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Principles and techniques of applied behaviour analysis for the management of anxiety related behaviour in children's dentistry

Coxon, James David

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**Principles and Techniques of Applied Behaviour Analysis for the
Management of Anxiety Related Behaviour in Children's Dentistry.**

This thesis is submitted as partial fulfilment for the degree of Doctor of
Philosophy
(PhD)

James Coxon

King's College London, Dental Institute

2019

DEDICATION

This thesis is for my wife, son and parents, because without your support I would not have been able to accomplish this.

Acknowledgement

This work would not have been possible without the generous help of my supervisors. My first supervisor, Professor Tim Newton, has offered great support throughout this process and I feel genuinely honoured to have worked under his guidance. His knowledge of psychology has not only helped guide me in my subject matter but steered me through the many rough times one goes through while undertaking a PhD. I started this journey in a meeting with Tim, stating a grand ambition that I wanted to make a difference in the treatment of our paediatric patients. In a small way, I hope we have achieved this.

My second supervisor, Professor Marie Therese Hosey has always been available for support and to keep Tim and myself from launching into behaviourist jargon. Thank you M.T. Your guidance and common sense have been truly appreciated.

Additional thanks go to Professor Lucy Di-Silvio, my coordinator, for her advice and support.

Many thanks go out to my cohort of postgraduate dentists whom I supervised. They allowed me to interrupt their sessions and put up with my endless talk of behaviour. I am also grateful to all the specialist paediatric dentists in the UK who completed our questionnaire.

Abstract

Patient management is a cornerstone of paediatric dental treatment. Applied Behavioural Analysis (ABA) provides an effective framework to develop small scale studies to research the effectiveness of behavioural interventions.

Aim

To explore the current status of ABA in children's dentistry and determine how it might be implemented.

Objectives

- i) To determine the impact of dental anxiety on children's oral health in the UK population at the age of 5, 8, 12 and 15 years.
- ii) To conduct a structured review of the published paediatric dental literature which has adopted ABA.
- iii) To determine the level of knowledge of the principles of ABA among specialist paediatric dentists in the UK
- iv) To determine the feasibility of adopting an ABA technique (reinforcer choice) in a paediatric dental setting.

Method

This project takes the form of two parts.

Part 1

ABA methodology requires that the target behaviour is deemed to have a detrimental effect on the individual or be socially significant.

Therefore part 1 looked to establish if dental anxiety in children predicted a worse health outcome. This was completed via a secondary and regression analysis of data from the 2013 Child Dental Health Survey, including children aged 5, 8, 12 and 15 years.

Part 2

To establish if ABA has the potential to be of use in resolving children's dental anxiety and uncooperative behaviour.

This takes the form of

- i) A structured review of published ABA literature related to paediatric dentistry.
- ii) A survey regarding the knowledge of ABA among specialist paediatric dentists in the UK.
- iii) Cross sectional study of children's reward choices.

Results

Part 1

i) Dental anxiety was associated with worse health in children in this population group. Dental anxiety predicted poorer oral health in 5 and 8 year olds, but not in 12 and 15 year olds. Dental anxiety predicted a detrimental effect on family life in younger children and a negative effect on everyday life of older children.

Part 2

i) Nineteen studies met the criteria for a published ABA study relating to paediatric dentistry. The majority of papers reported studies reported on interventions involving a small number of participants, typically at the age of 8 years or under. The study design was typically multiple baselines across subjects. Behaviours studied included disruptive behaviour in the dental surgery, digit sucking, bruxism, dietary choices, and interproximal cleaning. Interventions were mainly contingency management.

ii) Dentist's knowledge of ABA - Participant's mean knowledge score was 38%, range 0 to 75%.

iii) The children's reward choice study showed that there was no clear preferred reward common to all children, and no child preferred a "sticker" as a reward. Approximately 35% of carers agreed with the child's choice, with significant differences in levels of agreement between child and carer across the age groups.

Conclusions

Part 1 suggests that dental anxiety, in this population group, is a socially significant problem that leads to a worse health outcome. Many of the recommended non-pharmacological behavioural techniques to manage dental anxiety are based on principles of behavioural psychology. While the structured review in Part 2 highlighted a small number of papers that used of ABA to help children cope with dental treatment, further research needs to be completed to further support its use. Our study on reinforcer preference of children under the age of 8 years demonstrates that ABA can be used to challenge existing norms as well as develop new innovative techniques.

However, as evidenced by the results of the questionnaire survey, at present paediatric dentists in the UK do not have the requisite knowledge to implement effective ABA strategies. If this can be rectified, with the increasing emphasis on evidence-based approaches to dentistry including methods of behaviour change, ABA may be a valuable tool to the provision of innovative behavioural interventions to help dentally anxious young children cope with dental treatment.

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Chapter 1 – Introduction and Literature Review

1.1 Why choose to look at the management of paediatric dental anxiety? A personal perspective.

A few years prior to commencing this thesis, I was struggling in my professional life, working as a community dentist in the South Wales Valleys. The behavioural management of dentally anxious children referred to me for treatment was a constant source of frustration. The undergraduate teaching I had gained at university had left me woefully unprepared for such a situation. Having failed to gain co-operation in the rather vague “acclimatisation” visit, I was quickly reaching for the general anaesthetic referral form. However, my long-standing interest in behavioural psychology left me feeling that there must be a better, more evidenced based approach to help a young child cope with dental treatment. This led me to commence this project, looking to establish the value of interventions based on behavioural psychology (and the associated science of Applied Behavioural Analysis) to help young dentally anxious children cope with the stress of dental treatment.

1.2 An overview of the thesis.

Behavioural management of paediatric dental patients is vital for gaining co-operation in the dental surgery, especially in the management of anxious patients. This chapter will provide a summary of the current literature regarding dental anxiety in the paediatric population, review the current guidelines on the non-

pharmacological management of anxious children attending the dentist, and introduce the concept of Applied Behavioural Analysis (ABA).

This thesis will take the form of accepted and published peer reviewed papers. The overall research questions are;

Part 1) Does a child's dental anxiety lead to a worse health outcome?

The first step of ABA methodology is to establish if the individual's behaviour is *socially significant*. That is, the behaviour being investigated must have immediate importance to the individual or society (Baer 1968). Therefore, it is vital to establish if dental anxiety (and the associated undesired behaviours, such as disruptive behaviour in the dental chair) is a socially significant problem for children. To this end, chapters 3 to 6 will take the form of accepted and published peer reviewed manuscripts which will analyse data from the Child Dental Health Survey 2013 (CDHS) to attempt to establish if dental anxiety predicts worse oral health and factors relating to oral health in children aged 5, 8, 12 and 15 years.

Part 1 will be supported by a preface, stating the benefits and limitations of using the data gathered from the CDHS, a detailed description of the methodology used and the rationale for following this method. A detailed discussion of the results will also be included.

Part 2) Does ABA have the potential to be of use in managing the behaviour of dentally anxious children in the surgery?

This question can be broken down into the following;

a) How has ABA been utilised by the dental profession previously in the management of paediatric dental patients? This is presented in chapter 7 as a published, peer reviewed, structured literature review of ABA and paediatric dentistry. This article is prefaced with appropriate supporting material which gives a more detailed description of the review's methodology, an in-depth critique of the papers chosen, and a full description of the review's limitations.

b) Does the profession have the requisite knowledge of behavioural psychology and ABA to implement its methodology effectively?

To choose and implement an intervention effectively, one must have good underlying theoretical knowledge. Theoretical knowledge also allows one to self-reflect and look for areas where improvement is possible in the future.

As most recommended non pharmacological management techniques for young children are based on principles of behavioural psychology, chapter 8 investigates the current level of knowledge that the profession has regarding behavioural psychology. This again takes the form a published peer reviewed manuscript with appropriate supporting material.

c) When considering the use of ABA, should we first challenge "accepted norms" utilised in paediatric dentistry? Chapter 9 seeks to challenge the preconceived notion that children are likely to find stickers a salient reward in the dental surgery. This chapter again takes the form of a peer reviewed manuscript with appropriate supporting material.

This will be followed by a discussion that looks to find the common themes of this thesis, answer the overall research questions and suggest a suitable direction to move this research forwards in the future.

1.3 Dental anxiety in the paediatric dental patient.

Dental anxiety and disruptive behaviour in children are closely linked. Such disruptive behaviour is difficult for the dental team to manage and can inhibit a child's ability to have much needed dental treatment (Moore and Brodsgaard 2001). Fear of dental treatment can often result in delayed attendance and disruptive behaviour and as a result the most anxious children often require invasive dental treatment (Nuttall et al 2008). For example, the Children's Dental Health Survey reported that 21% of children judged themselves to have moderate to extreme anxiety related to dentistry (Children's Dental Health Survey Report 1) and studies suggest that between 20% to 25% of children show disruptive problems at the dentist (O'Callaghan et al 2006). While the prevalence of dental fear and anxiety has been widely studied in a variety of cultures, there is scarce research that looks at the impact of dental phobia on the oral health of children or the psychological impact on the individual and family life.

As mentioned in section 1.2, to establish the validity of ABA methods to improve patient behaviour and decrease paediatric dental anxiety, it is first vital to show that dental anxiety impacts on the oral health of paediatric patients.

1.3.1 Definitions of dental fear, anxiety and phobia

The terms dental fear and dental anxiety are often used interchangeably. This can be defined as an individual having a feeling of dread that something will happen in

relation to dentistry, combined with a sense of losing control (Klingberg and Broberg 2007). This response has been documented in a wide variety of cultures (Armfield et al 2006, Hakeberg et al 1992 , Milgrom et al 1988).

Dental phobia is viewed as a “step up” in terms of the grading of fear. This is defined by the Diagnostic and Statistical Manual of Mental Disorders (DSM–V) as a specific phobia that is

“ severe and out of proportion fear within a certain context to the presence or anticipation of a specific object or situation, (ii) the subject becomes immediately anxious following exposure to the stimuli. This may take the form of a situationally bound or situationally predisposed panic attack, (iii) the person is able to understand that the reaction is out of proportion, (iv) the subject avoids the situation or endures it with intense distress. (v) the subject’s reaction to the fearful stimulus interferes significantly with the person's everyday life.” (Diagnostic and statistical manual of mental disorders (Fifth Edition) 2013).

Dental anxiety, even in a mild form, can lead to profound behavioural management problems in children (Klingberg and Broberg 2007). Children are likely to become non-compliant when faced with novel stimuli, are subjected to an aversive stimuli such as pain or discomfort, or are not allowed to escape from potential threat. As a result, the non-co-operation of children often leads to a profound challenge for the profession.

1.3.2 Reported prevalence of dental fear/anxiety among children.

The prevalence of dental fear in children has been widely studied in different cultures and among different socio-economic groups. Despite the considerable

number of studies undertaken, the reported figures are extremely wide ranging with even structured review articles struggling to find a narrow range. For example, estimates of prevalence ranged from 5.7% to 20.6% in a review of 19 studies by Klingberg and Broberg (2007).

These diverse results may be explained by cultural differences affecting reported dental anxiety, the methodology and sampling method used, whether the dental anxiety was self-reported or gathered via a proxy report and the measure used to rate the degree of anxiety.

