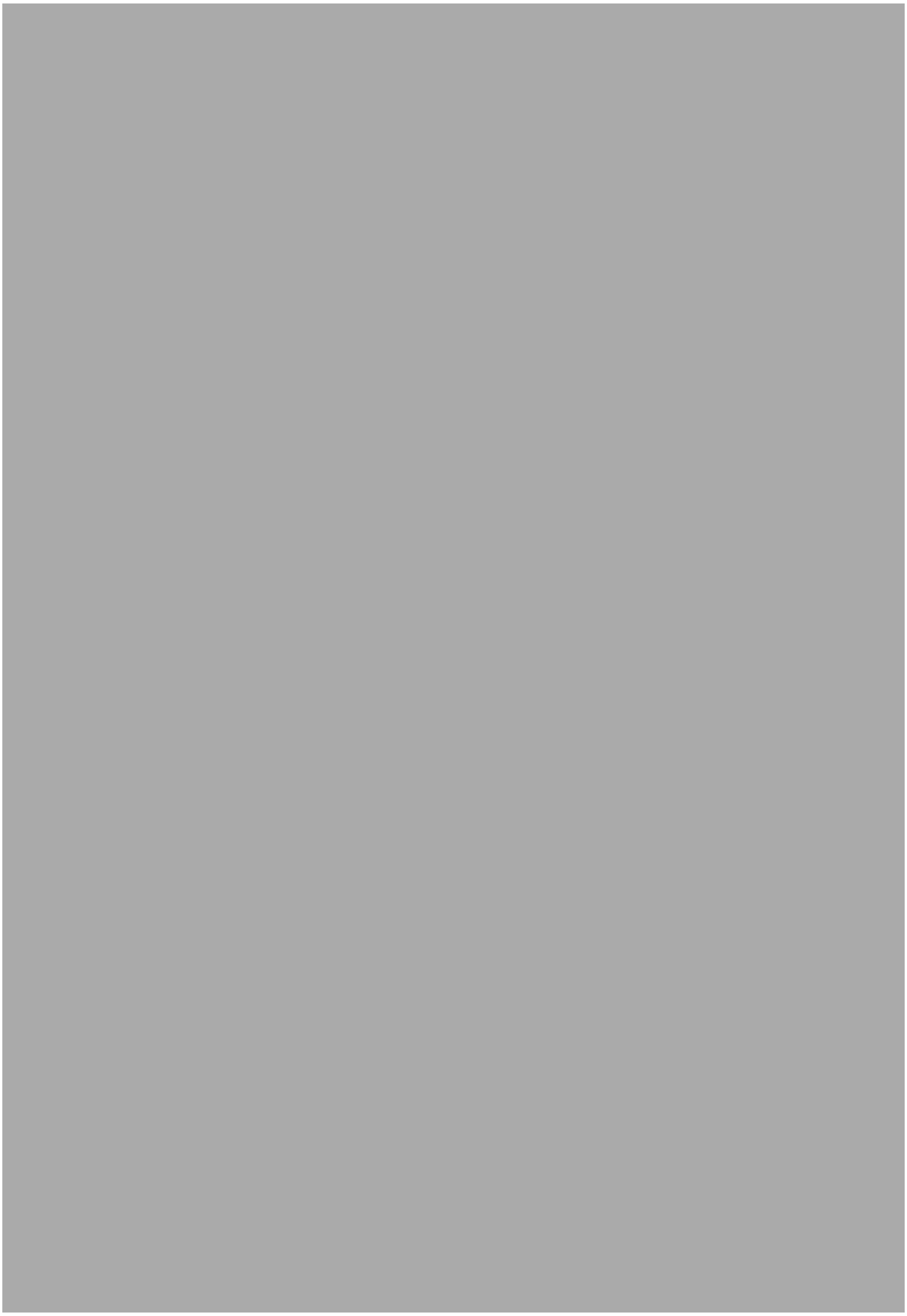
Appendix 5 – Information sheet for parents of child participants, page 1

Appendix 5 – Information sheet for parents of child participants, page 2

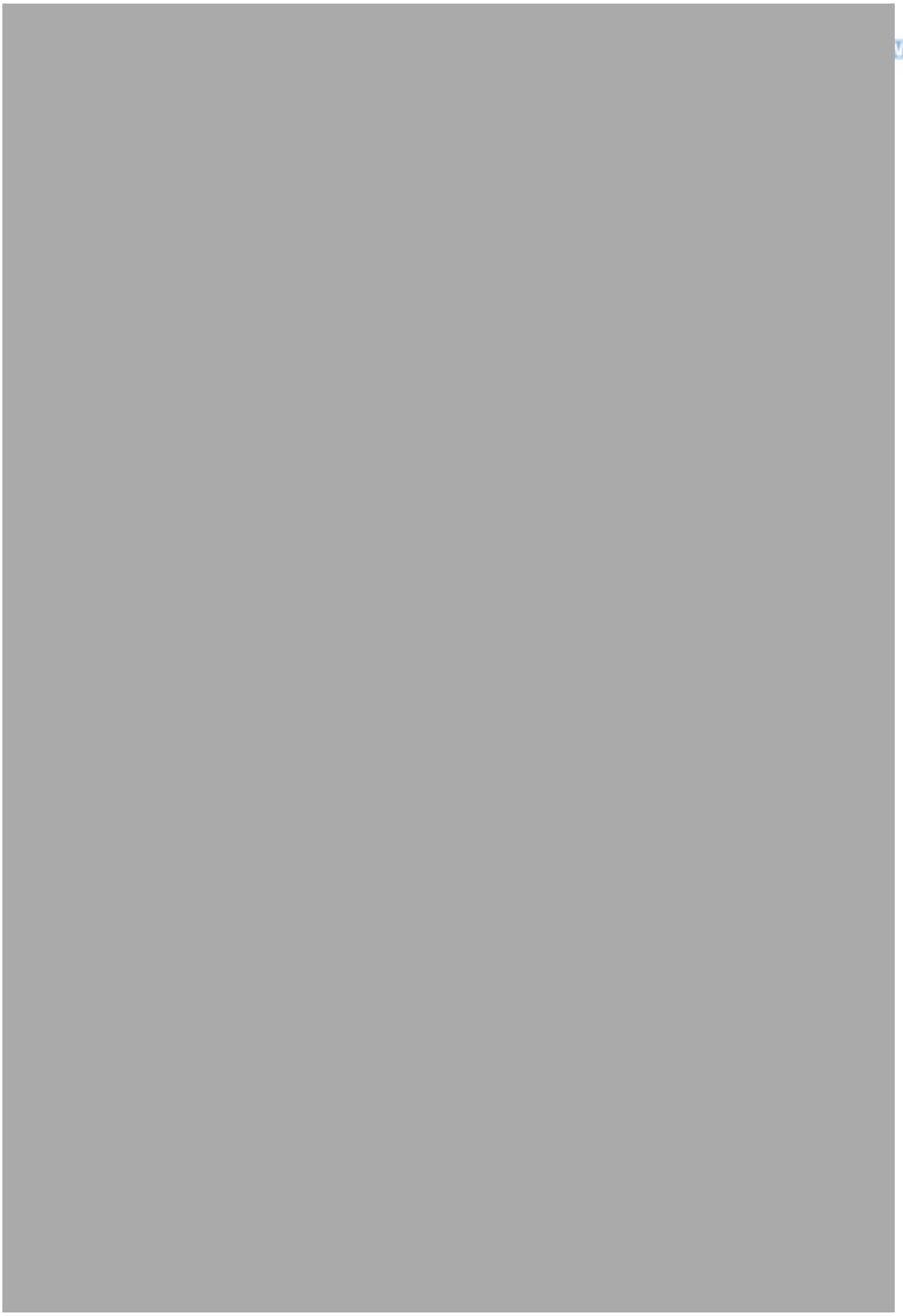
Appendix 6 – Consent form for lay adults, general dentists and orthodontists