The differences in the prevalence of dental anxiety is noted, not only across different countries, such as comparing child populations in the USA to China (Morgan et al 1980, Milgrom et al 1994), but across different population groups in the same geographical area. For example, Christian children tended to report more dental anxiety than Muslim children in an African population (Ingram et al 1999).

In the UK there are no accepted figures on the prevalence of dental anxiety. A survey of Scottish children, of 13 and 14 years of age, suggested 7.1% of children reported high levels of dental anxiety (Bedi et al 1992). A review of the Child Dental Health Survey 2003 reported that dental anxiety, sufficient enough to impact on a child's ability to attend the dentist, occurred in three to four percent of cases across the four age ranges of 5, 8, 12 and 15 years (Nuttall et al 2008). This contrast to the latest Child Dental Health Survey in 2013 which reported that 21% of five-year olds and 17% of eight-year-olds suffered from moderate to severe anxiety, while 14% of 12-year-olds and 10% of 15-year-olds stated they had extreme anxiety (Child Dental Health Survey Report 1).

Aside from culture, there are numerous other reasons for these wide-ranging prevalence figures. Firstly, the participants may not represent a true reflection of the population group. For example, the data may be collected from a specialist referral centre for dental anxiety, leading to higher reported prevalence of dental anxiety. As an illustration of this, Bezabih et al (2013) reported 74.1% of children attending a specialist hospital dental clinic in Ethiopia, reported moderate to severe anxiety. Conversely, in epidemiological studies, such as the Child Dental Health Survey, participants who are extremely anxious may not consent to take part, leading to a lower reported prevalence. Also, sampling methods may affect results. For example, children with disabilities and chronic health problems may not be included in the data collection, despite making up a sizeable proportion of the overall population group (Klingberg 2013).

Secondly, if another party rates the child's anxiety, it may well not be a true reflection of the child's actual fear. For example, in children aged between 7 to 16 years attending two community clinics in Scotland, Patel et al (2015) demonstrated a poor correlation between self-reported dental anxiety and the parent's estimate of the child's dental anxiety. This may be due to the child showing behavioural problems at the dentist that is not motivated by fear associated specifically with the dental environment. The observer may attribute this to anxiety. Conversely, a group of children may be co-operative at the dentist but not show any of their inner fear. If the dental fear of younger children is assessed and reported by the parent, their reported fear may just reflect their own fear (Themessl-Huber et al 2010). The dental team are also unlikely to accurately score dental anxiety in the child patient, with previous studies only suggesting a low to moderate agreement between dentist and child anxiety ratings (Buchanan and

Niven 2003, Barros and Buchanan 2011). As a result, proxy measures of a child's dental anxiety are often said to lack accuracy (Gustafsson et al 2010).

Thirdly, even if the level of dental anxiety is self-reported, there is no universal measure in accepted use. Porritt et al (2013) completed a systematic review of current measures for assessing children's dental anxiety. The studies were reviewed and assessed in terms of validity, reliability and if specific aspects of dental anxiety (using the Five Areas Model as a template). The results are summarised in table1 below relating to the nine measures reviewed.

Table 1 – Summary of self reported measures of anxiety as reported by Porritt et al 2012.

Measure	Features	Pros	Cons
Children's fear survey schedule dental subscale CFSS-DS (Cuthbert 1982)	Children asked to rate anxiety regarding 15 situations related to dentistry.	- High reliability - Established cut off points to distinguish non anxious and anxious - Used over a wide age range.	-Does not assess contributing physical reactions, thoughts or behaviours -Lacks specificity of language. -No evidence that children involved in development of questionnaire. - Format of measure has been changed making comparison difficult
Dental fear schedule subscale short form DFSS -SF (Carson and Freeman 1997)	Shorter version of CFSS-DS Child ask to rate anxiety regarding 8 situations related to dentistry	- High reliability - Shorter than CFSS-DS so quicker to complete. - More specific to dental environment compared to CFSS-DS	Does not assess contributing physical reactions, thoughts or behaviours
Dental anxiety scale (DAS) and modified DAS (MDAS) (Corah 1969)	Four (DAS) or five (MDAS) items Choice of series of responses to different dental situations Picture elements incorporated in some instances	High reliability	- Developed for adults; may be inappropriate for children. - No validity with child participants. - No assessment of unhelpful thoughts or behaviours.

Table 1 continued

Measures	Features	Pros	Cons
Smiley faces programme (SFP) (Buchanan 2005) and revised SFP (Buchanan 2010)	Computerized measures including items from MDAS Seven item facial image scale SFP requires response to four different dental scenarios Revised SFP included one more scenario	Developed with children.	Relies on computer access Not assessment of unhelpful behaviours, thoughts and physical reactions.
Short version of dental anxiety inventory (S-DAI) (Aartman, 1998)	Nine items with respondent required to show level of agreement with a number of statements related to dentistry	Examines response to different triggers of dental related anxiety. Assesment of physical reactions, thoughts and behavioural aspects of dental anxiety.	May not be suitable to child friendly No reliability measures and validity estimates for child population group.

Poritt et al (2013) suggested any measure should be short in length, suitable for a wide age range, examine a participant's reaction to a variety of different stimuli and be developed with children.

Al-Namankany et al (2012) reviewed 14 dental anxiety measures and advised that the following criteria should be met for a suitable anxiety measure for children

- 1) should be age appropriate, with the child able to comprehend the questions
- 2) demonstrate reliability in scoring and when retested.
- 3) correlate with other measures such as the dentists' rating of child cooperation
- 4) have a numerical order to allow ranking of fear inducing stimuli

5) children at the age of 6 or above should be assessed for negative cognitions.

Al-Namankany's review suggested no index was deemed to be totally satisfactory and it was noted that no measure was accurately able to estimate what percentage of the population group were anxious or non anxious, due to lacking a formal sample size technique. The majority of samples did not have sufficient validation. For example, the visual analogue scale (Luyk 1988), as used in the Child Dental Health Survey 2013 to measure anxiety in the 5 and 8 year age group was validated by comparing it to the Frankl and Houpt measure, which itself was not validated (Frank et al 1962). In addition, some measures, like the previously mentioned visual analogue scale, only ask in general terms about the child's level of anxiety. There is, therefore, no assessment of the exact nature of the individual child's dental anxiety. Other measures, such as the modified child dental anxiety scale, have this capability by asking a series of questions about anxiety normally associated with dental treatment. However, young children may struggle to use the 5 point scale ranging from "relaxed" to "extremely worried". The addition of 5 faces instead of the 5 point scale attempted to correct this potential issue, but there has been concern raised about this introducing a bias towards the patient being rated as non-anxious (Tickle 2009).

In conclusion, there is wide variation in the estimated prevalence of dental anxiety. The interaction of the above factors undermine the results of the studies undertaken and make it impossible to draw any firm conclusions. As an example, the Child Dental Health Survey 2003 was an epidemiological study whose sampling method did not attempt to correct reporting bias related to dental anxiety. In addition, it utilised an "ad hoc" by proxy measure, where the parent estimated the

child's anxiety in only 50 percent of cases. As a result, the stated dental anxiety prevalence of 3 to 4% is likely to be considerably under-reported, as illustrated when compared to the results from the Child Dental Health Survey 2013. Even the updated methodology of this more recent survey is by no means perfect as outlined in the preface of Part 1.

1.3.3 The aetiology of dental fear

Initial acquisition

The dental environment and dental treatment are full of possible perceived threats and aversive stimuli (Willumsen et al 2013). Firstly, the instruments used in dentistry, such as needles and dental forceps are in themselves threatening. There is a suggestion that we are hard wired to be fearful of items that pierce the skin (Bracha 2006). Secondly, the close proximity of the patient to the dentist impinges on the patient's personal space, which in itself is aversive to many people. Finally, the oral cavity is involved in vital functions, such as providing an airway. It is natural for one to feel protective of this sensitive area.

Therefore, without suitable habituation to dental treatment young children are likely to react with fear when exposed to this environment. However, the majority of older children and adults do not suffer with dental anxiety. As described below, this has led to research in to specific events that leads to individuals developing dental anxiety

Anxiety disorders are often proposed to be as a result of classical conditioning as described by Pavlov (1929). In the dental environment pain is often given as the

example of an unconditioned stimulus that then becomes associated with other stimuli in the dental setting, such as the smell. Indeed, there is evidence to suggest that people with dental anxiety often have memories of painful dental treatment (Berguis et al 1997). However, studies report 48 to 60% of the population have experienced pain at the dentist (Vassend 1993, Armfield 2010) which is far more than the stated figures on dental anxiety prevalence.

It may be the case that people with dental anxiety are more reactive to aversive stimuli or cues that an unpleasant event may occur (Bradley et al 2008). There is also evidence to suggest that phobic individuals report higher pain scores following the event, even though there is no reported differences between non-phobic and phobic groups at the time the pain occurred (Kent 1985).

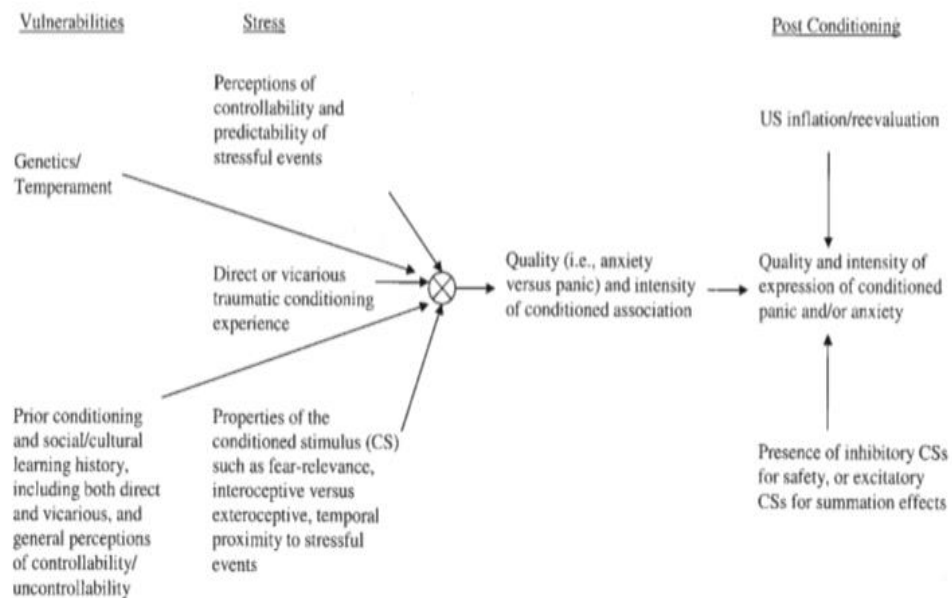
Aside from pain, the patient's lack of control is also stated as a reason for dental anxiety. This has been associated with previous treatment where the patient felt they had limited control of the situation (Logan et al 1991, Milgrom et al 1995). Studies have also suggested that increasing perceived control leads to a decrease in dental fear (Law et al 1994).

Aside from direct conditioning, Rachman (1977) proposed that patients could also acquire dental anxiety from modelling or via instructions or information. There is previous evidence to support this (Holst 1988, Klingberg 1995). However, contemporary models look at variables including genetics, that make certain individuals more likely to develop phobias.

Mineka et al (2006) discussed the acquisition of specific fears and phobias by looking at any vulnerability an individual may have to developing a phobia, what happened at the moment of stress, be it direct or vicarious and if there were

additional stimuli that led to increase or decrease in the anxiety after the event (see figure 1).

Figure 1. Overview of Major Elements Incorporated in Contemporary Learning Models of the Etiology of the Anxiety Disorders, taken from Mineka et al (2006).



Factors that make an individual vulnerable to dental anxiety.

There is some evidence to suggest that there is a hereditary component that makes an individual more likely to develop anxiety disorders, such as a vasovagal response and a low threshold to being alarmed (Page 1998). In addition, certain traits in an individual's temperament are more likely to be seen in children with dental anxiety such as inhibition, shyness and negative emotionality (Klingberg and Broberg 2007). Previous experience can make an individual more or less likely to develop dental anxiety. For example, vicarious learning may occur from a parent who is dental phobic. Conversely a parent who is relaxed and carefree when having dental treatment may immunise the child against developing a phobia. A perception that an individual will have no control over what the dentist does to

them are often encouraged in the media, in both films and even children's books.

Direct conditioning prior to the stressful event can also take place. For example, a previous fear of injections is often associated with dental fear (Poulton et al 1998).

Previous pleasurable associations may immunise the patient against dental anxiety, through latent inhibition (Lubow, 1959).

Factors related to the stressful event.

Direct classical conditioning

Conditioning, as described by Pavlov (1929) can occur very rapidly, leading to a learned fear of dental associated stimuli. In addition this can take place via vicarious learning. For example, an individual watching a brother have a traumatic extraction. In addition, a lack of perceived control and an especially relevant stimuli (for example, something piercing the skin) can lead to a greater association between dental stimuli and anxiety.

Post conditioning

What occurs following the stressful event can also impact on the level of dental fear felt. For example, a further stressful event after the dental visit may lead to inflation of the original fear response (Mineka et al 2006). Re-appraising the visit in a positive light may decrease the fear response, or increase fear if the patient re-appraises in a negative fashion (Chapman and Kirby-Turner 1999). Other previously conditioned stimuli may inhibit the fear response. For example, a calm and supportive dentist and parent.

The further development of dental fear.

Various models have been proposed relating to the development of dental phobia over time (for example, Clark 1986). Many state non-attendance as a factor. For example, Berggren (1984) proposes that the negative cognitions about an individual's own oral health and how they are viewed by others leads to non-attendance, encouraged by the negative reinforcement of avoiding the perceived threat. This leads to the further deterioration of the individual's health.

1.3.4 The relationship of children's dental fear with other factors.

Klingberg and Broberg (2007) reviewed the literature and found the following relationships

- 1) Dental fear has a positive relation with general fear.
- 2) Younger children have more general fear in comparison to older children.
- 3) Younger children tended to experience higher levels of anxiety when exposed to a fear inducing stimuli.
- 4) Children who showed signs of dental fear were more at risk of developing an internalizing disorder, such as depression and loneliness.
- 5) The child's temperament appears to be linked to dental fear if there are traits such as inhibition, shyness and negative emotionality. Behaviour management problems are linked with impulsivity and activity.

1.4 – Managing the anxious child in the dental surgery.

In terms of interventions to help a child cope with dental treatment, the majority of research has concentrated on pharmacological methods. These approaches, such as general anaesthetic will always have a place in paediatric dentistry. Nearly 8,000 children still receive a general anaesthetic for dental treatment in Wales (Child Dental General Anaesthetics in Wales 2015), with the mean age of 5-6 years. However, there is a noted morbidity attached to such procedures, such as distress at induction and after the procedure, nausea, sickness and prolonged bleeding (Bridgeman 1999, Hosey, 2006). Other pharmacological techniques such as inhalation sedation are also indicated for use in young children displaying dental anxiety (Standards of Conscious Sedation in the Provision of Dental Care, RSeng, 2015). Inhalation sedation is widely used both globally (Veerkamp et al 1995) and in the UK (Holroyd 2008). However, whilst this allows successful completion of dental treatment, the evidence base for such techniques altering the underlying behaviour is limited (Matharu and Ashley 2006). In addition, inhalation is not readily used in a general practice setting, and often only available in a secondary care setting (Standards of Conscious Sedation in the Provision of Dental Care, RSeng, 2015).

The limitations of pharmacological techniques have led to an increasing push towards non-pharmacological methods of behaviour control and advice on how they should be used (American Academy of Paediatric Dentistry 2011 and Campbell 2011).

1.4.1 Suggested non-pharmacological techniques

Both the American Academy of Paediatric Dentistry (AAPD 2011) and the British Society of Paediatric Dentistry (Campbell 2011) offer guidelines for managing a child's behaviour in the dental chair. These are outlined in the table below, stating the technique, a brief explanation of the technique and an example of studies outlining the use of these interventions.

Table 2 – Summary of suggested non-pharmacological techniques outlined by the AAPD and BSPD

Management technique	Guideline	Method	Example of study outlining techniques.
Preparatory information	BSPD AAPD	Aimed to decrease parent anxiety via pre-appointment letter to give the family information on the practice prior to the dental visit	Rosengarten (1969)
Non-verbal communication	BSPD AAPD	Used to give encouragement and enhance other management techniques	Weinstein et al (1982)
Voice Control	BSPD AAPD	Alteration of dentist's voice contingent on behaviour of child. Change to loud voice if child is not cooperating	Greenbaum et al (1990)
Tell-show-do	BSPD	To familiarise a patient with a new procedure. Tell – explain verbally using age appropriate terms Show – physically show patient e.g rose head bur on finger Do- complete procedure as quickly as possible	Carson and Freeman (1998)
Enhanced control	BSPD	Increased perceived control via a stop signal, usually lifting an arm	Wardle (1982)
Behaviour shaping and positive reinforcement	BSPD AAPD	Shaping via reinforcement of gradual approximations towards an ideal behaviour.	Lencher and Wright (1975)

Table 2 continued

Management technique	Guideline	Method	Example of study outlining technique
Modelling	BSDP	Patients learn to behave via observation of another. Can observe in the surgery or via a recording	Stokes and Kennedy (1980)
Distraction	BSPD AAPD	To move attention from dental environment to another stimuli e.g cartoons, audio book. Can be contingent or non contingent of desirable behaviour Can be active or passive	Ingersol et al (1984)
Systematic Desensitisation	BSPD	Patient taught an alternative behaviour which they then practice when exposed to fear inducing stimuli which have previously been ranked in hierarchical order.	Levitt et al (2000)
Negative Reinforcement	BSPD	Being allowed access to escape from aversive stimuli contingent on desirable behaviour . For example, hand over mouth technique	Nunn et al (2008)
Empathy	BSPD	Communication based on empathy towards the child's concerns	Samat et al (2001)
Coping strategies	BSPD	Cognitive strategies to allow a child to manage dental treatment. For example, rationalisation.	Van Meurs et al (2005)
Magic trick	BSPD	Use of a magic trick prior to treatment to gain cooperative behaviour in the dental surgery	Peretz and Gluck (2005)

Table 2 continued

Management technique	Guideline	Method	Example of study outlining technique
Memory restructuring strategy	BSPD AAPD	Technique to encourage positive memories of dental visit	Pickrell et al (2007)
Hypnosis	BSPD	Technique to encourage individual into more susceptible state to help alleviate dental anxiety	Gold et al (2007)
Snoezelen environment	BSPD	Treatment in environment featuring dimmed lighting, vibroacoustic stimuli and deep pressure.	Shapiro et al (2007)
Ask-tell-ask	AAPD	Ask – enquire about feelings about planned procedure Tell – explain with age appropriate and non threatening language Ask – enquire again about feelings about planned procedure	Goleman (2014)
Parental presence/absence	BSPD AAPD	BSPD guidelines describe using the selective exclusion of the parent contingent on the child's behaviour but with specific informed consent from parent. AAPD advises parent be present to aid child emotional support	Fenlon et al (1993)

The majority of these techniques are based in behavioural psychology principles. For example, behavioural shaping via positive reinforcement, or the positive punishment and negative reinforcement of hand over mouth technique. ABA is a science devoted to developing procedures which will produce observable changes in behaviour utilising the principles of behavioural psychology (Baer et al 1968). It

therefore may have the potential to be a potent tool for ensuring the correct intervention is delivered in the optimum manner to aid the treatment of uncooperative children in the dental environment.

1.4.2 An introduction to Applied Behaviour Analysis (ABA).

As outlined in greater depth in the published manuscript in chapter 2, ABA is an approach to the modification of behaviour that is based upon the principles of operant and classical conditioning. Broadly, the ABA approach consists of (i) defining in behavioural terms the nature of the problem, (ii) exploring those factors that are antecedent to the behaviour (and thus ‘acting’ as triggers of the behaviour) and (iii) noting any consequences of the behaviour that reinforce it i.e. make the behaviour more likely to happen.

This process is known as ‘Functional Analysis’ (Sturmey 2008) and seeks to determine a “functional relationship” – that is, to determine the function of the behaviour in terms of whether the behaviour leads to a reward either directly or indirectly such as the avoidance of a negative consequence e.g. escape from an aversive situation.

The methods of ABA focus on providing individual, evidence based methods for both behaviour modifications and the measurement of it. Since ABA provides practitioners with structured approaches to evaluating individualized programmes of behaviour change, the technique can also be used to directly evaluate the effect of the intervention in real time. In this way, the need for auxiliary outcome measures is reduced and the technique can be used as a research tool in its own right. As such, it is an important complement to Randomised Controlled Trial methodology in reporting the effect of behavioural interventions.

ABA comprises a range of methods which seek to demonstrate a functional relationship between a chosen behaviour and its consequences and then to devise an intervention in single cases or small group studies to create a new functional relationship between a new behaviour and reward. This research may then be used to inform the development of a randomised controlled trial to further support the generality and transportability of the procedure (for examples of this approach see Allen and Wallace 2013) therefore promoting the intervention further in the scientific community.

Conversely ABA provides a link between the evidence base, gathered from randomised controlled trials, to the practical application of a behavioural intervention. Randomised Controlled Trials provide high level evidence of the general effect of an intervention. However, few interventions work universally for all individuals. ABA is a delicate and precise tool to assess both barriers to the implementation of research findings, and those variables which mitigate or promote the impact of an intervention.

Ultimately the purpose of ABA is to benefit patient care through the promotion of the scientist-practitioner model. The gathering of sufficient data prior to an intervention (for example, what reward is likely to motivate a child to co-operate for dental treatment) while potentially time consuming, parallels the recommendation of good history taking in all other areas of medicine and can be used to motivate patients and carers to accurately assess if the problem is getting worse or better. This empowers individuals to progress towards a valued goal.

1.4.3 The use of ABA outside of dentistry.

Outside of healthcare, ABA has been utilised in a wide range of settings as outlined in table 3 to demonstrate the effectiveness of behavioural interventions.