Appendix 7 - Consent form for parents of child participants



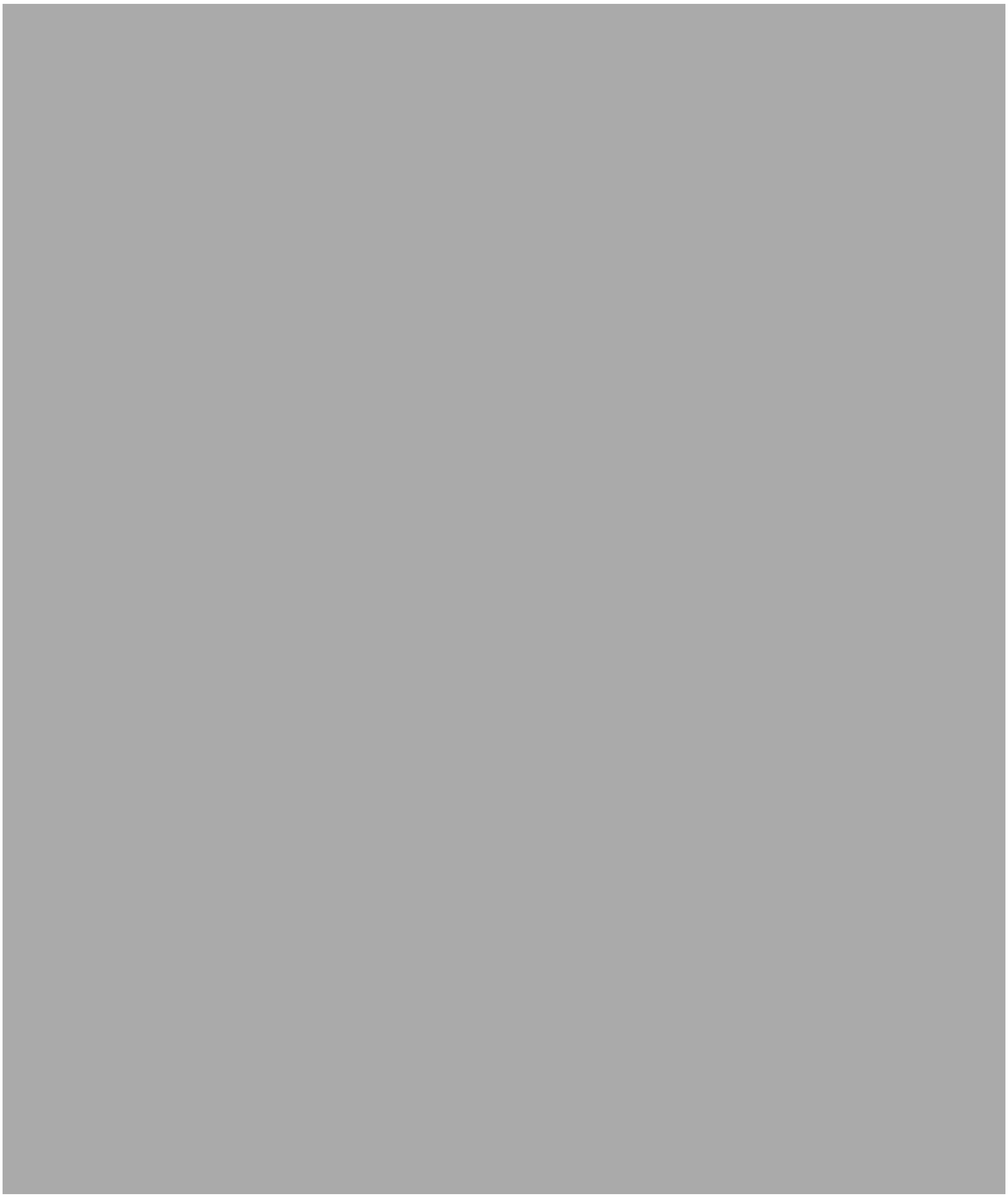
Appendix 8 – Children's Assent form

Appendix 9 – Data collection proforma for lay adults

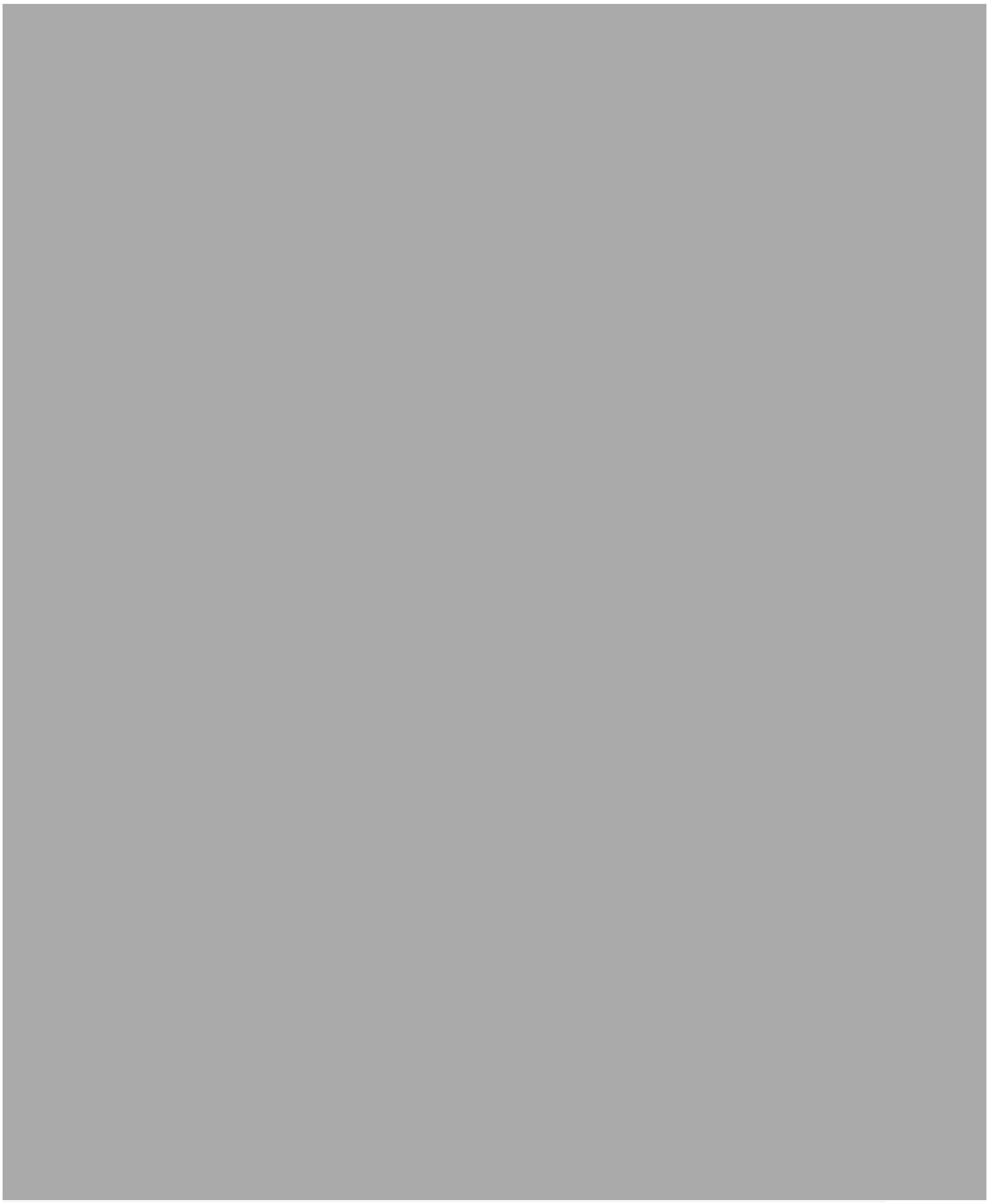


Appendix 10 – Data collection proforma for children

Appendix 11 – Data collection proforma for general dentists



Appendix 12 – Data collection proforma for orthodontists



Appendix 13 – Questionnaire

- Only mark once on the line. If you make a mistake, put a cross over it and write your initial. Then make the new mark. See below.

Appendix 13 – Questionnaire

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Birmingham Community Healthcare NHS Trust

Version 1.8 17/08/2016

FIRST: TWO WARM UP QUESTIONS…

Place a mark on the ten centimeter line below. The mark indicates how attractive you feel the smile is. See the previous example. A mark at the:

- **Far right means that you think the smile is very attractive**
- **Far left means that you this the smile is very unattractive**

If you feel that that the smile is somewhere in between 'very attractive' and 'very unattractive,' mark on the line clearly where you feel the attractiveness lies. The mark you place should represent how only you feel. There are no right or wrong answers, so go with you think.

Practice Image 1:

Very **Unattractive** Very **Attractive**

Practice Image 2:

Very **Unattractive** Very **Attractive**

- **Do you have any questions?**
- **Are you clear about what we would like you to do?**

If you are unsure, or feel you do not wish to participate anymore please speak to Aarti Mehta now.

If you are happy please fill out the remaining questionnaire by rating the following images as you did in the practice above. Thank you.

Appendix 13 – Questionnaire

UNIVERSITY OF BIRMINGHAM

Birmingham Community Healthcare NHS Trust

Version 1.8 17/08/2016

THE ACTUAL QUESTIONNAIRE

Place a mark on the ten centimeter line below. The mark indicates how attractive you feel the smile is.

Image 1

Very **Unattractive** Very **Attractive**

Image 2

Very **Unattractive** Very **Attractive**

Image 3

Very **Unattractive** Very **Attractive**

Appendix 13 – Questionnaire

Version 1.8 17/08/2016

Image 4

Very **Unattractive** Very **Attractive**

Image 5

Very **Unattractive** Very **Attractive**

Image 6

Very **Unattractive** Very **Attractive**

Appendix 13 – Questionnaire

UNIVERSITY OF BIRMINGHAM

Birmingham Community Healthcare NHS Trust

Version 1.8 17/08/2016

Image7

Very **Unattractive** Very **Attractive**

Image 8

Very **Unattractive** Very **Attractive**

Image 9

Very **Unattractive** Very **Attractive**

Appendix 13 – Questionnaire

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Birmingham Community Healthcare NHS

Version 1.8 17/08/2016

Image 10

Very **Unattractive** Very **Attractive**

Image 11

Very **Unattractive** Very **Attractive**

Image 12

Very **Unattractive** Very **Attractive**

Appendix 13 – Questionnaire

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Birmingham Community Healthcare NHS Trust

Version 1.8 17/08/2016

Image 13

Very **Unattractive** Very **Attractive**

Thank you…You're over half way there! Keep going..

Image 14

Very **Unattractive** Very **Attractive**

Image 15

Very **Unattractive** Very **Attractive**

Appendix 13 – Questionnaire

Version 1.8 17/08/2016

Image 16

Very **Unattractive** Very **Attractive**

Image 17

Very **Unattractive** Very **Attractive**

Image 18

Very **Unattractive** Very **Attractive**

Appendix 13 – Questionnaire

UNIVERSITY OF BIRMINGHAM

Birmingham Community Healthcare NHS

Version 1.8 17/08/2016

Image 19

Very Unattractive Very Attractive

Image 20

Very Unattractive Very Attractive

Image 21

Very Unattractive Very Attractive

Appendix 13 – Questionnaire

UNIVERSITY OF BIRMINGHAM

Birmingham Community Healthcare NHS

Version 1.8 17/08/2016

Image 22

Very **Unattractive** Very **Attractive**

Image 23

Very **Unattractive** Very **Attractive**

Image 24

Very **Unattractive** Very **Attractive**

Appendix 13 – Questionnaire

UNIVERSITY OF BIRMINGHAM

Birmingham Community Healthcare NHS Trust

Version 1.8 17/08/2016

Image 25

Very Unattractive

Very Attractive

THERE, IT'S FINISHED!

We appreciate the time and thought you have given to this questionnaire

THANK YOU FOR HELPING US

THANK YOU FOR YOUR PARTICIPATION!

Appendix 14 – VAS data from questionnaire

Key for Data

ID = Unique identification number given to each participant

MD = Midline diastema

LS = Lateral Spacing

LD = Lateral Diastema

GS = Generalised spacing

Time of measurement

1a = Measurement of photo 1 at time point 1

1b = Measurement of photo 1, 2 weeks after time point 1**roups:**

1 = Orthodontists

2 = GDPs

3 = Lay Adults

4 = Children

Qualification for orthodontists

1 = CCST (specialist)

2.= Post CCST

3 = Consultant

Qualification of General dentists

1 = BDS only

2 = Further post graduate qualification

Gender

1 = Male

2= Female

Country of primary qualification

1 = UK and Ireland

2 = Europe

3 = India

4 = South African

Appendix 14 – VAS data from questionnaire for images with no spacing

ID	Group	Qual	Gender	Ethnic Gp	Age	Country of P	Do you provide ortho Tx?(GDPS only)	No Spacing	
								1a	1b
1									
2	1	1	1	3	39	1	.	92.28	
3	1	1	1	1	52	1	.	100	
4	1	3	1	1	49	1	.	93.83	
5	1	1	2	1	59	1	.	94.07	
6	1	1	2	5	51	1	.	69.8	
7	1	3	1	3	47	1	.	92.16	
8	1	3	1	1	63	1	.	99.12	98.87
9	1	3	2	4	42	1	.	91.82	
10	1	3	1	3	56	1	.	94.2	
11	1	3	1	1	59	1	.	97.6	
12	1	1	2	1	35	2	.	83.17	
13	1	3	2	1	59	1	.	91.56	
14	1	1	2	1	33	1	.	89.59	
15	1	1	1	1	60	3	.	99.39	
16	1	3	1	3	42	1	.	89.53	
17	1	2	1	1	33	2	.	91.68	
18	1	3	2	3	43	1	.	44.12	44.01
19	1	3	1	3	42	4	.	93.93	
20	1	2	1	1	30	2	.	80.9	
21	1	1	1	1	54	1	.	100	
22	1	3	1	2	36	1	.	71.92	
23	1	1	2	1	29	1	.	74.69	
24	1	3	2	3	35	1	.	98.08	98.2
25	1	1	1	1	65	1	.	87.18	
26	1	3	1	1	35	1	.	93.83	
27	1	3	2	1	49	1	.	99.07	

Appendix 14 – VAS data from questionnaire for images with no spacing

ID	Group	Qual	Gender	Ethnic Gp	Age	Country of P	Do you provide ortho Tx?(GDPS only)	No Spacing	
1								1a	1b
27	1	3	2	1	49	1	.	99.07	
28	1	3	1	3	35	1	.	98.94	
29	1	3	1	1	46	1	.	100	
30	1	3	2	1	36	1	.	91.21	
31	1	3	2	3	32	1	.	84.74	85
32	1	3	2	5	38	1	.	93.18	
33	1	3	2	3	38	1	.	81.06	
34	1	3	1	1	46	1	.	93.53	
35	1	2	2	1	42	1	.	99.59	
36	1	3	1	1	37	1	.	96.7	
37	1	3	1	1	44	1	.	89.51	
38	1	1	2	1	42	5	.	100	
39	1	2	2	3	32	1	.	86.59	
40	1	3	1	1	68	1	.	90.29	
41	1	1	1	3	45	1	.	100	
42	2	2	1	5	50	3	2	94.81	
43	2	2	1	3	34	1	2	97.41	
44	2	2	1	3	36	4	1	73.34	
45	2	1	2	1	23	1	2	67.91	
46	2	1	2	3	23	1	2	100	
47	2	1	2	1	25	1	2	59.95	
48	2	1	2	3	23	1	2	82.63	
49	2	2	2	1	27	1	2	83.99	
50	2	1	2	1	23	1	2	100	
51	2	2	1	3	39	1	2	94.06	
52	2	2	2	3	30	1	2	74.3	74.49
53	2	2	1	3	29	1	1	82.29	
54	2	1	1	1	23	1	2	72.36	
55	2	1	2	4	25	1	2	100	
56	2	2	1	3	27	1	2	61.42	
57	2	1	2	3	25	1	2	97.41	