Table 3 – use of ABA outside of health care

Area of Application	Specific Area of Study	Author
Developmental disabilities	Decreasing self-harming, dangerous and aggressive behaviour	Repp & Horner (1999)
Mental Illness	Teaching self-control	Dixon, M.R. and Holcomb, S. (2000)
Education and Special Education	Reducing problem behaviours in the class room Developing teaching methods for improving teaching of students with special needs	Bambara and Kern (2005) Rusch et al (1988)
Rehabilitation after injury or trauma	Decrease delay in responding of trauma victim	Heinicke, Carr & Mozzini (2009)

Community Psychology (to change behaviour to benefit a large number of people)	Decreased illegal parking Prompting seat belt use	Cope & Allred (1991) Cox & Geller (2010)
Clinical Psychology	Behaviour therapy and cognitive behaviour therapy	Hersen and Rosqvist (2005)
Sports Performance	Improving gymnastics skills	Boyer et al (2009)

Traditionally, ABA was utilised to aid individuals with special needs (Keenan, 2006.). However, this has changed rapidly, with more studies devoted to supporting paediatric health care (Allen et al 1993). One of the earliest and well publicised studies helped a 3 year old autistic child to show compliance in wearing prescription glasses following cataract surgery (Wolf et al 1964). Other studies, which followed ABA methodology, have looked to improve compliance of paediatric medical patients. For example, ABA was utilised to prompt participants to take medication (Heinssen 2002) and to increase compliance of juvenile diabetic patients with foot care regimes, dieting and urine testing (Lowe and Lutzker 1979). Examples of other areas studied in paediatric medicine include sleep disorders (Piazza and Fisher 1991), managing chronic pain (Allen and McKeen 1991) and habit disorders (Watson and Allen 1993). There are numerous studies

that are of direct relevance to the problems faced by the paediatric dental team. For example, systematic desensitisation has been used to help an adult patient with severe needle phobias (Fernandes 2003) or interventions to aid appointment keeping (Friman et al 1985).

Chapter 2 -Applied Behaviour Analysis and Paediatric

Dentistry: An overview

Published in the Journal of Disability and Oral Health

Authors J.D Coxon, M.T. Hosey and J.T. Newton

2.1Supplementary information.

2.1.1 Overview of article

This published article follows on from the short introduction to ABA given in Chapter 1 (1.4.2). ABA is an applied science which inevitably is weighed down with its own terminology, which may be a considerable communication barrier to those in the dental profession. As stated by Allen et al (1993) in relation to paediatric medicine, the technological language of ABA often prevents a combined approach between behavioural therapists and medics. Therefore, the articles inclusion in the thesis is justified to clarify the terms used, to explain the methodology often used in published studies and to detail the interventions commonly implemented.

The papers referenced broadly fall into two categories. Firstly, many of the definitions are taken from review articles and text, which have been commonly cited by numerous other authors. For example, Cooper et al's Applied Behavioural Analysis (1987) textbook is often viewed as a valuable source of information to aid definition and summarise methodology principles. Secondly, empirical research papers have been referenced to clarify types of studies designs. For example, the multiple baseline design utilised by Jin et al (2013) to help children with sleep problems. These studies were chosen as they followed accepted ABA principles of good practice in terms of methodology.

2.1.3 This article's place in the thesis narrative.

At the start of the following article ABA is defined a science which concentrates on socially significant behaviour.

As quoted in the article, Wolf stated;

“the focus is on behaviours that are socially significant – that is that have meaning and importance for the individual and their family/carers (Wolf, 1978).”

There is therefore clearly a need to examine the effect of dental anxiety on the individual and the people closely associated with them; in other words, is children's dental anxiety a socially significant problem? This leads us on to the first part of this thesis which examines if dental anxiety is associated with worse health in young children and adolescents.

Applied Behaviour Analysis and paediatric dentistry: an overview

J Coxon,¹ M T Hosey² and J T Newton³

1. Senior Dentist, Porth Dental Teaching Unit, Qwm Taf Morgannwg University Health Board. 2. Professor of Paediatric Dentistry, Centre for Oral, Clinical and Translational Science, Faculty of Dentistry, Oral and Craniofacial Sciences, King's College London. 3. Professor of Psychology as Applied to Dentistry/ Honorary Consultant Health Psychologist, Faculty of Dentistry, Oral & Craniofacial Sciences, King's College London.

Abstract

This article seeks to provide an overview of the definition and methods of Applied Behaviour Analysis (ABA). ABA is an approach to the systematic analysis and modification of behaviour and is of huge potential value to paediatric dental specialists seeking to evaluate the effectiveness of their behaviour management strategies. The authors suggest that ABA provides a clinical link between evidence collated from randomised controlled trials and the clinical management of individual cases.

Date Manuscript Received: 06/10/2018

Date Manuscript Accepted: 20/05/2019

Doi: 10.443/JDOH/Coxon/08

Introduction

Paediatric oral health is, to a large degree, dependent on encouraging desirable behaviours while looking to modify undesirable behaviours. Outside the dental clinic, behaviours such as dietary choices and adherence to oral hygiene regimes impact greatly on a young patient's oral health (Kaewkamnerdpong and Krisdapong, 2018). In the dental surgery one of the main barriers practitioners face when treating paediatric patients is controlling un-co-operative behaviour (O'Callaghan *et al.*, 2006), often triggered via previous learning, such as a previous traumatic experience leading to anxiety which is then inadvertently maintained by avoiding the dentist in the future (Mowrer 1939).

Applied Behaviour Analysis (ABA) is an approach to the modification of behaviour that is based upon the principles of operant and classical conditioning. In broad terms the ABA approach consists of defining in behavioural terms the nature of the problem, exploring those factors that are antecedent to the behaviour (and thus 'acting' as triggers of the behaviour) and any consequences of the behaviour that reinforce it (that is make the behaviour more likely to happen) - a process termed 'Functional Analysis' (Sturmey, 2008). The methods of ABA focus on providing individual,

evidence-based solutions to behaviour and as such provide a complement to the use of Randomised Controlled Trials to provide evidence of the average or typical effect of behavioural interventions (Sedgwick, 2014). We will argue that ABA provides practitioners with structured approaches to evaluating individualised programmes of behaviour change within their clinical practice.

This article will provide an overview of the definition and methods of Applied Behaviour Analysis, drawing on published literature from paediatric dentistry where available to demonstrate these methods.

The definition of Applied Behaviour Analysis

Applied Behaviour Analysis has been defined as:

"The science in which the analysis of behavior is applied systematically to improve socially significant behavior, and in which experimentation is used to identify the variables responsible for change in behavior"

(Cooper *et al.*, 1987).

This definition contains several important elements. First and foremost is the focus on *behaviour*. Defining behaviour

has not proved a simple process. Following a review of 174 members of three scientific behaviour centred societies, Levitt *et al.*, (2009) amalgamated the wide range of responses to "Behaviour is the internally coordinated responses (actions or inactions) of whole living organisms (individuals or groups) to internal and/or external stimuli, excluding responses more easily understood as developmental changes". ABA concentrates on overt behaviour; behaviour that can be seen and observed. However, it is untrue to state that ABA ignores thoughts, feelings and glandular secretions (covert behaviour). Radical behaviourism, from which ABA stems, acknowledges the existence of processes and thoughts that cannot be observed (Skinner, 1953).

Secondly, ABA identifies itself as strongly scientific, based on the careful control of variables, the systematic change of one or more variables and observing the effects that this has on the specified outcome. Note also that the focus is on behaviours that are socially significant – that is that have meaning and importance for the individual and their family/carers (Wolf, 1978).

The methods of Applied Behaviour Analysis

Research into ABA seeks to demonstrate a functional relationship between the procedure and the target behaviour. A functional relationship can be defined as an association in which one variable changes systematically according to the value of another. An example relevant to dental practitioners may be the sending of appointment reminder letters or text reminders (the procedure, intervention or independent variable) resulting in patients attending their appointments (the target behaviour or dependent variable) more frequently.

A functional relationship, can be demonstrated if:

- The target behaviour changes when the intervention is manipulated. For example, a child brushing more frequently once a sticker chart has been introduced.
- The intervention is introduced a number of times, and the target behaviour changes each time.

Although there are numerous experimental designs the following are most commonly used:

- A-B design
- Reversal designs
- Multiple Baseline designs
- Changing Criterion designs.

A-B design

The most basic design, this methodological approach is analogous to a before-after design for either a small group of individuals or a single case study. The target behaviour is measured for a period, giving baseline data and then the intervention is introduced, and data from the treatment phase is recorded.

For example, McMullen *et al.*, (2017) studied the effect of a package intervention on a 5-year-old boy with Down syndrome who had previously shown severe problematic

behaviour at the dentist, including punching and biting. As described above, baseline data were gathered over two visits, recording the frequency of appropriate behaviour. The intervention was then introduced. This comprised of an audio recording, played on a loop to allow the habituation of the child to the sounds of a dental clinic. The parent also 'played dentist' with the child to allow further desensitisation to stimuli associated with the dentist and to give the opportunity for the child to learn an appropriate behaviour. The data gathered during dental visits post intervention showed a marked increase in the desired behaviour, from zero percent to 71% by visit 5.

However, despite the apparent results above, A-B designs are not capable of demonstrating a functional relationship as criterion (b) is not satisfied; the intervention is not introduced a number of times to show a consistent relationship with the target behaviour. Some researchers have attempted to strengthen the conclusions that can be drawn from such a design by, for example, extending the baseline phase (Bailey and Burch, 2002).

Therefore, the most one can state from the results of an A-B design is that behavioural change occurred. It is not possible to state that the intervention led to the change in target behaviour unless the intervention is withdrawn, and the behaviour reverts to baseline measures. This leads to an ethical dilemma especially in medical and dental situations. Should one remove an intervention that is leading to possible improvements in health to fully establish there is a relationship between independent and dependent variable? Fortunately there are other experimental designs, such as multiple baseline designs, that are far more capable of demonstrating a functional relationship.

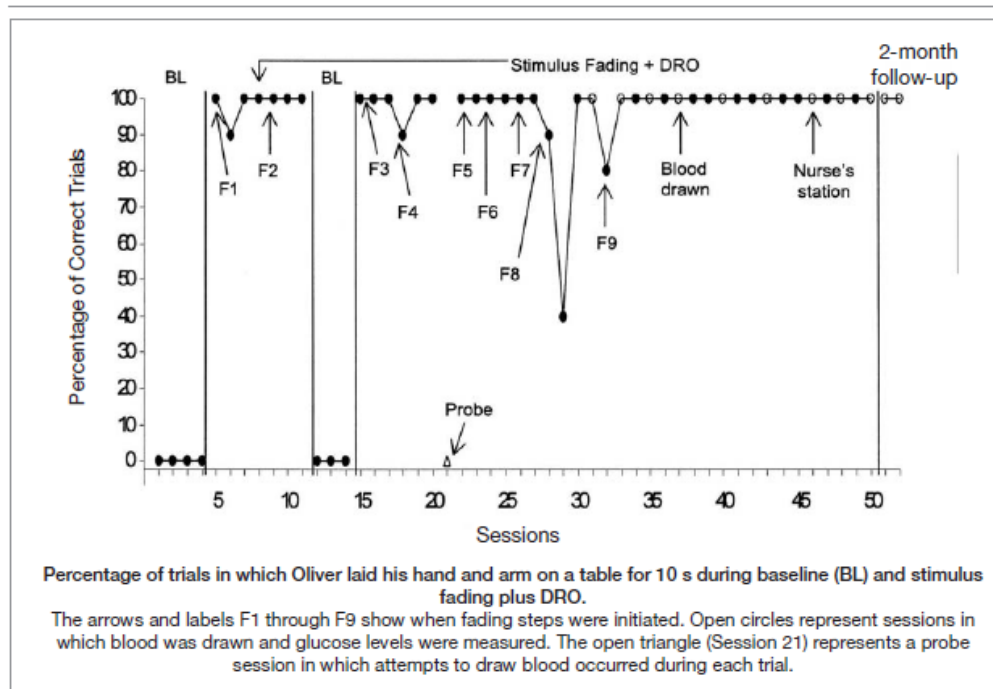
Reversal designs (A-B-A, B-A-B, A-B-A-B)

Reversal designs provide a stronger proof of a functional relationship between the dependent and independent variable by adding a third phase of the method – that is reversing the intervention in anticipation of a reversal in behaviour. Once the intervention is withdrawn, the dependent variable should return to baseline levels. For example, this design has been used to demonstrate the functional relationship of reinforcement with a child's compliance to adhere to a medication regime (Costa *et al.*, 1997).