Appendix 14 – VAS data from questionnaire for images with no spacing

ID	Group	Qual	Gender	Ethnic Gp	Age	Country of P	Do you provide ortho Tx?(GDPS only)	No Spacing	
1								1a	1b
57	2	1	2	3	25	1	2	97.41	
58	2	2	1	3	28	1	2	90.85	
59	2	1	1	3	24	1	2	92.31	
60	2	1	1	1	24	1	2	94.03	
61	2	1	1	3	24	1	2	81.27	
62	2	1	1	3	24	1	2	76.15	
63	2	1	2	1	23	1	2	70.85	71.01
64	2	1	2	1	23	1	2	73.32	
65	2	1	2	1	25	1	2	74.62	
66	2	2	1	1	50	1	2	84.01	
67	2	2	1	3	27	1	2	95.63	
68	2	1	1	3	25	1	2	50.56	
69	2	1	1	3	25	1	2	65.88	
70	2	1	2	1	27	1	2	90.37	
71	2	1	2	3	23	1	2	77.44	
72	2	1	2	3	23	1	2	96.57	96.72
73	2	1	2	1	24	1	2	85.1	
74	2	1	2	3	23	1	2	99.02	
75	2	1	1	1	23	1	2	86.27	
76	2	1	2	1	24	1	2	95.29	
77	2	2	2	3	25	1	2	97.83	
78	2	1	2	3	24	1	2	66.84	66.64
79	2	2	1	3	30	1	2	93.86	
80	2	1	1	2	57	1	1	75.77	
81	2	1	2	1	25	1	2	86.55	
82	3	.	2	1	19	.	.	36.27	
83	3	.	2	1	23	.	.	89.43	
84	3	.	2	1	20	.	.	88.97	
85	3	.	2	1	19	.	.	85.54	
86	3	.	2	1	21	.	.	76.68	
87	3	.	1	3	23	.	.	75.29	

Appendix 14 – VAS data from questionnaire for images with no spacing

ID	Group	Qual	Gender	Ethnic Gp	Age	Country of P	Do you provide ortho Tx?(GDPS only)	No Spacing	
1								1a	1b
87	3	.	1	3	23	.	.	75.29	
88	3	.	1	1	20	.	.	49.4	
89	3	.	2	1	20	.	.	78.07	
90	3	.	1	1	20	.	.	66.24	
91	3	.	2	1	19	.	.	85.55	
92	3	.	1	1	19	.	.	51.39	51.07
93	3	.	2	1	28	.	.	95.46	
94	3	.	2	3	19	.	.	78.97	
95	3	.	1	1	20	.	.	84.77	
96	3	.	1	2	19	.	.	73.81	
97	3	.	1	1	18	.	.	97.21	
98	3	.	1	3	20	.	.	49.67	
99	3	.	1	2	20	.	.	45.25	
100	3	.	1	1	19	.	.	76.31	76.38
101	3	.	2	1	23	.	.	78.52	
102	3	.	2	3	22	.	.	61.73	
103	3	.	1	3	20	.	.	100	
104	3	.	2	3	22	.	.	81.69	
105	3	.	2	1	22	.	.	75.16	
106	3	.	2	1	19	.	.	72.8	
107	3	.	1	3	19	.	.	46.32	
108	3	.	2	1	19	.	.	90.17	
109	3	.	2	3	20	.	.	32.51	
110	3	.	2	3	28	.	.	100	
111	3	.	2	2	19	.	.	64.53	
112	3	.	2	1	20	.	.	85.57	
113	3	.	2	1	20	.	.	97.79	
114	3	.	2	1	21	.	.	89.44	
115	3	.	1	1	21	.	.	66.98	67.13
116	3	.	1	1	23	.	.	66.6	
117	3	.	2	3	19	.	.	100	

Appendix 14 – VAS data from questionnaire for images with no spacing

ID	Group	Qual	Gender	Ethnic Gp	Age	Country of P	Do you provide ortho Tx?(GDPS only)	No Spacing	
1								1a	1b
117	3	.	2	3	19	.	.	100	
118	3	.	2	4	18	.	.	78.22	
119	3	.	1	1	19	.	.	100	
120	3	.	2	3	20	.	.	75	74.93
121	3	.	1	1	22	.	.	40.67	
122	3	.	1	3	20	.	.	71.57	
123	4	.	2	1	15	.	.	56.17	
124	4	.	2	4	14	.	.	38.08	
125	4	.	2	1	12	.	.	94.05	
126	4	.	1	2	13	.	.	90.12	
127	4	.	1	1	14	.	.	20.95	
128	4	.	2	1	13	.	.	5.27	5.11
129	4	.	2	1	13	.	.	27.17	
130	4	.	1	1	14	.	.	69.99	
131	4	.	2	1	14	.	.	100	
132	4	.	1	1	14	.	.	67	
133	4	.	1	3	12	.	.	47.53	
134	4	.	2	1	16	.	.	96.43	
135	4	.	2	1	15	.	.	29.5	
136	4	.	1	3	12	.	.	18.67	
137	4	.	2	2	16	.	.	90.68	90.87
138	4	.	1	1	12	.	.	90.72	
139	4	.	2	1	13	.	.	81.1	
140	4	.	2	1	16	.	.	79.99	
141	4	.	2	3	13	.	.	94.5	
142	4	.	1	3	14	.	.	64.37	

Appendix 14 – VAS data from questionnaire for images with no spacing.

ID	Group	Qual	Gender	Ethnic Gp	Age	Country of P	Do you provide ortho Tx?(GDPS only)	No Spacing	
1								1a	1b
142	4	.	1	3	14	.	.	64.37	
143	4	.	1	3	13	.	.	62.14	
144	4	.	1	3	13	.	.	15.3	
145	4	.	2	3	13	.	.	78.07	
146	4	.	1	3	16	.	.	59.77	
147	4	.	2	3	13	.	.	96.18	
148	4	.	1	3	12	.	.	84.49	
149	4	.	1	3	12	.	.	63.94	63.93
150	4	.	1	2	13	.	.	40.19	
151	4	.	2	3	13	.	.	94.53	
152	4	.	1	3	13	.	.	0.41	
153	4	.	2	1	16	.	.	83.35	
154	4	.	2	1	14	.	.	74.44	
155	4	.	1	3	12	.	.	70.66	
156	4	.	1	3	16	.	.	94.22	
157	4	.	2	3	12	.	.	53.19	
158	4	.	2	3	16	.	.	72.21	
159	4	.	1	3	14	.	.	89.57	
160	4	.	1	1	15	.	.	14.06	13.94
161	4	.	1	1	12	.	.	89.95	

Appendix 14 – VAS data from questionnaire for images with a midline diastema

ID	Group	MD 0.5		MD 1		MD 1.5		MD 2		MD 2.5			MD 3
1		17a	17b	7a	7b	14a	14b	16a	16b	3a	3b	10a	10b
2	1	51.92		64.23		48.13		48.83		60.21		44.81	
3	1	93.47		86.9		90.27		78.46		62.35		50.08	
4	1	52.87		48.15		47.24		43.89		40.68		40.25	
5	1	93.06		91.41		89.77		83.19		56.47		78.78	
6	1	51.05		56.31		43.2		47.53		42.19		44.18	
7	1	36.57		75.16		43.25		46.69		60.9		37.79	
8	1	94.37	94.42	95.34	95.66	86.31	86.26	74.47	74.57	60.2	60.12	78.6	78.46
9	1	98.55		99.02		96.5		96.44		81.62		95.88	
10	1	53.24		32.26		28.27		29.23		30.17		28.97	
11	1	88.01		96.18		67.36		78.8		90.75		64.21	
12	1	68.06		29.95		27.81		15.92		29.84		9.07	
13	1	94.66		67.22		67.89		62.01		50.6		43.04	
14	1	85.3		75.84		78.7		68.47		56.5		47.59	
15	1	95.41		90.01		92.61		84.63		72		80.44	
16	1	40.07		31.15		28		23.88		5.81		19.67	
17	1	82.53		67.96		49.23		59.77		47.46		54.24	
18	1	51.91	51.79	81.38	81.41	55.08	54.96	56.11	56.1	36.32	36.19	38.43	38.41
19	1	61.33		36.28		38.33		30.88		28.36		17.42	
20	1	73.39		71.86		65.08		64.13		69.94		62.46	
21	1	93.33		92.35		82.04		59.3		64.11		59.74	
22	1	25.93		26.77		16.8		16.04		24.39		19.23	
23	1	89.33		60.05		40.91		46.92		23.16		3.11	
24	1	67.87	68.17	50.86	50.74	66.51	66.6	46.88	46.57	38.24	38.12	50.37	50.34
25	1	56.87		33.19		37.09		29.1		34.07		25.72	
26	1	80.67		45.06		29.54		40.58		22.23		34.19	
27	1	93.65		86.82		85.34		64.64		50.37		49.91	

Appendix 14 – VAS data from questionnaire for images with a midline diastema

ID	Group	MD 0.5		MD 1		MD 1.5		MD 2		MD 2.5			MD 3
1		17a	17b	7a	7b	14a	14b	16a	16b	3a	3b	10a	10b
27	1	93.65		86.82		85.34		64.64		50.37		49.91	
28	1	37		17.5		25.85		17.06		32.89		21.99	
29	1	68.78		84.28		49.48		49.66		44.76		46.52	
30	1	72.06		72.17		52.44		34.33		48.57		39.78	
31	1	38.87	38.87	36.39	36.24	34.59	34.58	32.34	32.27	17.97	18.1	33.1	32.98
32	1	86.42		24.63		33.38		35.25		14.74		21.48	
33	1	85.38		68.52		63.07		63.22		38.56		44.58	
34	1	25.72		26.12		23.31		16.32		18		4.42	
35	1	67.16		41.94		27.54		26.78		39.28		27.54	
36	1	69.74		68.82		35.83		28.28		31.06		34.9	
37	1	66.4		65.7		55.81		55.01		24.41		31.55	
38	1	94.39		89.86		80.69		81.58		81.77		77.89	
39	1	73.99		19.07		42.36		60		13.97		14.48	
40	1	91.67		85.94		51.8		56.04		44.56		50.11	
41	1	94.27		84.46		85.61		82.22		49.14		51.23	
42	2	86.17		71.47		58.94		56.67		53.77		55.75	
43	2	85.25		19.61		36.41		27.23		19.25		23.09	
44	2	71.15		50.08		48.63		37.63		48.5		35.46	
45	2	58.14		44.89		43.78		33.27		35.9		44.9	
46	2	95.05		94.68		80.33		70.3		51.54		29.79	
47	2	73.58		61.68		54.75		59.86		45.94		40.65	
48	2	62.95		21.43		48.61		13.65		24.46		9.39	
49	2	91.98		79.54		78.28		75.19		64.86		19.09	
50	2	43.62		38.79		14.27		26.96		4.16		9.97	
51	2	78.46		65.62		62.67		60.73		53.66		44.65	
52	2	40.93	41.29	48.38	48.78	24.34	24.55	22	22.23	25.39	25.66	18.69	18.8
53	2	94.07		86.82		71.94		56.68		58.98		66.02	
54	2	66.54		39.86		47.26		43.79		35.68		38.46	
55	2	50.47		29.72		29.06		17.67		14.64		23.87	
56	2	53.34		54.68		37.49		44.43		63.63		37.54	
57	2	73.42		57.58		26.12		25.28		26.12		19.25	