Variations on the Reversal design include a design where the baseline is sandwiched between two phases of the intervention (B-A-B Design). The advantage of this design is that it finishes with the desired behaviour established. The A-B-A-B design adds a forth stage where the intervention is introduced again, also ensuring the study finishes with the completion of behavioural change.

This design has also been used to show how reinforcing another desirable behaviour can be used to help a child with autism overcome their needle phobia (Shabani & Fisher, 2006), a situation with which most paediatric dental practitioners are familiar. *Figure 1* shows that the child would not allow a needle near him during the baseline phase of the study. By reinforcing the participant for holding his arm still (measured by the use of a posterboard outline) with food reinforcement, it was possible to gradually shape the desired behaviour until the needle could be inserted. As the *Figure 1*

Figure 1: Example of an A-B-A-B Design taken from Shabani and Fisher (2006)



shows, once the intervention was withdrawn the behaviour returned to previous levels.

However, reversal designs are only of value if the target behaviour is reversible. This is not the case if the change in behaviour is maintained by other reinforcers. For example, weight loss, as result of eating healthy food, may be reinforced by the social reinforcement of peers. In addition, a reversal design is not suitable for behaviours that are considered dangerous, where reversal back to baseline behaviour may affect the health of the subject or others. This obviously has an impact on the use of reversal designs in medicine and dentistry, where it may be deemed unethical to allow the participant to lapse back to old undesired behaviours. In general, such situations are addressed by the use of multiple baseline designs in these areas.

Multiple baseline designs

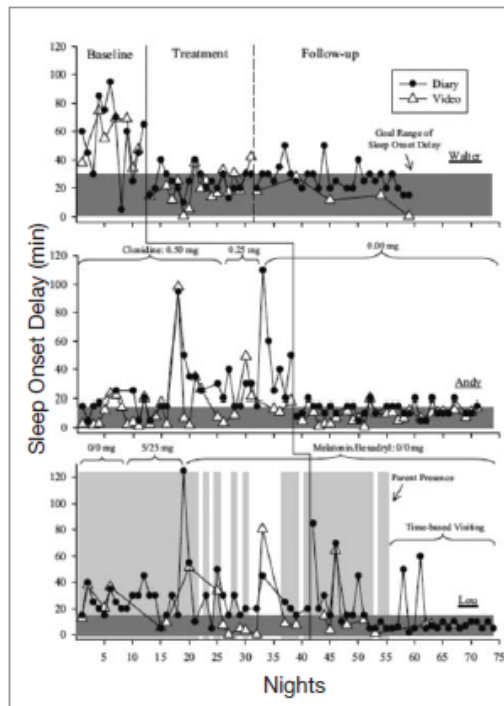
Multiple baseline designs have been widely used in ABA studies in paediatric dentistry (Stokes 1980; Poche, 1982; Dahlquist, 1984; Allen 1987; Allen 1992; O'Callaghan 2006). Bailey and Burch (2002) describe a multiple baseline design as an intervention or interventions that is/are applied over two or more baselines. In essence, the multiple baseline design consists of several A-B designs. Multiple baselines can be categorised by the types of applications:

a) Applications across participants – here a functional relationship can be demonstrated if the same effect is seen

on the target behaviour of a number of participants, once the intervention is introduced. For example, this design of study has been used to demonstrate the effect of individualised treatment packages for children with sleep problems (Jin et al., 2013). In this instance, three children with sleep problems were assessed over a baseline period, and then the intervention introduced for each child sequentially. The intervention in this instance consisted of a tailor made package based on contributing environmental factors from the Sleep Assessment and Treatment Tool. Only when the child received the intervention was there improvement in their sleeping difficulties (Figure 2).

- b) Applications across settings – here a functional relationship can be demonstrated if there is the same effect on the target behaviour after the intervention is introduced in a number of different settings. This normally involves the same subject. For example, this design was used to demonstrate the effectiveness of an intervention to decrease the drooling of a 17-year-old with autism (Kay et al., 2006) in multiple settings. The intervention consisted of i) teaching the participant to swallow and wipe his mouth ii) reinforcement via an edible treat if no saliva was present when the observer checked at gradually increasing time intervals. Figure 3 demonstrates that the drooling decreased following the introduction of the intervention for each setting.
- c) Applications across different behaviours of the same participant – this design is useful for measuring the effect of an intervention on several different behaviours. Studies

Figure 2: An example of a multiple baseline across participants design (Jin et al., 2013)



have used this design to demonstrate the effect of interventions in areas such as inappropriate behaviour in the class room (Higgins et al., 2001) and teaching of work related skills (Westerland et al., 2006).

It should be noted that multiple baseline experiments can be concurrent or non-concurrent. Concurrent designs will involve all the participants undergoing treatment at the same time. The major advantage of this design compared to non-concurrent designs is that it controls several threats to validity. This design is especially useful at controlling for history effects; effects on the outcome due to events that happen in the environment that change the conditions of a study (Harris and Jenson, 1985). Non-concurrent designs, where interventions are applied to individuals at delayed intervals, suffer far greater threats to validity but offer researchers greater flexibility in terms of recruitment and the locations used (Harvey et al., 2004).

Changing-Criterion design

This design seeks to show experimental control by showing a change in the level of the behaviour when the criterion for reinforcement changes.

Functional assessment

Prior to the implementation of any behavioural intervention, a functional behavioural assessment should take

place to examine a) what happens before an undesired behaviour occurs b) a description of the undesired behaviour and c) what are the consequences to the subject of the undesired behaviour. In other words, one should look to gather information regarding antecedents and consequences that are functionally related to an undesired behaviour. For example, if a child will not allow their teeth to be brushed, what is happening in the environment prior to the child's teeth being brushed, what behaviour is displayed when the teeth are being brushed and what are the consequences of this behaviour?

A functional assessment may be conducted via an indirect assessment, a direct assessment, or a functional analysis. An indirect assessment consists of using behavioural questionnaires to gather the above information regarding the problem behaviour. A direct assessment involves the gathering of information via observation of the participant. A functional analysis involves the manipulation of antecedents and consequences to establish if there is a functional relationship between the problem behaviour and antecedents and consequences.

Methods of intervention

The interventions adopted in ABA are typically based upon the principles of operant and classical conditioning, and include the following:

- Stimulus pairing
- Graded exposure
- The use of extinction
- Antecedent control procedures
- The use of a token economy
- Differential reinforcement
- Time out
- Modelling
- Shaping
- Promoting generalisation.

Techniques utilising classical conditioning

Classical conditioning is often described as Pavlovian conditioning, following Pavlov's familiar experiment where a dog was repeatedly presented with meat, just after a bell had been rung. The stimulus pairing of the bell sound and meat resulted in the dog salivating even when just the bell was rung (Pavlov, 1927).

While the above describes a pleasant association, dental patients' anxiety can stem from a negative classical association of the dental clinic stimuli and discomfort (Carter et al., 2014). The dental team have often heard patients report that the smell of the dental clinic leads to them experiencing feelings of fear and anxiety. It is therefore important that young children have a pleasant association with the dental environment, such as a reassuring approach suggested by Zhou et al., (2011) and Zhou et al., (2013). This will help to immunise children against any chance of aversive classical conditioning through an uncomfortable event in the future (a term called latent inhibition, Milsom, 2003).

Relaxation training is often stated as a method to help aid patients suffering from dental anxiety and phobia. These

techniques are based on classical stimulus pairing techniques. Typically the subject is first taught methods to aid relaxation, such as progressive muscle relaxation. They are then asked to practice these techniques while gradually increasing the levels of exposure to the fear inducing stimulus. Such a technique is often termed as systematic desensitisation and counter conditioning or graded exposure. Sanders and Jones (1990) used an intervention based on systematic desensitisation to help adolescents with needle phobias accept injections for medical and dental treatment, where participants paired relaxation with the presence of a injection needle through gradual exposure over a number of sessions.

Techniques utilising operant conditioning

The learning that occurs in operant conditioning is via the association made between a behaviour and a consequence for that behaviour in the presence of a certain stimulus. The consequence that follows the behaviour can be described as punishment if the behaviour decreases in frequency in the future. Conversely, the consequence is described as reinforcement if the behaviour becomes more frequent thereafter.

Positive reinforcement involves the giving of a pleasurable stimulus. For example, giving a child a sticker for having clean teeth. Negative reinforcement involves the withdrawal of an aversive stimulus. For example, a parent who is not taking a child to the dentist due to the child's protests (Morgan *et al.*, 2017). Positive punishment involves the addition of an aversive stimulus. Such punishment does not have to be overt physical correction. Even a dentist's harsh criticism of a child's oral hygiene can act as punishment if it results in the child not attending the dental appointments in the future. Negative punishment is described as the withdrawal of anticipated reinforcement.

The use of extinction

Some undesirable behaviours are inadvertently reinforced and one of the challenges the dental team face is the identification of the reinforcer which is maintaining the behaviour. For example, not realising that allowing a child to escape from treatment when they display disruptive behaviour is likely to lead to disruptive behaviour more often; an example of negative reinforcement.

Extinction refers to the withdrawal of reinforcement from a behaviour. It results in an initial increase in the non-desired behaviour (extinction burst) followed by a long term reduction in the behaviour as a result of new learning – specifically that the behaviour does not produce reinforcement. In the example stated above, not allowing the child to escape from treatment would be likely to lead to a short term escalation in disruptive behaviour. If this outburst is endured there is likely to be a marked decrease of the undesirable behaviour in the future. Of course, apart from clinical examinations and very simple treatment, it is often impossible to carry on dental treatment, such as cavity preparation, once a child becomes disruptive. In such a situation, the use of non-contingent escape is often useful

(Allen and Stokes, 1987; Allen and Wallace 2013); allowing the child to rest and escape treatment for short periods at prescribed time periods. This utilises the principles of extinction by breaking the association of disruptive behaviour and escape from treatment.

Antecedent control procedures

An antecedent is a stimulus in the environment that results in the display of a learned behaviour. For example, a red traffic light signals stopping behaviour. Antecedent control involves the manipulation of these stimuli to result in an increase in desirable or undesirable behaviour.