Appendix 14 – VAS data from questionnaire for images with a midline diastema

ID	Group	MD 0.5		MD 1		MD 1.5		MD 2		MD 2.5			MD 3
1		17a	17b	7a	7b	14a	14b	16a	16b	3a	3b	10a	10b
57	2	73.42		57.58		26.12		25.28		26.12		19.25	
58	2	75.19		60.95		49.47		48.86		49.48		35.76	
59	2	62		37.69		45.09		34.33		56.75		50.91	
60	2	81.9		80.04		69.37		66.44		58.55		69.56	
61	2	69.44		56.36		29.37		26.73		28.49		33.24	
62	2	80.6		60.26		60.43		49.01		25.88		36.09	
63	2	72.44	72.35	72.09	72.12	57.28	57.33	50.15	50.24	57.51	57.9	47.53	47.47
64	2	76.54		67.4		67.15		73.6		54.76		73.28	
65	2	86.73		81.21		84.49		86.97		75.31		65	
66	2	86.96		84.7		84.34		80.19		75.72		74.56	
67	2	63.99		45.53		37.04		39.4		16.35		34.69	
68	2	50.68		57.73		52.56		44.25		32.6		40.41	
69	2	66.84		59		48.22		49.2		44.09		44.89	
70	2	67.13		76.21		52.79		52.02		66.41		51.19	
71	2	55.51		45.48		35.01		31.63		29.73		27.74	
72	2	66.5	66.77	50.58	50.62	49.1	48.91	48.89	48.81	38.34	38.21	34.57	34.74
73	2	98.82		97.71		86.57		80.8		47.05		52.79	
74	2	94.31		84.07		81.07		72.6		78.3		77.3	
75	2	75.84		83.61		65.15		68.58		45.1		35.48	
76	2	96.47		83.14		89		93.95		76.83		48.05	
77	2	85.97		19.57		52.8		16.18		2.5		4.16	
78	2	53.48	53.34	54.85	54.92	46.33	46.43	37.26	37.54	23.42	23.47	36.85	36.89
79	2	54.14		47.05		42.62		32.85		12.02		23.88	
80	2	51.62		55.7		40.41		33.68		34.58		22.8	
81	2	97.56		66.25		45.08		66.64		46.33		40.26	
82	3	51.97		48.91		37.33		30.54		27.7		35.31	
83	3	74.33		81.41		60.09		45.03		85.39		37.52	
84	3	75.6		62.52		56.65		47.53		45.8		28.68	
85	3	99.04		83.67		95.05		54.36		39.87		62.84	
86	3	67.19		54.17		67.2		60.73		38.85		40.28	
87	3	81.4		39.45		30.65		22.36		16.04		43.94	

Appendix 14 – VAS data from questionnaire for images with a midline diastema

ID	Group	MD 0.5		MD 1		MD 1.5		MD 2		MD 2.5			MD 3
1		17a	17b	7a	7b	14a	14b	16a	16b	3a	3b	10a	10b
87	3	81.4		39.45		30.65		22.36		16.04		43.94	
88	3	76.87		64.48		43.26		46.8		12.74		22.99	
89	3	72.6		77.44		30.89		33.13		47.85		33.38	
90	3	77.69		22.08		5.03		6.07		7.38		8.49	
91	3	66.75		59.4		43.19		35.33		44.47		32.52	
92	3	62.45	62.73	57.8	57.59	25.65	25.73	40.14	39.96	36.81	37	37.49	37.33
93	3	75.73		83.55		64.5		62.61		67.16		51.87	
94	3	88.32		79.48		53.61		66.12		63.41		52.87	
95	3	68.99		72.29		55.84		58.46		53.79		28.11	
96	3	85.17		67.54		61.69		69.08		73.1		58.74	
97	3	92.46		43.34		63.55		60.79		40.45		42.41	
98	3	94.37		43.96		51.78		31.25		18.8		34.75	
99	3	48.61		44.62		28.24		40.27		31.42		35.63	
100	3	62.53	62.74	32.45	32.4	35.37	35.38	34.32	34.35	29.25	29.05	21.02	20.99
101	3	85.07		77.82		78.65		71.27		70.01		60.25	
102	3	56.11		66.98		46.87		39.53		30.88		39.43	
103	3	60.12		29.67		39.52		15.11		28.99		4.47	
104	3	45.34		41.07		21.89		33.51		6.42		27.22	
105	3	78.4		59.78		75.2		68.93		39.66		41.8	
106	3	77.51		73.21		66.69		64.02		42.05		35.4	
107	3	70.77		61.41		40.87		41.29		34.65		30.78	
108	3	85.98		78.35		74.5		55.58		47.12		40.2	
109	3	60.17		34.25		27.62		14.54		1.87		23.6	
110	3	89.48		91.26		94.86		65.84		50.04		32.27	
111	3	45		51.28		47.66		26.61		41.47		34.35	
112	3	97.41		83.36		47.9		45.1		42.17		29.84	
113	3	69.15		62.45		49.44		28.34		48.89		48.23	
114	3	89.35		71.89		71		59.68		54.25		41.05	
115	3	65.72	65.83	49.82	49.72	37.14	37.17	35.78	35.57	54.5	54.35	8.34	8.43
116	3	89.36		88.59		62.6		50.39		56.29		55.36	
117	3	24.33		5.1		4.53		4.68		2.72		4.99	

Appendix 14 – VAS data from questionnaire for images with a midline diastema

ID	Group	MD 0.5		MD 1		MD 1.5		MD 2		MD 2.5			MD 3
1		17a	17b	7a	7b	14a	14b	16a	16b	3a	3b	10a	10b
117	3	24.33		5.1		4.53		4.68		2.72		4.99	
118	3	26.91		30.23		18.8		29.89		26.56		15.18	
119	3	66.9		22.22		18.78		8.91		30.87		0	
120	3	54.53	54.45	55.93	55.64	50.94	51	34.12	34.12	50.27	50.38	38.92	38.88
121	3	52.32		45.71		40.88		34.82		31.58		27.81	
122	3	67.5		47.16		34.66		19.74		20.24		12.47	
123	4	95.02		66.67		56.04		61.2		38.79		42.47	
124	4	55.86		37.07		49.54		36.96		25.41		28.08	
125	4	81.16		66.19		49.4		54.94		24.45		24.31	
126	4	92.58		82.76		88.9		61.57		9.91		9.87	
127	4	16.43		11.59		1.77		10.07		11.99		10.55	
128	4	95.07	95.03	79.13	79	49.85	49.88	23.37	23.14	38.42	38.56	39.45	39.18
129	4	49.25		48.95		35.91		41		25.62		33.71	
130	4	73.89		48.72		30.89		39.3		12.3		22.11	
131	4	87.36		77.01		84.15		76.12		48.79		39.66	
132	4	95.57		80.04		69.35		76.74		38.51		57.02	
133	4	74.56		67.42		66.89		31.85		55.04		4.87	
134	4	85.93		89.87		88.29		77.13		69.2		63.03	
135	4	32.67		20.12		16.03		43.04		33.62		19.52	
136	4	48.95		47.49		48.76		41.01		13.01		36.6	
137	4	55.3	55.45	11.74	11.8	40.28	40.31	14.28	14.39	9.21	9.57	17.28	17.35
138	4	69.19		52.65		45.36		56.46		32.83		43.54	
139	4	78.48		58.78		54.17		44.31		52.66		43.4	
140	4	79.3		75.31		38.13		66.07		52.08		41.38	
141	4	75		59		46.5		40		35.5		26.5	
142	4	75.25		59.86		65.65		52.36		24.12		53.69	

Appendix 14 – VAS data from questionnaire for images with a midline diastema

ID	Group	MD 0.5		MD 1		MD 1.5		MD 2		MD 2.5			MD 3
1		17a	17b	7a	7b	14a	14b	16a	16b	3a	3b	10a	10b
142	4	75.25		59.86		65.65		52.36		24.12		53.69	
143	4	64.48		77.08		64.89		43.39		50.65		45.32	
144	4	38.05		49.6		16.1		35.15		10.26		25.46	
145	4	44.89		37.76		31.97		37.54		46.16		17.3	
146	4	71.83		51.68		33.06		16.27		2.91		5.48	
147	4	85.49		68.8		66.55		65.42		26.2		49.88	
148	4	66.67		35.73		30.88		35.62		28.19		29.15	
149	4	56.46	56.28	71.68	71.66	46.77	46.89	51.99	52	32.11	21.25	21.4	21.3
150	4	66.45		49.87		29.85		4.58		9.95		12.04	
151	4	57.12		50.65		35.36		23.06		14.97		27.17	
152	4	37.84		13.13		38.83		5.45		0.41		19.48	
153	4	48.79		19.61		28.66		15.29		25.68		12.57	
154	4	93.84		83.89		13.09		17.38		1.85		3.95	
155	4	49.01		34.53		58.83		27.67		27.04		13.42	
156	4	77.04		53.64		41.4		36.13		1.45		41.42	
157	4	44.9		30.99		36.28		36.68		28.79		28.35	
158	4	73.98		15.29		35.73		48.44		1.67		13.45	
159	4	89.42		49.33		47.76		49.34		45.97		23.37	
160	4	10.14	10.23	6.75	6.83	2.72	2.78	1.19	1.05	6.34	6.43	1.15	1.23
161	4	48.67		22.08		17.03		21.85		9.68		14.29	

Appendix 14 – VAS data from questionnaire for images with a lateral diastema

ID	Group	LD 0.5		LD 1		LD 1.5		LD 2		LD 2.5			LD 3
1		11a	11b	6a	6b	8a	8b	5a	5b	22a	22b	9a	9b
2	1	58.08		30.33		21.76		18.43		25.72		25.56	
3	1	83.95		81.51		73.22		71.36		58.42		61.37	
4	1	39.2		32.76		30.32		28.14		25.63		27.14	
5	1	88.94		39.86		39.14		38.67		59.9		30.32	
6	1	38.94		31.96		32.45		33.55		34.05		32.53	
7	1	63.26		41.29		25.12		13.01		35.44		12.58	
8	1	91.84	91.76	88.02	88.15	64.22	64.1	61.53	61.34	52.79	52.65	63.44	63.58
9	1	95.82		87.35		43.1		30.95		14.62		36.86	
10	1	46.66		39.28		30.52		17.69		13.37		24.63	
11	1	82.85		52.17		34.25		28.45		54.37		40.3	
12	1	37.09		23.42		23.11		21.44		28.57		12.86	
13	1	74.39		40.88		37.3		34.16		31.96		27.9	
14	1	83.29		54.8		42.63		37.7		37.24		48.87	
15	1	92.49		58.97		58.45		65.13		65.88		66.18	
16	1	28.56		34.05		35.2		26.27		20.09		10.55	
17	1	74.18		44.26		43.15		50.78		37.28		41.14	
18	1	38.96	38.76	47.28	47.37	40.75	40.75	39.17	39.01	41.33	41.5	24.81	24.89
19	1	47.4		37.96		29.19		24.55		25.99		16.86	
20	1	66.2		31.66		28.51		24.63		25.27		24.36	
21	1	79.7		39.89		39.99		36.44		19.11		28.67	
22	1	23.59		4.38		0		0		9.6		0	
23	1	45.09		22.61		22.18		17.69		8.66		17.37	
24	1	48.78	48.7	52.12	51.98	34	34.02	40.95	41.02	57.8	57.65	23.58	23.45
25	1	47.86		39.26		35.43		31.14		25.91		29.52	
26	1	66.39		35.82		26.41		19.46		26.68		25.4	
27	1	81.91		56.1		40.39		34.74		31.95		25.65	

Appendix 14 – VAS data from questionnaire for images with a lateral diastema

ID	Group	LD 0.5		LD 1		LD 1.5		LD 2		LD 2.5			LD 3
1		11a	11b	6a	6b	8a	8b	5a	5b	22a	22b	9a	9b
27	1	81.91		56.1		40.39		34.74		31.95		25.65	
28	1	35		16.44		14.98		12.5		13.33		18.36	
29	1	65.22		45.58		38.81		33.35		38.66		32.13	
30	1	65.96		47.39		40.32		35.43		27.16		35.54	
31	1	37.31	36.92	23.54	23.2	11.77	11.65	8.06	7.98	19.57	19.37	8.06	7.95
32	1	77.09		29.38		24.33		19.21		21.89		9.1	
33	1	73.03		44.17		33.21		29.48		46.27		34.83	
34	1	34.35		17.94		15.21		13.99		21.4		10.31	
35	1	79.6		34.83		24.43		19.62		28		25.45	
36	1	79.15		60.89		45.22		41.84		31.96		22.83	
37	1	54.67		55.96		34.23		25.69		29.58		33.31	
38	1	95.15		55.25		52.36		49.68		80.76		35.07	
39	1	60.54		30.86		25.2		25.4		12.31		32.07	
40	1	77.62		61.1		51.93		46.35		42.97		58.26	
41	1	82.36		72.19		31.73		16.24		46.72		18.18	
42	2	70.18		31.84		28.06		24.76		28		13.33	
43	2	79.58		29.39		23.98		16.23		10.6		11.96	
44	2	78.64		23.04		22.59		20.18		26.68		23.38	
45	2	52.77		40.79		38.1		34.66		42.16		34.63	
46	2	74.18		17.89		11.18		0		11.64		6.01	
47	2	76.55		69.62		61.55		52.89		48.79		45.67	
48	2	69.45		35.85		11.39		8.3		13.48		11.24	
49	2	24.26		25.27		24.91		20.33		13.25		8.2	
50	2	44.05		0		0		0		0		2	
51	2	63.04		50.63		46.93		40.31		52.24		47.22	
52	2	73.01	73.27	48.13	48.29	44.94	44.9	39.85	39.87	19.27	19.13	11.35	11.42
53	2	77.73		69.61		60.71		54.35		48.28		34.84	
54	2	69.16		51.86		41.4		32.24		38.6		28.48	
55	2	62.72		24.19		15.99		10.01		11.24		11.41	
56	2	50.69		54.68		47.34		37.83		32.45		36.01	
57	2	69.19		55.12		53.88		36.24		26.13		28.95	
58	2	[illegible]		[illegible]		[illegible]		[illegible]		[illegible]		[illegible]	

Appendix 14 – VAS data from questionnaire for images with a lateral diastema

ID	Group	LD 0.5		LD 1		LD 1.5		LD 2		LD 2.5			LD 3
1		11a	11b	6a	6b	8a	8b	5a	5b	22a	22b	9a	9b
57	2	69.19		55.12		53.88		36.24		26.13		28.95	
58	2	71.19		59.31		41.8		37.36		46.88		35.88	
59	2	70.2		43.67		40.37		34.83		30.38		33.39	
60	2	75.84		55.98		54.87		51.5		37.21		37.36	
61	2	62.38		14.4		14.44		15.64		28.57		16.8	
62	2	67.87		23.2		23.51		20.98		27.57		35.39	
63	2	55.31	55.42	31.78	31.76	28.07	28.14	25.46	25.5	26.65	26.69	24.23	24.22
64	2	70.05		66.81		65.01		64.12		65.94		60.41	
65	2	51.73		37.17		33.21		34.58		16.9		22.69	
66	2	83.64		75.84		69.51		63.13		72.21		78.31	
67	2	55.17		18.43		15		13.2		6.36		1.21	
68	2	49.63		47.73		41.14		37.71		41.94		37.45	
69	2	69.3		47.53		44.84		41.61		38.52		42.55	
70	2	72.91		53.76		53.88		52.96		49.12		54.68	
71	2	57.62		46.12		29.85		19.82		32.75		14.34	
72	2	59.78	59.66	59.38	59.49	44.24	44.33	36.24	36.19	20.18	20.23	17.66	17.6
73	2	98.92		59.28		46.64		38.78		52.27		39.97	
74	2	91.27		65.58		58.5		43.53		36.57		48.13	
75	2	73.98		66.49		60.53		54.6		54.06		58.66	
76	2	78.01		49.3		38.67		36.31		13.85		27.67	
77	2	88.94		85.22		81.68		63.42		38.43		17.29	
78	2	61.91	62	70.42	70.53	45.31	45.22	40.56	40.61	38.23	38.13	39.62	39.78
79	2	41.17		14.68		11.12		9.46		11.5		4.63	
80	2	46.72		38.73		36.1		34.35		14.79		26.79	
81	2	74.27		37.37		31.02		25.44		22.87		20.62	
82	3	58.31		52.62		48.99		45.65		26.52		22.55	
83	3	67.14		52.75		48.62		38.47		17.65		26.71	
84	3	80.48		31.86		29.11		24.31		42.75		12.3	
85	3	78.82		40.94		26.8		13.38		26.15		5.47	
86	3	72.01		55.04		54.31		52.86		44.31		41.53	
87	3	86.03		47.83		32.98		8.56		10.01		25.2	

Appendix 14 – VAS data from questionnaire for images with a lateral diastema

ID	Group	LD 0.5		LD 1		LD 1.5		LD 2		LD 2.5			LD 3
1		11a	11b	6a	6b	8a	8b	5a	5b	22a	22b	9a	9b
87	3	86.03		47.83		32.98		8.56		10.01		25.2	
88	3	57.72		40.33		41.14		47.75		48.86		44.08	
89	3	41.89		37.37		22.46		13.33		21.99		11.49	
90	3	86.71		13.88		10.4		7.22		9.52		7.91	
91	3	71.95		40.57		37.44		33.42		35.59		43.2	
92	3	42.15	42.16	29.68	29.56	17.11	17.17	20.11	20.1	37.15	37.1	20.66	20.46
93	3	64.75		31.9		24.71		19.68		22.25		7.86	
94	3	66.82		70.04		60.58		52.37		54.73		44.82	
95	3	61.79		68.24		63.81		55.73		55.5		53.33	
96	3	81.88		72.55		65.28		59.17		43.26		58.4	
97	3	92.73		86.42		74.15		53.49		16.37		31.31	
98	3	80.07		69.63		58.37		42.1		30.97		35.81	
99	3	45.65		40.31		36.5		32.28		44.31		25.6	
100	3	61.4	61.34	45.74	45.58	39.78	39.68	30.88	30.68	20.88	20.39	25.89	25.86
101	3	83.03		52.39		45.39		34.71		45.19		33.91	
102	3	65.54		49.67		43.26		30.76		30.87		21.31	
103	3	43.98		46.87		40.2		33.72		18.11		13.88	
104	3	45.33		32		26.02		19.71		17.89		8.03	
105	3	69.11		34.43		23.28		16.55		33.96		32	
106	3	84.07		65.98		53.76		44.74		50.53		44.61	
107	3	65.54		28.64		15.58		8.97		6.71		6.4	
108	3	70.88		67.19		62.25		54.79		54.07		44.98	
109	3	70.71		22.91		17.48		5.41		7.43		1.83	
110	3	91.57		83.74		79.82		29.12		1.81		6.38	
111	3	57.49		58.55		50.89		39.87		33.92		17.01	
112	3	86.17		76.49		68.6		57.45		47.98		27.23	
113	3	51.76		32.16		24.23		21.35		13.33		6.91	
114	3	79.22		68.88		48.55		41.46		57.13		33.16	
115	3	59.1	58.92	73.69	73.65	57.84	57.77	52.37	52.18	16.27	16.02	34.38	34.5
116	3	91.44		79.41		66.27		56.47		56.37		38.49	
117	3	41.74		1.86		2		2.49		3.21		1.36	

Appendix 14 – VAS data from questionnaire for images with a lateral diastema

ID	Group	LD 0.5		LD 1		LD 1.5		LD 2		LD 2.5			LD 3
1		11a	11b	6a	6b	8a	8b	5a	5b	22a	22b	9a	9b
117	3	41.74		1.86		2		2.49		3.21		1.36	
118	3	56.49		32.14		30.55		30.87		15.67		32.01	
119	3	63.43		26.66		25.37		23.76		18.68		5.06	
120	3	73.4	73.51	53.36	53.18	49.51	49.56	43.58	43.57	53	52.9	48.86	48.77
121	3	47.74		41.93		34.25		28.63		39.56		42.47	
122	3	74.58		69.51		46.02		37.31		29.31		33.61	
123	4	90.92		61.54		52.17		44.26		33.17		55.77	
124	4	60.82		52.04		48.08		32.07		48.15		37.84	
125	4	72.43		41.67		40.22		37.12		25.25		30.72	
126	4	79.59		93.91		90.88		82.91		8.77		75.79	
127	4	17.53		18.41		18.33		10.53		13.93		3.49	
128	4	73.94	73.87	39.31	39.48	37.85	37.86	35.25	35.2	21.62	21.61	49.45	49.5
129	4	46.94		28.03		30.36		32.17		28.99		22.6	
130	4	76.71		38.02		32.23		30.35		20.71		20.75	
131	4	85.29		48.76		42.3		36.98		30.41		28.75	
132	4	91.93		76.54		70.41		61.6		50.22		49.65	
133	4	70.67		33.87		28.43		25.58		7.46		33.3	
134	4	85.91		84.74		81.96		79.25		64.28		48.66	
135	4	73.43		11.43		11.51		10.33		40.23		20.51	
136	4	48.12		42.15		37.35		23.74		39.33		28.64	
137	4	60.05	60.1	24.41	24.39	21.03	21	19.83	19.82	12.3	11.93	13.6	13.74
138	4	73.2		37.93		20.63		18.39		36.65		30.58	
139	4	62.14		60.25		59.71		57.38		46.17		39.15	
140	4	70.25		58.19		55.32		51.75		24.05		30.68	
141	4	68.25		32.25		23		20.5		21.1		25.5	
142	4	69.12		45.84		44.11		16.23		48.76		43.24	

Appendix 14 – VAS data from questionnaire for images with a lateral diastema

ID	Group	LD 0.5		LD 1		LD 1.5		LD 2		LD 2.5			LD 3
1		11a	11b	6a	6b	8a	8b	5a	5b	22a	22b	9a	9b
142	4	69.12		45.84		44.11		16.23		48.76		43.24	
143	4	70.75		52.38		46.83		41.16		46.83		44.29	
144	4	11.64		40.47		31.1		42.13		3.5		13.34	
145	4	35.16		49.43		49.89		54.78		31.27		46.58	
146	4	38.47		17.03		16.13		15.78		10.34		6.39	
147	4	86.44		72.17		66.53		50.86		54.27		52.11	
148	4	50.84		30.29		30.25		30.38		14.74		27.64	
149	4	30.42	30.25	54.2	54.18	44.73	44.73	29.07	29.21	10.7	10.64	21.86	21.89
150	4	62.04		26.25		19.86		9.79		21.15		13.45	
151	4	50.27		47.47		46.12		49.05		45.71		33.73	
152	4	27.64		0		0		0.98		14.88		6.48	
153	4	67.65		33.61		23.36		11.37		9.86		19.23	
154	4	91.87		71.86		44.16		29.62		44.06		9.9	
155	4	55.67		39.29		29.39		23.28		46.22		39.26	
156	4	76.82		37.87		31.12		16.47		31.01		15.77	
157	4	41.93		34.86		33.04		32.47		30.97		22.22	
158	4	52.45		19.22		19.86		24.02		34.73		15.77	
159	4	73.42		3.09		2.67		1.91		13.93		8.95	
160	4	10.12	10.04	7.1	7.14	5.71	5.62	2.09	1.97	1.15	1.49	2.81	2.71
161	4	59.18		36.73		30.92		24.5		12.32		13.76	

Appendix 14 – VAS data from questionnaire for images with a lateral spacing

ID	Group	LS 0.5		LS 1		LS 1.5		LS 2		LS 2.5		LS3	
1		20a	20b	21a	21a	12a	12b	24a	24b	2a	2b	23a	23b
2	1	58.61		31.87		31.42		26.25		37.83		15.63	
3	1	90.43		80.15		77.6		49.17		47.69		42.04	
4	1	40.25		34.97		28.23		11.6		13.16		9.97	
5	1	83.33		68.05		63.31		33.49		28.51		29.16	
6	1	44.77		37.9		37.25		26.61		36.48		26.42	
7	1	56.1		39.87		33.24		30.11		16.66		31.83	
8	1	90.38	90.39	56.26	56.22	38.49	38.23	44.38	44.47	32.87	32.76	30.73	30.68
9	1	92.83		88.03		17.02		9.32		32.45		8.34	
10	1	31.85		25.37		7.99		2.17		4.24		7.15	
11	1	71.86		44.7		61.34		39		2.63		34.03	
12	1	69.2		31.15		18.77		11.95		17.81		13	
13	1	89.85		59.94		21.32		17.51		32.73		11.1	
14	1	88.57		63.45		47.65		19.75		15.85		17.14	
15	1	94.59		91.08		66.51		67.62		58.46		64.36	
16	1	30.02		20.09		38.34		19.37		17.71		29.96	
17	1	59.24		53.21		32.71		28.55		31.12		33.19	
18	1	14.37	14.24	16.4	16.46	6.68	6.51	8.65	8.66	14.54	14.55	20.27	20.25
19	1	58.37		48.66		20.85		5.28		8.52		2.42	
20	1	63		43.87		28.06		18.53		23.28		19.44	
21	1	94.97		60.63		38		15.25		26.15		9.07	
22	1	19.49		8.21		0		0.58		1.82		1.01	
23	1	73.7		34.57		18.82		10.03		0.74		9.13	
24	1	27.86	27.78	23.42	23.23	32.59	32.57	3.64	3.53	11.02	10.99	8.39	8.48
25	1	64.17		49.88		26.32		24.76		20.92		18.92	
26	1	42.4		33.54		18.31		11.57		5.78		7.45	
27	1	85.29		55.85		45.16		21.21		19.21		18.85	