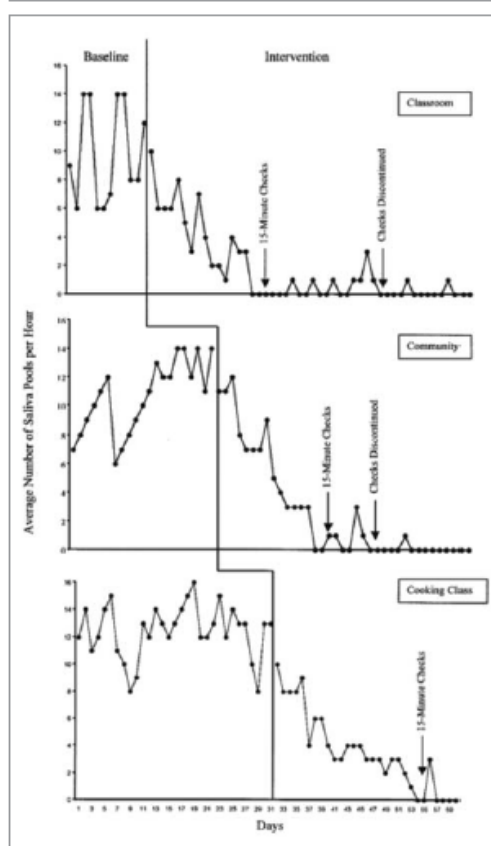
To provoke a desired response, the following methods can be used to manipulate the antecedent stimuli:

- If a stimulus has control over a desirable behaviour, ensure this is presented. For example, a quiet environment, free of distractions will encourage a student to revise (Miltenberger, 2001). For a young child, toys in the waiting room will encourage the participant to be more relaxed prior to seeing the dentist.
- Ensure the consequences of a behaviour are more reinforcing by arranging an establishing operation. To clarify, to create a state of temporary deprivation that raises the value and salience of the reinforcer. For example, training that uses food reinforcement will be more reinforcing if it occurs before meal times (Vollmer & Iwata, 1991). An establishing operation in paediatric dentistry might involve asking the parent to not provide any special prizes for the child *before* they have received dental treatment to ensure they are well motivated to receive this reward if they co-operate with dental treatment.
- Increase the likelihood of a desired behaviour occurring by decreasing the response effort. For example, giving away free toothbrushes at a dental practice may increase the likelihood of a child brushing, as it saves the parent the effort and cost of buying one.

To decrease the likelihood of the occurrence of a competing and undesirable behaviour the following methods can be used:

- Remove a stimulus that leads to a competing behaviours. For example, removing confectionary from supermarket tills helps decrease children asking for sweets at the checkout. In the dental surgery, dental staff should avoid certain words, such as injection, drill, and extraction that may trigger a child's disruptive behaviour (Faile & Crawford, 1997).
- Making the outcome of an undesirable behaviour less reinforcing, termed abolishing operation. A good example of this method is ensuring any diet advice given in the dental clinic describes suitable alternatives for cariogenic snacks. This measure will decrease the likelihood of the child requesting unhealthy food.
- Increase the response effort for the competing behaviours. For example, to increase the consumption of healthy food, removing any unhealthy food from the house will increase the effort required to acquire it, making its consumption less likely.

Figure 3: Number of saliva pools (average per hour) recorded during base-line and intervention Ophases (taken from Kay *et al.*, 2006)



The use of a token economy

A token economy refers to the use of 'tokens' with no inherent value to signify future tangible reinforcement. A token economy can be defined by three features. Firstly, behaviours to be reinforced are identified and carefully defined. Secondly, a generalised conditioned reinforcer, or token, is used. Thirdly, the tokens may be exchanged for backup reinforcers, which are the real driving force behind the token economy (Cooper 1987).

Ideally the token should be paired with a wide variety of backup reinforcers including food, valued activities, praise etc. By using a token it is possible to provide reinforcement immediately after the response, improving the timing of reinforcement (Miltenberger, 2012). For example, a conditioned reinforcer can be used to "mark" the correct speech of young children and aid articulation (Johnston & Johnston, 1972). The use of tokens also allows the token to be presented in one setting, but exchanged for a backup reinforcer in another (Cooper, 1987). An example might be to give children stickers in the dental surgery for appropriate behaviour which they can exchange for another reinforcement outside the surgery.

Differential reinforcement

Differential reinforcement can be defined as rewarding a different behaviour and ignoring the undesired behaviour. Four techniques are commonly used: differential reinforcement of incompatible behaviour (DRI), differential reinforcement of alternative behaviour (DRA), differential reinforcement of other behaviour (DRO) and differential reinforcement of low rates of responding (DRL).

A dental example of differential reinforcement of incompatible behaviour would involve reinforcing children for sitting in the chair, while not reinforcing children out of the chair. The reinforced behaviour is totally incompatible with the undesired behaviour. Differential reinforcement of alternative behaviour differs slightly from DRI in that it is possible for the alternative and the undesired behaviour to take place at the same time. For example, Stark *et al.* (1989) looked to reinforce attention to audiotape and a picture board to decrease disruptive behaviour in the dental chair. It was possible for the child to pay attention to the distracting stimulus and display disruptive behaviour at the same time.

With proper selection of the behaviour to be reinforced, both DRI and DRA can promote skill development and be educational. However, there is often only a slow decrease in the undesired behaviour, as there is no consequence when the undesired behaviour is shown, as opposed to DRO.

Cooper (1987) suggests that in using differential reinforcement the behaviour to be reinforced should be in the subject's behavioural repertoire and emitted regularly. In addition, the strength of the reinforcer is vital, and will need to be stronger than the reinforcement(s) maintaining the undesired behaviour. For example, the negative reinforcement of escaping from the dental setting may be stronger than the reinforcement of a sticker for remaining there. Finally, DRI/DRA is more effective if combined with other reductive procedures. These may include extinction or punishment. Stokes and Kennedy (1980) used DRI to decrease disruptive behaviour by praising co-operative behaviour. However, they also used negative punishment by telling the child that they would have earned a desired prize if they had cooperated.

Time out (negative punishment)

Time out is "the withdrawal of the opportunity to earn positive reinforcement or the loss of access to positive reinforcers for a specified period of time, contingent upon the occurrence of a behaviour" (Heron, 1987). The general perception of a time out procedure is placing an individual in a secluded room. However, any loss of access to positive reinforcers can be deemed as 'time out'. Note that time out differs from extinction in that for time out access to the reinforcer is reinstated after a certain period.

The benefits of time out procedures are that they are easily implemented, are deemed acceptable by its consumers, can lead to a rapid suppression in behaviour if implemented successfully, and that time out has been shown to generalise from one setting to another and change the behaviour of non-participants. Time out procedures can also be readily combined with other procedures such as differential reinforcement for compliance.

Modelling

Modelling has been widely used in paediatric dentistry. A model can be an actual demonstration of the behaviour required. Williams *et al.*, (1983) used peers to model behaviour in the dental setting for a group of uncooperative boys. A model may also be symbolic, such as a book, video or television. Melamed *et al.*, (1975) used a video as a model to decrease disruptive behaviour in the dental setting. In another study of 28 children Stokes and Kennedy (1980) observed another child having dental treatment, before acting as the model patient themselves. There was a substantial reduction in the disruptive behaviour shown in patients who had previously shown severe uncooperative behaviour.

Shaping

Shaping is defined as “*differential reinforcement of successive approximations of a target behaviour until the person exhibits the target behaviour*” (Miltenberger, 2001). In essence, the behaviour to be acquired is built up over a period of time through reinforcement of small steps towards the final behaviour. For example, Allen and Stokes (1987) asked patients to remain still for a short amount of time while being exposed to mock procedures, such as injections and drilling. This length of time was gradually increased.

The starting behaviour to be reinforced, must be already in the subjects behavioural repertoire and be of relevance to the terminal behaviour. For example, will the nervous child happily sit in the dental chair? If so, this can be used as a starting step to shape holding still while undergoing dental treatment. The shaping steps that will be reinforced should be progressive; gradually moving towards the target behaviour. If the steps are too large, the rate of reinforcement will drop, slowing the process. Progress will also be slowed if one shaping step is reinforced too many times, making it more difficult for this behaviour to be put on extinction.

Interventions solely relying on shaping are often time intensive. Cueing and prompting a subject, as well as telling the subject what is expected may speed up the shaping process (O’Neil and Gardner, 1983). Telling the child what will be rewarded and when a reward will not be given is often referred to as rule governed behaviour (Skinner, 1969) and can speed up any intervention that involves shaping. For example, Allen and Stokes (1987) ensured children were told prior to the intervention that disruptive behaviour will not be reinforced by escape from treatment.

Promoting generalisation

Often the challenge of behaviour change lies not in establishing a behaviour but in ensuring it is consistent – that is the child can demonstrate the behaviour in different

settings or with different people. Generalisation is defined as “*the occurrence of the behaviour in the presence of all relevant stimuli outside the training situation*” (Miltenberger, 2001). In most cases of ABA, the ultimate goal is for the change in behaviour to continue outside the training setting. In relation to paediatric dentistry this is especially true. Reducing disruptive behaviour or improving oral hygiene is of little success if the behaviour does not generalise to real life situations. Despite this need, there are few studies in ABA related to paediatric dentistry that look to see if generalisation has occurred.

Generalisation can be encouraged by a number of strategies (Stokes and Osnes, 1989), such as ensuring behaviours are reinforced that show evidence of generalisation: i.e. reinforcing behaviours that occur outside the training setting. For example, by reinforcing good oral hygiene in the home environment (Dahlquist, 1986), or encouraging a nervous patient to see another practitioner as soon as they feel comfortable to do so. Ideally one would choose natural reinforcers to help the behaviour generalise. For example, by enquiring what the child likes to do and utilising that behaviour as a reinforcer.

Conclusions

Applied Behaviour Analysis comprises of a range of methods which seek to demonstrate a functional relationship between a chosen behaviour and an intervention in single cases or small group studies. This research may then be used to inform the development of a randomised controlled trial to further support the generality and transportability of the procedure (for examples of this approach see Allen, 2013.) therefore promoting the intervention further in the scientific community. Conversely, ABA provides a link between the evidence base, gathered from randomised controlled trials, to the practical application of a behavioural intervention. Randomised Controlled Trials provide high level evidence of the general effect of an intervention. However, few interventions work universally for all individuals. ABA is a delicate and precise tool to assess both barriers to the implementation of research findings, and those variables which mitigate or promote the impact of an intervention.

Ultimately the purpose of ABA is to benefit patient care through the promotion of the scientist-practitioner model. The gathering of sufficient data prior to an intervention, while potentially time consuming, parallels the recommendation of good history taking in all other areas of medicine and can be used to motivate patients and carers to accurately assess if the problem is getting worse or better. This empowers individuals to progress towards a valued goal.

Address for correspondence:

Dr J Coxon

Porth Dental Teaching Unit, Leith House, Pontypridd Rd, Porth CF39 9PH

Email: jcoxonabc@gmail.com

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Chapter 3- Part 1

Is dental anxiety in children associated with worse health?