Appendix 14 – VAS data from questionnaire for images with a lateral spacing

ID	Group	LS 0.5		LS 1		LS 1.5		LS 2		LS 2.5		LS3	
1		20a	20b	21a	21a	12a	12b	24a	24b	2a	2b	23a	23b
27	1	85.29		55.85		45.16		21.21		19.21		18.85	
28	1	42.52		23.6		16.08		11.76		11.45		6.29	
29	1	45.23		38.84		37.44		32.14		24.59		27.76	
30	1	61.66		49.55		25.06		24.77		30.43		19.46	
31	1	36.28	36.26	24.47	24.59	23.74	23.63	4.88	4.75	2.44	2.45	3.26	3.32
32	1	81.41		26.64		24.74		2.89		7.28		1.57	
33	1	72.53		65.75		43.6		29.4		21.35		25.51	
34	1	23		15		12.17		15.34		9.65		6.4	
35	1	78.93		59.17		18.36		18.75		24.83		22.77	
36	1	76.83		26.4		26.34		13.49		17.03		7.18	
37	1	76.28		61.63		49.11		27.69		19.66		20.79	
38	1	94.91		89.01		37.27		36.1		29.85		34.83	
39	1	33.85		21.88		4.87		4.51		8.05		4.19	
40	1	50.85		32.52		27.29		30.21		12.94		29.88	
41	1	99.11		96.33		51.09		49.17		23.56		43.37	
42	2	43.29		41.06		32.08		28.54		14.44		30.21	
43	2	77.11		63.32		17.27		15.43		7.03		4.98	
44	2	71.04		53.55		13.29		27.52		25.62		30.41	
45	2	60.57		31.72		24.56		16.65		26.36		17.76	
46	2	95.51		60.5		24.75		9.77		20.09		11.64	
47	2	80.34		78.55		65.33		31.03		40.91		31.32	
48	2	57.22		26.12		23.85		0		22.53		0	
49	2	77.75		45.79		6.73		5.28		25.25		2.21	
50	2	14.96		0		0		0		0		0	
51	2	75.41		66.24		36.48		22.42		15.03		26.63	
52	2	83.43	83.42	38.87	38.91	30.69	30.6	2.8	2.83	11.2	11.44	4.06	4.16
53	2	85.95		75.27		35.57		37.79		37.43		24.43	
54	2	43.88		34.82		33.99		29		36.67		22.45	
55	2	20.24		15.29		9.93		12.98		0		7.54	
56	2	50.93		36.86		32.46		24.03		47.69		19.8	
57	2	84.32		69.09		34.13		24.37		20.35		10.52	

Appendix 14 – VAS data from questionnaire for images with a lateral spacing

ID	Group	LS 0.5		LS 1		LS 1.5		LS 2		LS 2.5		LS3	
1		20a	20b	21a	21a	12a	12b	24a	24b	2a	2b	23a	23b
57	2	84.32		69.09		34.13		24.37		20.35		10.52	
58	2	87.66		76.83		27.85		27.51		27.81		20.03	
59	2	56.66		39.95		30.92		20.87		37.36		20.86	
60	2	38.5		34.11		41.18		29.98		35.81		26.01	
61	2	70.48		30.41		16.05		14.2		7.59		18.82	
62	2	48.97		33.18		16.74		17.74		18.61		14.62	
63	2	27.22	27.21	18.04	17.89	33.26	33.37	7.83	7.88	19.37	19.38	7.49	7.42
64	2	75.64		71.82		64.92		55.78		57.13		63.09	
65	2	48.02		55.29		30.07		34.44		46.48		30.83	
66	2	87.58		56.1		57.29		55.52		53		50.97	
67	2	35.69		15.38		2.95		4.97		4.11		2.63	
68	2	65.37		52.76		46.39		32.31		20.16		36.26	
69	2	67.72		43.94		36		23.98		24.6		26.46	
70	2	70.13		55.44		58.11		50.89		66.07		36.31	
71	2	29.76		21.55		12.83		37.04		3.38		19.4	
72	2	63.29	63.36	51.92	51.83	4.58	4.36	9.36	9.19	13.64	13.77	1.63	1.6
73	2	99.79		94.8		65.74		51.44		34.74		53.85	
74	2	37.11		64.59		65.06		41.75		25.58		17.24	
75	2	76.35		50.47		50.47		45.71		30.05		24.37	
76	2	72.83		49.08		21.39		15.82		19.54		11.55	
77	2	64.47		31.65		70		17.45		26.32		6.59	
78	2	69.29	69.47	51.42	51.47	30.35	30.07	21.14	21.26	10.05	10.19	16.36	16.27
79	2	47.39		18.33		18.96		1.08		2.98		1.31	
80	2	64.97		56.64		33.75		19.34		28.37		14.58	
81	2	81.64		48.07		18.26		16.6		20.66		15.14	
82	3	57.59		46.08		19.52		12.91		22.34		16.21	
83	3	31.54		16.5		25.22		0		23.07		6.97	
84	3	85.76		62.05		57.63		14.99		6.23		9.92	
85	3	85.9		61.41		66.09		18.53		3.67		10.14	
86	3	57.82		50.78		40.99		21.68		15.11		27.01	

Appendix 14 – VAS data from questionnaire for images with a lateral spacing

ID	Group	LS 0.5		LS 1		LS 1.5		LS 2		LS 2.5		LS3	
1		20a	20b	21a	21a	12a	12b	24a	24b	2a	2b	23a	23b
87	3	69.59		51.45		21.01		4.26		0		1.51	
88	3	43.45		29.38		15.28		25.96		26.03		22.41	
89	3	56.82		25.883		14.86		23.74		41.59		25.55	
90	3	36.32		25.17		4.43		2.03		3.5		1	
91	3	59.29		39.01		24.63		21.61		29.15		21.26	
92	3	63.99	63.92	50.34	50.29	30.68	30.26	20.88	21.12	32.83	32.5	20.53	20.22
93	3	83.93		57.57		14.18		4.62		16.09		2.87	
94	3	75.26		58.04		29.04		42.83		44.19		42.99	
95	3	81.66		70.15		43.6		36.53		28.48		40.96	
96	3	70.08		57.81		57.45		36.35		58.97		38.85	
97	3	72.02		9.8		32.3		11.8		3.31		0.21	
98	3	47.3		31.5		26.13		15.43		5.2		15.79	
99	3	39.83		25.08		26.92		10.55		11.81		21.85	
100	3	54.25	53.88	34.55	34.39	35.02	35.32	7.55	7.31	21.23	21.01	6.63	6.76
101	3	78.24		60.65		23.28		25		9.29		21.9	
102	3	62.09		36.32		18.67		21.95		13.53		9.66	
103	3	67.89		23		31.2		1.96		2.75		7.52	
104	3	32.56		9.63		6.32		2.13		3.89		4.72	
105	3	70.24		61.01		32.88		18.35		18.07		16.27	
106	3	68.76		58.5		37.38		22.5		33.12		20.06	
107	3	25.8		7.14		9.93		12.83		8.34		13.63	
108	3	76.13		56.27		42.14		14.31		32.44		22.23	
109	3	55.94		29.25		15.25		3.83		5.78		3.78	
110	3	44.74		28.82		4.32		0		2.82		0	
111	3	29.38		30.77		35.29		28.12		27.2		17.04	
112	3	81.32		55.76		30.2		7.82		8.23		4.23	
113	3	50.49		30.1		35		5.27		19.2		7.52	
114	3	78.08		32.16		18.48		5.6		21.89		0.8	
115	3	80.62	80.45	69.45	69.73	26.36	26.11	3.77	3.69	14.07	14.57	3.57	3.43
116	3	62.8		52.12		30.23		20.91		15.45		30.28	
117	3	30.69		10.66		8.45		2.92		0		0.84	

Appendix 14 – VAS data from questionnaire for images with a lateral spacing

ID	Group	LS 0.5		LS 1		LS 1.5		LS 2		LS 2.5		LS3	
1		20a	20b	21a	21a	12a	12b	24a	24b	2a	2b	23a	23b
117	3	30.69		10.66		8.45		2.92		0		0.84	
118	3	48.88		31.35		23.22		16.76		23.95		15.19	
119	3	29.52		28.76		2		8.06		2.24		6.86	
120	3	62.06	62.16	47.2	47.39	38.06	37.99	24.92	24.98	49.01	48.86	27.26	27.33
121	3	53.41		38.98		32.38		16.85		20.63		18.38	
122	3	60.1		19.66		12.34		3.54		1.54		4.76	
123	4	90.88		86.62		40.8		52.75		21.68		52.17	
124	4	39.59		43.32		25.38		22.49		12.39		24.05	
125	4	40.96		11.73		6.43		2.63		10.58		8.06	
126	4	87.53		50.08		44.21		13.96		28.96		16.11	
127	4	17.31		5.17		2.86		0		13.15		0	
128	4	49.74	49.89	19.95	20.03	26.08	25.99	2.15	2.11	4.19	4.24	15.98	16.07
129	4	35.15		29.64		22.41		12.1		10.35		13.77	
130	4	41.19		12.36		24.78		4.11		1.72		2.63	
131	4	86.41		73.27		35.96		10.97		11.67		10.97	
132	4	88.58		73.96		47.25		34.12		29.76		31.68	
133	4	83.79		63.25		12.65		5.46		50.01		0.99	
134	4	94.15		74.97		50.83		29.13		29.54		48.39	
135	4	25.73		23.8		17.82		0		1.61		0	
136	4	53.53		26.71		22.08		4.87		4.51		12.98	
137	4	71.71	71.7	22.69	22.81	12.62	12.78	2.66	2.58	7.11	6.93	0.53	0.48
138	4	65.47		32.89		22.07		26.33		24.09		13.04	
139	4	60.85		54.17		41.36		37.4		56.85		42.73	
140	4	78.27		53.63		23.81		5.78		21.52		8.87	
141	4	69.25		48.5		15.5		10.93		26		6.12	
142	4	71.73		50.65		12.01		8.78		21.06		5.05	

Appendix 14 – VAS data from questionnaire for images with a lateral spacing

ID	Group	LS 0.5		LS 1		LS 1.5		LS 2		LS 2.5		LS3	
1		20a	20b	21a	21a	12a	12b	24a	24b	2a	2b	23a	23b
142	4	71.73		50.65		12.01		8.78		21.06		5.05	
143	4	67.58		55.83		54.66		28.42		36.61		38.26	
144	4	26.62		3.92		2.62		8.47		5.49		3.62	
145	4	54.78		22.88		2.88		6.28		21.1		18.29	
146	4	13.81		5.92		1.61		5.44		5.27		4.3	
147	4	72.37		65.2		60.05		42.01		22.26		40.58	
148	4	29.9		23.61		25.27		14.49		18.56		1.64	
149	4	55.2	55.26	30.09	29.95	31.03	31.04	31.76	31.76	50.24	50.2	27.79	27.75
150	4	59.31		22.47		5.62		15.96		6.92		4.88	
151	4	75.63		54.28		17.51		24.78		18.22		18.31	
152	4	26.48		29.51		9.73		11.56		0		22.96	
153	4	23.09		9.69		7.75		3.59		2.31		1.88	
154	4	71.91		19.37		42.84		27.48		5		19.48	
155	4	38.61		14.97		14.41		26.39		9.57		14.93	
156	4	71.57		47.75		6.28		24.54		2.9		2.18	
157	4	54.31		37.08		11.6		6.04		18.21		1.38	
158	4	72.19		46.88		26.6		5.3		4.99		9.01	
159	4	53.44		26.31		29.96		5.02		12.77		4.05	
160	4	6.47	6.53	5.07	5.03	2.58	2.71	0.76	0.82	2.17	2.23	0.38	0.43
161	4	50.73		31.13		21.38		5.96		1.18		2.71	

Appendix 14 – VAS data from questionnaire for images with a generalised spacing

ID	Group	GS 0.5			GS 1	GS 1.5		GS 2		GS 2.5			GS 3
1		19a	19b	15a	15b	25a	25b	13a	13b	18a	18b	4a	4b
2	1	59.15		34.33		33.34		27.19		31.19		34.31	
3	1	86.14		80.52		52.35		57.28		53.71		33.37	
4	1	36.02		29.56		14.26		9.23		6.02		7.11	
5	1	91.66		74.03		33.56		40.61		28.29		28.55	
6	1	35.51		26.71		35.22		30.83		33.71		26.44	
7	1	56.22		40.51		31.95		32.66		29.76		20.88	
8	1	95.17	95.21	75.45	75.54	47.94	47.84	43.2	43.08	36.7	36.81	25.21	25.16
9	1	90.6		85.17		6.97		18.99		14.81		11.57	
10	1	7.08		8.14		2.28		5.23		2.9		3.64	
11	1	53.31		24.65		14.89		7.73		11.82		4.87	
12	1	68.17		27.02		17.5		16.01		16.1		15.66	
13	1	93.01		66.76		22.2		22.67		26.25		20.09	
14	1	80		59.71		23.74		28.92		23.84		29.07	
15	1	85.31		79.85		47.57		49.47		42.16		47.31	
16	1	38.67		25		33.13		15.85		16.55		13.98	
17	1	63.24		55.66		31.19		36.87		38.52		42.85	
18	1	20.48	20.46	13.26	13.23	23.89	23.94	5.7	5.79	5.31	5.43	8.42	8.38
19	1	51.28		42.13		10.04		5.69		9.72		4.6	
20	1	56.18		23.04		19.62		17.41		15.89		22.3	
21	1	96.34		63.51		40.11		24.55		12.86		10	
22	1	17.86		5.64		0		0		0.56		0	
23	1	70		35.47		7.18		10.25		21.99		0.97	
24	1	40.04	40	36.22	36.13	11.69	12.14	15.5	15.57	9.73	9.87	0	0
25	1	60.38		55.56		26.61		28.21		29.49		15.42	
26	1	39.23		21.32		20.2		8.32		16.71		15.6	
27	1	76.02		46.25		31.64		29.97		21.24		11.49	
28	1	30.37		21.17		12.33		[illegible]		11.53		7.25	

Appendix 14 – VAS data from questionnaire for images with a generalised spacing

ID	Group	GS 0.5			GS 1	GS 1.5		GS 2		GS 2.5			GS 3
1		19a	19b	15a	15b	25a	25b	13a	13b	18a	18b	4a	4b
57	2	74		38.51		15.04		19.04		8.36		7.52	
58	2	84.75		75.08		21.16		30.17		28.21		5.76	
59	2	59.39		44.96		30.03		33.29		35.93		25.82	
60	2	40.63		41.15		41.42		43.38		25.6		38.44	
61	2	69.62		32.98		16.5		17.33		12.33		2.25	
62	2	46.61		30.94		11.26		15.51		16.06		9.81	
63	2	62.83	62.76	38.64	38.71	32.11	32.36	22.52	22.56	28.89	28.95	14.44	14.35
64	2	83.97		70.36		65.35		61.01		59.48		60.35	
65	2	51.96		58.76		43.28		31.05		37.74		48.96	
66	2	84.4		54.19		53.68		56.89		51.77		53.52	
67	2	37.4		10.56		5.69		6.35		1.84		1.49	
68	2	60.86		48.35		40.42		39.62		31.5		17.25	
69	2	70.69		46.31		33.33		33.94		32.48		24.65	
70	2	74.07		57.67		53.71		42.26		33.38		47.77	
71	2	32.01		25.4		20.24		15.23		7.09		3.6	
72	2	66.01	59.69	55.46	55.41	7.95	8.15	4.35	4.55	4.22	4.06	17.68	17.64
73	2	91.92		86.84		51.29		52.5		52.97		55.56	
74	2	42.63		58.49		51.17		42.06		53.63		25.79	
75	2	72.04		48.65		30.52		24.94		33.98		12.89	
76	2	78.23		55.17		15.51		11.64		22.96		5.34	
77	2	56.18		37.48		26.74		18.2		23.84		0	
78	2	52.16	52.09	40.3	40.43	11.26	11.38	11.68	11.87	5.96	6	1.2	1.35
79	2	35.37		12.03		0.92		7.38		6.66		1.88	
80	2	62.77		49.39		33.83		25.96		24.9		24.85	
81	2	74.19		38.76		13.36		19.43		24.03		22.85	
82	3	54.46		40.94		14.89		20.56		20.31		14.83	
83	3	92.51		14.86		14.45		20.71		7.18		4.23	
84	3	80.37		59.7		28.4		24.28		14.79		2.2	
85	3	81.24		57.62		41.47		26.41		13.89		2.35	
86	3	50.03		28.27		21.39		28.52		16.12		22.35	
87	3	41.77		33		6.58		11.52		15.45		6.94	

Appendix 14 – VAS data from questionnaire for images with a generalised spacing

ID	Group	GS 0.5			GS 1	GS 1.5		GS 2		GS 2.5			GS 3
1		19a	19b	15a	15b	25a	25b	13a	13b	18a	18b	4a	4b
87	3	41.77		33		6.58		11.52		15.45		6.94	
88	3	45.5		33.35		18.98		17.46		26.56		16.87	
89	3	58.48		30.51		33.08		18.52		13.96		7.35	
90	3	35.26		23.5		4.52		2.44		18.65		2.34	
91	3	70.63		47.31		32.15		22.63		28.36		29.26	
92	3	56.75	56.69	52.2	52	42.72	42.81	20.43	20.6	39.79	39.57	14.86	14.79
93	3	75.18		53.06		4.95		2.52		2.62		6.79	
94	3	79.77		62.86		47.13		33.23		35.66		34.09	
95	3	82.83		73.33		56.9		53.91		47.09		32.58	
96	3	67.16		52.08		47.01		42.24		52.86		40.24	
97	3	53.71		15.25		11.47		13.81		2.93		2.67	
98	3	54		36.1		19.19		10.22		16.97		2.17	
99	3	43.4		32.64		29.09		17.52		15.08		14.49	
100	3	49.9	50.11	26.84	26.8	18.75	18.36	19.46	19.53	12.96	12.88	7.93	8.04
101	3	61.51		42.92		16.13		26.21		15.27		5.78	
102	3	42.98		27.1		12.61		12.98		17.77		10.72	
103	3	62.43		20.73		5.39		23.02		12.41		0	
104	3	29.18		8.65		3.93		5.95		4.17		12.19	
105	3	72.05		63.19		32.44		26.35		27.62		22.19	
106	3	90.63		55.25		20.84		10.4		18.21		25.11	
107	3	92		13.94		7.76		8.84		14.51		6.67	
108	3	68.15		45.49		19.92		25.09		20.5		17.98	
109	3	25.08		13.75		1.57		15.65		5.45		1.69	
110	3	29.18		6.84		0		0		0		0	
111	3	46.23		37.46		36.45		20.2		9.78		23.99	
112	3	88.15		61.79		39.99		14.76		8.09		2.95	
113	3	45.78		27.96		20.28		13.67		15.26		16.2	
114	3	62.12		23.16		6.91		3.27		7.92		5.19	
115	3	91.39	91.51	74.22	74.2	24.64	24.67	8.56	8.27	6.5	6.28	3.7	3.66
116	3	66.12		57.79		32.15		27.38		18.22		23.76	
117	3	26.05		8.15		2.68		4.73		6.24		6.35	

Appendix 14 – VAS data from questionnaire for images with a generalised spacing

ID	Group	GS 0.5			GS 1	GS 1.5		GS 2		GS 2.5			GS 3
1		19a	19b	15a	15b	25a	25b	13a	13b	18a	18b	4a	4b
117	3	26.05		8.15		2.68		4.73		6.24		6.35	
118	3	53.45		33.04		24.31		18.1		27.46		15.15	
119	3	18.52		8.12		3.3		0		4.35		2.51	
120	3	58.33	58.2	42.26	42.2	24.78	24.84	31.75	31.6	25.39	25.37	33.62	33.58
121	3	55.08		43.87		31.8		30.57		30.61		13.7	
122	3	69.25		30.35		19.28		3.14		12.41		1.65	
123	4	94.74		71.39		54.67		46.8		50.3		30.45	
124	4	51.36		40.53		16.08		24.67		26.32		13.61	
125	4	46.79		20.2		15.91		10.51		10.6		10.18	
126	4	97.57		86.25		71.59		28.62		15.1		21.52	
127	4	16.56		7.8		2.72		3.77		0		0	
128	4	60.29	60.12	41.63	41.72	31.42	31.32	36.68	36.68	9.82	9.67	13.49	13.21
129	4	32.11		27.17		4.49		14.55		18.62		14.72	
130	4	36.26		10.26		7.96		6		18.43		9.39	
131	4	79.5		35.69		12.17		11.8		11.74		0	
132	4	73.48		50.19		34.45		26.26		26.5		15.88	
133	4	88.01		70.89		15.47		28.3		11.43		21.06	
134	4	80.38		60.24		36.13		20.97		30.48		17.06	
135	4	20.21		18.66		0		0		0		0	
136	4	49.53		22.66		4.22		2.69		20.85		3.18	
137	4	65.29	65.21	20.54	20.61	3.15	3.31	6.88	6.89	2.08	2.14	2.02	2.11
138	4	66.19		35.58		23.22		10.26		12.56		3.14	
139	4	65.99		58.09		45.33		38.88		39.93		49.66	
140	4	70.13		46.2		12.51		4.78		27.13		20.19	
141	4	75		57.25		16.75		5.5		10.5		6.5	
142	4	75.89		59.32		23.35		21.87		15.22		3.08	

Appendix 14 – VAS data from questionnaire for images with a generalised spacing

ID	Group	GS 0.5			GS 1	GS 1.5		GS 2		GS 2.5			GS 3
1		19a	19b	15a	15b	25a	25b	13a	13b	18a	18b	4a	4b
142	4	75.89		59.32		23.35		21.87		15.22		3.08	
143	4	50.05		39.35		29.05		48.78		43.54		37.85	
144	4	52.13		36.33		33.75		2.8		3.59		3.73	
145	4	57.93		27.02		8.27		12.39		7.14		19.32	
146	4	17.22		7.51		3.64		1.29		1.29		1.67	
147	4	69.26		59.22		49.54		38.54		33.98		23.78	
148	4	31.69		24.79		25.6		24.1		14.94		19.36	
149	4	49.59	49.75	24.05	24	16.96	17.02	0	0	13.99	13.87	17.91	18.04
150	4	63.15		27.67		12.97		5.98		9.15		1.32	
151	4	77.38		57.84		33.65		17.87		33.6		16.1	
152	4	19.25		27.51		3.36		0		18.98		2.52	
153	4	10.92		3.76		0		2.32		2.32		0.58	
154	4	33.32		10.1		4.93		6.82		5.96		3.74	
155	4	35.38		10.53		8.35		12.09		7.62		6.22	
156	4	73.36		49.24		8.06		0.88		2.11		0.83	
157	4	48.7		32.27		3.12		2.85		6.08		5.92	
158	4	51.82		33.11		6.18		13.83		7.51		4.35	
159	4	49.95		22.4		7.41		20.86		12.82		7.12	
160	4	5.16	5.23	3.02	3	0.66	0.68	1.19	1.37	0.93	0.86	3.32	3.17
161	4	46.23		27.15		9.77		9.73		10.6		5.8	