3.1 Supplementary information

3.1.1 Overview of Part 1

Part 1 comprises four papers published in the British Dental Journal to attempt to answer the first research question; is dental anxiety in children a socially significant problem that the dental profession should seek to manage and resolve? Only after answering this question is it possible to determine whether ABA has the potential to be used effectively by the profession to aid the behavioural management of dentally anxious individuals.

As the thesis concentrates on dental anxiety in the UK population, these analyses utilised the data collected from the Child Dental Health Survey of England, Wales and Northern Ireland in 2013. This survey has been carried out with slight modifications every 10 years since 1973 to monitor the dental health of children. In addition, the survey sought to explore the relationship between oral health, experiences, attitudes and behaviour and monitor the changes in children's dental health and related behaviour over time.

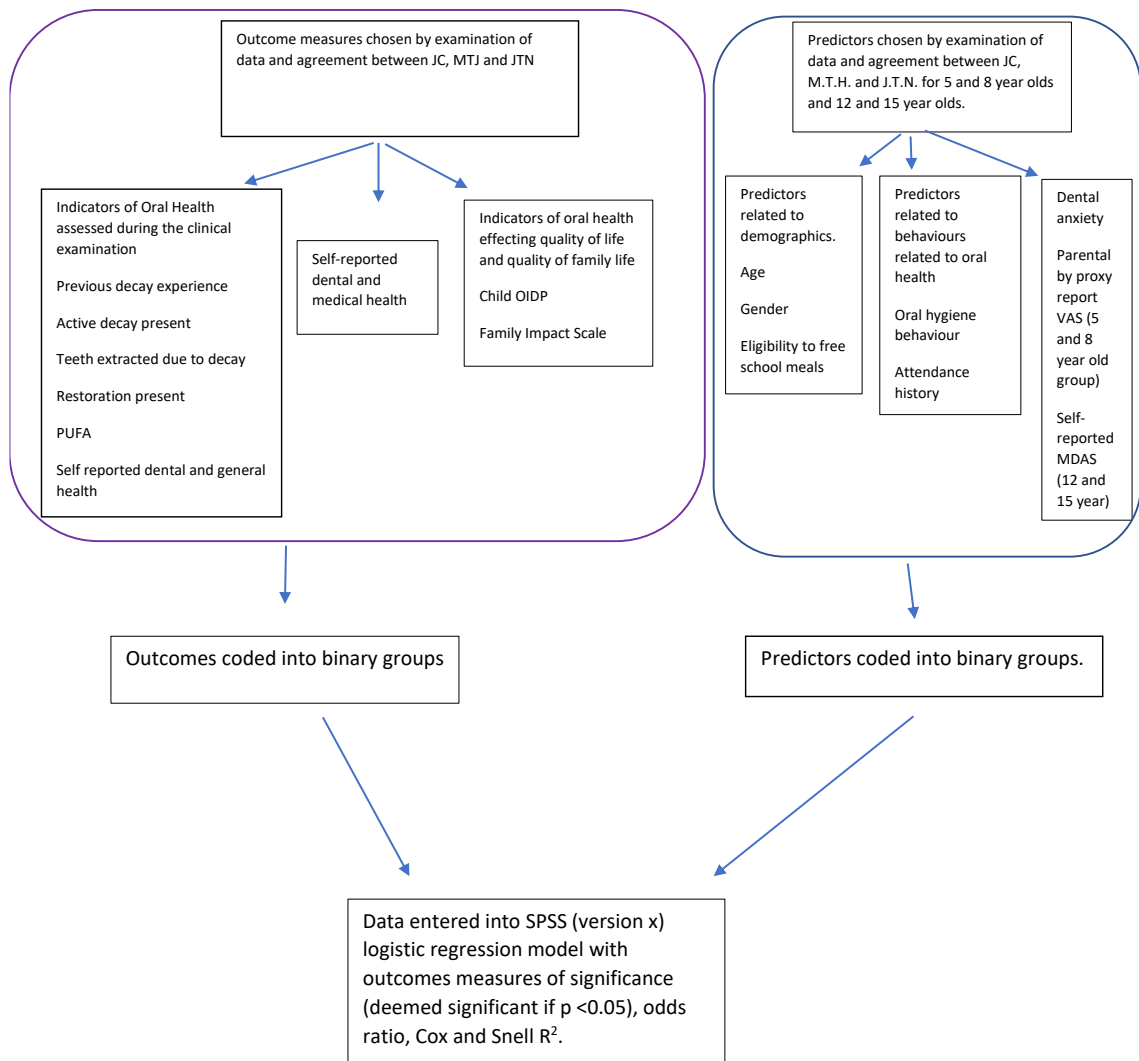
The 2013 Child Dental Health survey included participants from four age groups – 5, 8, 12 and 15-year olds). The descriptive analyses highlighted variables which had a significant association with dental anxiety. Variables chosen related to oral health, oral health related behaviour and the impact oral health had on an

individual (12 and 15 year olds only) and their family. It was necessary to separate analyses by age group since there were differences in the methodologies used for the two age groups. Many of the variables related to oral health related behaviour in the younger age groups (5 and 8 year olds) were ascertained by proxy reports from the parent/carer. The older age groups (12 and 15 year olds) completed a questionnaire themselves, including stating their level of dental anxiety.

A regression analysis was conducted to determine whether any relationship between dental anxiety and oral health was maintained once the effect of confounders had been considered. Put in simple terms this regression analysis aimed to ask the question “Does dental anxiety still predict worse health in children once the effect of other variables has been taken into account?”.

The methodology is described in in Figure 1 with all the statistical analysis undertaken by myself.

Figure 1 – Diagrammatic representation of regression analysis



3.1.2 Limitations of using the CDHS 2013

Bias introduced due to sampling technique

As mentioned in section 1.3.2, epidemiological surveys are prone to under reporting the prevalence of dental anxiety. This is likely to be true of the CDHS 2013, where positive consent was required from the parents of 5 and 8 year olds and from the actual child in the 12 and 15 year old groups (White et al 2007). Children could also opt out on the day of the examination. As such, children (or

indeed parents) with high levels of dental anxiety may not have consented to take part in the survey resulting in under reporting the prevalence of high dental anxiety. In addition, due to the sampling taking place in schools, certain groups of children were excluded from the survey. For example, children who were home schooled, attending special schools, or in pupil referral units.

The CDHS aimed to survey the oral health of 5, 8, 12 and 15 year olds in England, Wales and Northern Ireland. Schools were treated as sampling units and the samples were clustered to reduce examiner travel time in England and Wales. While the methodology aimed to sample a group representative of the population, children in “deprived” areas were oversampled in order to ensure the sample size had adequate numbers to allow for statistical testing as stated in the technical report below.

http://doc.ukdataservice.ac.uk/doc/7774/mrdoc/pdf/7774_cdhs_2013_technical_report.pdf

As such, the sampling methodology was not designed to accurately reflect the level of dental anxiety in this population. For instance, factors such as culture which are known to affect the prevalence of reported dental anxiety (see section 1.3.2) were not considered.

3.1.3 Variables chosen.

The data set had a considerable number of variables to choose from. These were examined by the authors of the paper and the KCL statistics department and agreement was made over which variables should be included based on the following criteria:

- a) The measure was assumed to measure oral health, a behaviour relating to oral health or the impact oral health had on an individual or family's quality of life.
- b) For categorical variables, there were sufficient numbers in all categories to enable significance level testing via cross tabulation

However, despite taking the above precautions there are some noticeable omissions. For example, dental trauma has not been selected which could well be related to dental anxiety. However, this was excluded since it was assumed that the relationship would be in the direction of dental trauma resulting in anxiety, rather than, as was the interest in these studies, whether dental anxiety resulted in increased dental treatment need (through the possible mechanism of delayed treatment).

As stated in all four of the published papers, the findings of these studies are limited by the measures used to rate the levels of the child's dental anxiety. To summarise, the Visual Analogue Scale used for the younger age groups was a proxy parental report of the anxiety that had no validated cut off between dental phobic and non-phobic. The older age range described their anxiety via the self-report Modified Dental Anxiety Scale. Although this measure has been validated previously and cut off score for dental phobia established, this research was conducted with an adult population. The measure has not been validated with adolescents.

Table 1 describes the other variable included in the descriptive and regression analysis.

Table 1 – Variables used in the secondary analysis of the Child Dental Health survey.

Variable	Description	Rationale for inclusion	Limitations
Gender	Male or Female.	Previous evidence to suggest that dental anxiety higher in females (for example, Porritt et al 2013)	
Age	5, 8, 12 and 15 year old age groups.	Previous evidence to suggest that dental anxiety related to age of child.	Study will not pick up if anxiety was related to other age groups e.g. 14 year olds because they are not included on the sample analysed.

Table 1 continued

Variable	Description	Rationale for inclusion	Limitations
Any decay experience	<u>Decay</u> experience according to the 2003 criteria which states 'All teeth with cavitated or visual dentine caries, restorations with cavitated or visual dentine caries, teeth with filled decay (otherwise sound) and teeth extracted due to caries. Excludes teeth with enamel caries present. ' (Pitts et al 2006) Grouped into two groups: no decay experience; and decay experience	Widely used measure of oral health for over 70 years.	

Table1 continued

Variable	Description	Rationale for inclusion	Limitations
Any decay experience continued..			Numerous limitations: For example, missing anterior teeth on 5 year old survey is assumed to be exfoliated rather than missing due to tooth decay. -Teeth may be restored due to trauma or other reasons such as hypoplastic enamel. -Total DMFT/dmft is blunt measure on its own e.g. DMFT of 2 could be due to 2 filled teeth OR 2 missing teeth or 2 decayed teeth or a combination of these. -Does not relate decay experience to number of teeth at risk -Excludes enamel caries, therefore not possible to judge the prevalence of lesions which may be reversed through preventative measures. Teeth can be lost due to orthodontic needs, trauma or they are congenitally missing or not scored as unerupted. -If all tooth surfaces are involved scoring reaches saturation point and not possible to score if caries is progressing -Does not give account for treatment needs or rate of caries progression. -Equal weighting to missing, untreated decayed and well restored teeth -Grouping of data into binary values may decrease the value of the analysis. E.g. no differentiation between a child with a small composite filling and a child with multiple teeth with gross caries.

Table 1 continued

Variable	Description	Rationale for inclusion	Limitations
Any teeth restored	Permanent and deciduous teeth restored. Grouped into no restorations present and restorations present.	Allows an estimate of decay experience which has been treated previously.	Possible to wrongly attribute restorations due to caries as may be due to trauma, enamel hypoplasia, aesthetic reasons etc. Grouping of variable into binary values prevents detailed analysis i.e. no difference between small restoration to multi surface restorations.
Any teeth extracted due to caries	Teeth removed due to dental decay Grouped into no teeth extracted due to caries or one or more teeth extracted due to caries.	Allows estimate of decay experience.	Difficulties in assessing if teeth removed due to orthodontic reasons, congenitally missing or unerupted. Also incorrect scoring possible due to teeth deemed to be exfoliated but actually extracted due to decay.