Appendix 15 – VAS data of 10% of participants who repeated the questionnaire. Results for images with no spacing

ID	Group	Qual	Gender	Ethnic Gp	Age	Country of P	Do you provi	No Spacing	
								1a	1b
16	1	1	2	1	33	1	.	89.59	96.19
31	1	3	2	5	38	1	.	93.18	92.59
19	1	2	1	1	30	2	.	80.9	86.01
34	1	2	2	1	42	1	.	99.59	100
78	2	2	1	3	30	1	2	93.86	89.18
52	2	2	1	3	29	1	1	82.29	76.55
66	2	2	1	3	27	1	2	95.63	91.95
56	2	1	2	3	25	1	2	97.41	100
87	3	.	1	3	23	.	.	75.29	93.13
102	3	.	2	3	22	.	.	61.73	80.99
110	3	.	2	3	28	.	.	100	98.35
119	3	.	1	1	19	.	.	100	92.72
153	4	.	2	1	16	.	.	83.35	96.75
132	4	.	1	1	14	.	.	67	94.03
148	4	.	1	3	12	.	.	84.49	90.33
134	4	.	2	1	16	.	.	96.43	88.26

Appendix 15 – VAS data of 10% of participants who repeated the questionnaire. Results for images with a midline diastema

ID	Group	MD 0.5		MD 1		MD 1.5		MD 2		MD 2.5		MD 3	
		2a	2b	3a	3b	4a	4b	5a	5b	6a	6b	7a	7b
16	1	85.3	59.41	75.84	36.87	78.7	33.46	68.47	34.64	56.5	34.64	47.59	31.45
31	1	86.42	88.37	24.63	90.94	33.38	78.93	35.25	77.53	14.74	43.61	21.48	29.65
19	1	73.39	79.11	71.86	77.46	65.08	59.78	64.13	68.12	69.94	48.72	62.46	39.66
34	1	67.16	81.86	41.94	41.45	27.54	46.28	26.78	38.41	39.28	15.54	27.54	27.48
78	2	54.14	55.62	47.05	26.76	42.62	7.77	32.85	19.16	12.02	13.93	23.88	8.85
52	2	94.07	79.88	86.82	63.26	71.94	52.66	56.68	48.61	58.98	31.66	66.02	36.73
66	2	63.99	64.31	45.53	49.54	37.04	38.95	39.4	39.8	16.35	27.02	34.69	33.89
56	2	73.42	55.87	57.58	10.13	26.12	8.95	25.28	10.69	26.12	8.19	19.25	5.23
87	3	81.4	21.23	39.45	27.11	30.65	4.36	22.36	6.9	16.04	3.11	43.94	10.65
102	3	56.11	65.04	66.98	65	46.87	30.51	39.53	30.23	30.88	16.6	39.43	40.77
110	3	89.48	94.45	91.26	98.1	94.86	81.91	65.84	73.06	50.04	2.16	32.27	7.78
119	3	66.9	67.78	22.22	52.94	18.78	36.47	8.91	45.03	30.87	36.37	0	23
153	4	48.79	50.02	19.61	27.91	28.66	12.49	15.29	23.05	25.68	49.58	12.57	13.92
132	4	95.57	91.61	80.04	90.79	69.35	67.02	76.74	38.71	38.51	71.46	57.02	50.58
148	4	66.67	76.39	35.73	76.39	30.88	59.12	35.62	48.33	28.19	41.5	29.15	33.46
134	4	85.93	67.92	89.87	48.68	88.29	52.17	77.13	51.07	69.2	51.15	63.03	49.03

Appendix 15 – VAS data of 10% of participants who repeated the questionnaire. Results for images with a lateral diastema

ID	Group	LD 0.5		LD 1		LD 1.5		LD 2		LD 2.5			LD 3
		8a	8b	9a	9b	10a	10b	11a	11b	12a	12b	13a	13b
16	1	83.29	46.6	54.8	46.6	42.63	32.46	37.7	22.43	37.24	31.91	48.87	25.39
31	1	77.09	82.31	29.38	53.15	24.33	49.05	19.21	41.69	21.89	37.09	9.1	38.21
19	1	66.2	71.26	31.66	41.59	28.51	39.95	24.63	29.46	25.27	35.58	24.36	28.89
34	1	79.6	64.31	34.83	36.6	24.43	29.66	19.62	24.25	28	29.96	25.45	20.79
78	2	41.17	18.84	14.68	19.96	11.12	16.79	9.46	10.92	11.5	3.79	4.63	0.79
52	2	77.73	64.6	69.61	48.42	60.71	45.4	54.35	43.76	48.28	39.15	34.84	25.35
66	2	55.17	38.3	18.43	32.7	15	25.72	13.2	22.13	6.36	11.94	1.21	20.1
56	2	69.19	11.85	55.12	24.32	53.88	17.71	36.24	11.55	26.13	11.15	28.95	4.5
87	3	86.03	72.53	47.83	29.65	32.98	12.53	8.56	4.72	10.01	8.23	25.2	1.67
102	3	65.54	77.64	49.67	40.36	43.26	34.91	30.76	23.87	30.87	14.29	21.31	17.25
110	3	91.57	89.82	83.74	27.3	79.82	15.53	29.12	1.95	1.81	3.59	6.38	3.51
119	3	63.43	70.15	26.66	46.78	25.37	26.37	23.76	28.4	18.68	21.39	5.06	19.83
153	4	67.65	57.25	33.61	37.11	23.36	21.46	11.37	21.14	9.86	19.62	19.23	21.1
132	4	91.93	92.55	76.54	82.86	70.41	73.95	61.6	64.75	50.22	54.72	49.65	50.92
148	4	50.84	61.73	30.29	37.89	30.25	34.09	30.38	35.77	14.74	22.1	27.64	23.56
134	4	85.91	35.9	84.74	46.54	81.96	35.84	79.25	37.2	64.28	30.51	48.66	31.63

Appendix 15 – VAS data of 10% of participants who repeated the questionnaire. Results for images with lateral spacing

ID	Group	LS 0.5		LS 1		LS 1.5		LS 2		LS 2.5		LS3	
		14a	14b	15a	15b	16a	16b	17a	17b	18a	18b	19a	19b
16	1	88.57	45.31	63.45	32.64	47.65	33.79	19.75	15.12	15.85	21.47	17.14	26.75
31	1	81.41	76.83	26.64	59.12	24.74	41.17	2.89	7.22	7.28	32.94	1.57	7.82
19	1	63	64.57	43.87	39.61	28.06	47.02	18.53	19.63	23.28	22.36	19.44	24.5
34	1	78.93	80.91	59.17	64.31	18.36	40.66	18.75	23.23	24.83	8.59	22.77	16.77
78	2	47.39	39.42	18.33	29.55	18.96	3.6	1.08	4.3	2.98	5.28	1.31	2.75
52	2	85.95	69.98	75.27	53.3	35.57	50.11	37.79	29.45	37.43	34.26	24.43	13.39
66	2	35.69	24.19	15.38	12.72	2.95	11.72	4.97	0.86	4.11	16.73	2.63	0.83
56	2	84.32	80.22	69.09	56.34	34.13	11.24	24.37	6.4	20.35	9.39	10.52	0.76
87	3	69.59	8.94	51.45	7.24	21.01	1.99	4.26	0.79	0	2.73	1.51	6.59
102	3	62.09	30.15	36.32	8.8	18.67	29.28	21.95	1.28	13.53	3.17	9.66	3.46
110	3	44.74	96.76	28.82	55.16	4.32	1.13	0	0.8	2.82	0.75	0	0
119	3	29.52	57.77	28.76	46.43	2	21.75	8.06	21.58	2.24	32.89	6.86	14
153	4	23.09	18.79	9.69	4.68	7.75	5.51	3.59	15.64	2.31	25.14	1.88	3.12
132	4	88.58	66.07	73.96	49.67	47.25	58.96	34.12	26.4	29.76	39.08	31.68	44.7
148	4	29.9	40.4	23.61	37.75	25.27	31.24	14.49	26.88	18.56	25.12	1.64	10.36
134	4	94.15	31.5	74.97	34.58	50.83	38.03	29.13	28.56	29.54	14.84	48.39	24.89

Appendix 15 – VAS data of 10% of participants who repeated the questionnaire. Results for images with generalised spacing.

ID	Group	GS 0.5			GS 1	GS 1.5		GS 2		GS 2.5			GS 3
		20a	20b	21a	21b	22a	22b	23a	23b	24a	24b	25a	25b
16	1	80	25.4	59.71	31.69	23.74	22.81	28.92	33.27	23.84	21.14	29.07	26.65
31	1	76.01	54.73	20.48	22.65	11.11	2.49	1.88	13.04	2.9	12.6	1.75	16.39
19	1	56.18	57.51	23.04	51.8	19.62	40.11	17.41	41.13	15.89	16.56	22.3	19.18
34	1	83.01	47.46	61.13	35.95	21.25	33.49	22.76	29.13	24.53	15.17	11.66	1.1
78	2	35.37	94.52	12.03	28.3	0.92	3.21	7.38	1.96	6.66	2.81	1.88	2.21
52	2	90.53	74.17	61.59	45.79	36.17	27.05	37.35	40.45	35.04	27.02	24.95	10.94
66	2	37.4	26.87	10.56	15.66	5.69	6.57	6.35	3.86	1.84	3.9	1.49	1.94
56	2	74	75.03	38.51	44.12	15.04	11.4	19.04	3.89	8.36	4.33	7.52	1.19
87	3	41.77	13.32	33	4.76	6.58	1.13	11.52	3.75	15.45	3	6.94	2.46
102	3	42.98	15	27.1	6.57	12.61	3.28	12.98	11.74	17.77	2.56	10.72	1.09
110	3	29.18	10.47	6.84	5.76	0	0.42	0	0	0	8.98	0	0
119	3	18.52	34.51	8.12	11.59	3.3	17.59	0	19.75	4.35	7.72	2.51	27.03
153	4	10.92	1.15	3.76	2.03	0	16	2.32	1.03	2.32	1.33	0.58	4
132	4	73.48	54.75	50.19	26.22	34.45	30.05	26.26	17.11	26.5	2.8	15.88	16.13
148	4	31.69	43.19	24.79	37.12	25.6	28.64	24.1	28.26	14.94	25.05	19.36	21.05
134	4	80.38	31.16	60.24	32.57	36.13	26.52	20.97	34.28	30.48	35.49	17.06	27.72

Appendix 16 – Intra class correlation coefficient score for intra – rater reliability

Image	ICC	R Squared
No Spacing	0.37	0.67
0.5mm Midline Diastema	0.37	0.67
1.0mm Midline Diastema	0.32	0.65
1.5mm Midline Diastema	0.48	0.73
2.0mm Midline Diastema	0.47	0.72
2.5mm Midline Diastema	0.31	0.64
3.0mm Midline Diastema	0.53	0.75
0.5mm Lateral Diastema	0.33	0.65
1.0mm Lateral Diastema	0.32	0.64
1.5mm Lateral Diastema	0.24	0.6
2.0mm Lateral Diastema	0.58	0.78
2.5mm Lateral Diastema	0.13	0.85
3.0mm Lateral Diastema	0.49	0.73
0.5mm Lateral Spacing	0.27	0.62
1.0mm Lateral Spacing	0.4	0.68
1.5mm Lateral Spacing	0.63	0.8
2.0mm Lateral Spacing	0.66	0.82
2.5mm Lateral Spacing	0.34	0.66
3.0mm Lateral Spacing	0.76	0.87
0.5mm Generalised Spacing	0.39	0.68

1.0mm Generalised Spacing	0.52	0.75
1.5mm Generalised Spacing	0.73	0.86
2.0mm Generalised Spacing	0.69	0.84
2.5mm Generalised Spacing	0.62	0.8
3.0mm Generalised Spacing	0.56	0.71

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