Table 1 continued

Variable	Description	Rationale for inclusion	Limitations
Any PUFA signs	Indications of soft tissue lesions: visible pulp, ulceration, fistula or abscess (PUFA). Grouped into: a) no soft tissue lesion seen; and b) soft tissue lesion seen.	Used as a measure of the clinical consequences of untreated dental caries which is not provided by DMFT.	Some suggest that ulceration should be dropped from the index and fistula and abscess combined to one score (Frencken et al 2011) Grouping into binary values prevents more in depth analysis.
Is patient undergoing orthodontic treatment at the time of the survey?	Only reported in adolescent age group. Grouped into yes or no	Previous research has highlighted that children who have experienced orthodontic treatment tend to be less anxious. (Luoto et al 2009)	Orthodontic treatment in the 12 year old age group is most likely to be confined to removable appliance therapy.
Has the patient worn an orthodontic appliance previously?	Grouped into yes or no	As above	Reliance on accurate self-reporting.

Table 1 continued

Variable	Description	Rationale for inclusion	Limitations
Have teeth been previously extracted for orthodontic reasons?	Grouped into yes or no	As above	Incorrect scoring as teeth may have been removed due to caries, trauma etc. For example, decayed first permanent molar teeth extracted as a part of orthodontic treatment planning.
Self rated general health	Scored on a scale of one to five, rating from very good to very poor. The variable was divided into two groups: 'very good/good' and 'fair/worse'	Examine the relationship of dental anxiety and self-rated general health	Grouping into binary variables prevents more in depth analysis.
Self rated dental health	Scored on a scale of one to five, rating from very good to very poor. The variable was divided into two groups: 'very good/good' and 'fair/worse'	Examine the relationship of dental anxiety and self-rated dental health.	Grouping into binary variables prevents more in depth analysis.

Table 1 continued

Variable	Description	Rationale for inclusion	Limitations
Reported toothache, sensitivity, swollen or bleeding gums, broken teeth, mouth ulcers and bad breath in last 3 months	Grouped for each variable into "yes" or "no" groups.	Allows a more in depth report compared to self-reported dental health above	Easy for individual to attribute normal event with perceived pathology. E.g. bleeding gums and toothache may be due to exfoliating deciduous tooth, referred pain from earache or sinusitis. Question of individuals ability to recall correct over last 3 months.

Table 1 continued

Variable	Description	Rationale for inclusion	Limitations
CHILD- OIDP	An oral health-related quality of life index for children, with a child responding by choosing one option from the eight items listed below. In the last three months the child reports difficulty eating, speaking, cleaning teeth, relaxing and sleeping, reports they feel different, difficulty smiling, laughing, and showing teeth difficulty doing schoolwork and difficulty enjoying being with people For descriptive analysis an overall score was then calculated. For the regression analysis these were grouped into two groups; not affected and affected.	Provides an insight into how child feels and how satisfied they are with their health Evidence to suggest these feelings effect an individual into adulthood (Reisine 1985) Validated in UK (Yusuf 2006)	The use of an overall score in the descriptive analysis and the binary groups used in the regression analysis prevents a more detailed examination of the relationship between quality of life and dental anxiety.

Table 1 cont.

Variable	Description	Rationale for inclusion	Limitations
Family impact scale.	Scale to measure impact of child oral and oro-facial conditions on family quality of life. Consisted of 7 items with 5 possible responses ranging from never to almost every day. Items are in relation to the child's dental health, in the last 6 months 1) Have you ever taken time off work? 2) Has your child's dental health caused financial difficulties for your family? 3) Has your child required more attention from you or the other parent? 4) Has your sleep been disturbed? 5) Have your normal family activities been interrupted? 6) Have you or the other parent felt guilty? 7) Have you or the other parent felt stressed or anxious. Grouped into two groups; not effected or effected	Important to judge the consequence of oral conditions impacting on the family due to a) the central role they play in child health b) chronic illness impacting on the family c) the recognition that paediatric care needs to recognise parental needs and concerns d) in order to assess if the parent's report on the child's health may be subject to bias due to the physical and emotional burden placed on them by the child's oral health. (Locker et al 2002)	Validity questionable as only seven from the original fourteen FIS items included in the CDHS. Collating variables into not effect and effected groups prevents analysis in greater depth.

Variable	Description	Rationale for inclusion	Limitations
Frequency of eating sugary food and sugary drinks.	The adolescent group reported how many times a day they usually eat a) Fruit b) Cakes or biscuits c) Sweets (candy or chocolate). They also reported how often they drank a) Diet coke or other non-sugar drinks b) Coke or other soft drink or squash that contain sugar. c) Energy (sports) drinks d) Water e) Fruit juices or smoothies Child reported frequency of consuming items on a 6 point scale (4 or more times a day to rarely or never) For the descriptive analysis this was grouped into a) Eating sugary food i) four times a day or more ii) less than four times a day. b) Drinking sugary drinks i) four times a day or more ii) less than four times a day For the regression analysis this was grouped into a) Consuming sugary food/drink four times a day or more b) less than four times a day	Well established link between frequently consuming cariogenic food and drink and dental decay (Moynihan and Kelly 2014) Therefore, needs to be included in analysis to establish if dentally anxious children consume more cariogenic items and to investigate if dental anxiety still predicts poor oral health once the effect of diet is taken into account.	Other, non-obvious source of sugar not reported on. E.g. tomato sauce. Possible bias due to socially desirable answer. Grouping of variables decreases the detail of the analysis. The none reporting of dietary habits in the younger age groups greatly decreases the validity of the regression analysis for 5 and 8 year olds as the effect of cariogenic food cannot be taken into account in assessing if dental anxiety still predicts poor oral health once other factors taken into account.

Table 1 continued

Variable	Description	Rationale for inclusion	Limitations
Frequency of brushing teeth	5 and 8 year old parents reported if child brushed twice a day or once a day or less and over the last year their child used i) Non electric toothbrush ii) Electric tooth brush iii) Toothpaste iv) Fluoride drops v) Mouth wash vi) Dental floss vii) Dental disclosing tablets viii) Sugar free gum This was grouped into no or yes for the descriptive analysis. Only the use of a manual brush, use of toothpaste and use of mouthwash was included in the regression analysis. For older age groups, only frequency of brushing reported on using 6 point scale ranging from more than 3 times a day to never. Grouped according to accepted guidelines of brushing frequency	Well established link between behaviours related to oral hygiene and oral health (toothbrushing frequency for example, Kumar 2016). Therefore, needs to be included to see if dental anxiety related to more or less reported oral health related behaviours and those deemed as significant also included in regression analysis.	Parental reporting in younger age groups may be inaccurate. Possible bias due to responders giving a socially desirable answer Only reports on frequency of brushing not the timing of brushing. I.e. are the just brushed in morning or evening? Not possible to state how effectively teeth are cleaned.

These limitations can be broadly grouped into:

- a) Limitations due to parental reporting versus self-reporting. In the younger age groups, all the variables related to dental anxiety, oral health associated behaviour, and the impact of oral health on family life were recorded by proxy parental reports. In addition, some information gained in the adolescent groups was also through parental reporting, such as a previous experience of sedation or general anaesthetic to aid dental treatment. Such proxy reports may be inaccurate compared to self-reported measures.
- b) Limitations due to an assumption of knowledge. Some questions asked via the questionnaire assume a level of knowledge that may be unrealistic. For example, questions regarding a child's previous dental experience assume that the caregiver can distinguish between their child having local anaesthetic, sedation or general anaesthetic.
- c) Limitations due to an assumption of question validity. For example, the consumption of sugary food and drink may have been underreported. 12 and 15 year olds were asked to report on their consumption of obvious cariogenic food such as cakes, biscuits and sweets, but other food, such as sugary breakfast cereal was not reported on.

Another example includes the assumption that free school meal eligibility is a direct indicator of poor economic status. Children were eligible for free school dinners at this time if the parents claimed an income related support allowance, unemployment benefits, or due to immigration status. However, there is debate about how well this measure correlates with socio-economic status with some suggesting the use of free school meals overestimates low socio-economic status (Hobbs and Vignoles, 2010). As such, this measure may not be a true reflection of deprivation. Equally the use of such a measure may introduce bias in the sampling methodology, with children outside the lower socio-economic group being overrepresented.

- d) Limitations due to grouping of responses. To ensure that there was a sufficient sample size to allow analysis some variables were grouped into binary groups. For example, the total score of seven questions taken from the family impact scale was grouped into two groups; family life not affected or affected. Whilst this gave adequate numbers in each group, inevitably some of the detail was lost. For example, the child's oral health may have had an impact on just the parent's emotions (question's relating to the parent feeling guilty, stressed or anxious) or only on the practicalities of family life (questions relating to taking time off work, financial pressure, sleep disturbance etc.).

The same statement is true of the CHILD-ODIP measure, used to rate the impact of oral health on a child's quality of life. The 12 and 15 year old questionnaire asked wide ranging questions such as if the child has had difficulty eating, speaking, cleaning their teeth, relaxing and sleeping, showing their teeth, doing their schoolwork, enjoying being with people

and feeling different due to their oral health. This detail was lost due to the need to group participants into not affected and affected groups to allow statistical analysis.

3.1.4 Implications of these papers' findings on the thesis narrative.

As stated previously, it was important to establish whether dental anxiety was a significant problem for individual children and their families. The results of these papers suggest that dental anxiety predicts worse oral health in 5 and 8 year old children and has an impact on their family's quality of life. What one cannot say is if dental anxiety led to worse oral health or vice versa. In adolescent children, a high level of dental anxiety predicted a negative impact of their oral health on their quality of life. Therefore, having established the need to manage and treat dental anxiety in children there is a need to explore the potential of ABA, a science devoted to interventions based on behavioural psychology. In part 2, the first study will look to see what ABA studies have taken place before related to paediatric dentistry. This is the first structured review of this type and will provide information on "typical" study design, target behaviour and type of intervention used. In addition, the results of this review will help establish if ABA is useful for particular child groups. For example, younger children versus adolescents.

Chapter 4 – The oral health of dentally anxious 5 and 8 year olds: A secondary analysis of the 2013 Child Dental Health Survey.

VERIFIABLE CPD PAPER

RESEARCH

The oral health of dentally anxious five- and eight-year-olds: a secondary analysis of the 2013 Child Dental Health Survey

James D. Coxon,^{1*} Marie-Therese Hosey² and J. Tim Newton¹

Key points

Suggests children with dental anxiety are more likely to experience dental decay and experience treatment that carries more risk, such as general anaesthetic.

Suggests dentally anxious children are less likely to be brought to the dentist for regular dental examinations and are less likely to brush their teeth twice a day.

Highlights the oral health of dentally anxious children impacts more on family life than children with no dental anxiety.

Argues by not considering the inter-relationship that factors such as poor oral health and attendance patterns have with dental anxiety, the standard definition of dental phobia may be too simplistic.

Abstract

Introduction Little research has been conducted into the relationships between dental anxiety and factors relating to oral health in small children. This research takes advantage of data from the Child Dental Health Survey 2013 to perform a secondary analysis for the five- and eight-year-old age groups.

Aim To compare the oral health of groups of children aged five and eight years old, classified into three levels of anxiety.

Design Secondary analysis of data from 2,289 children aged five and eight years in the Child Dental Health Survey 2013.

Materials and methods Participants were divided into three groups, depending on the parent's report of their child's dental anxiety. Descriptive analyses compared the three groups on social demographic factors, clinical status, self-reported oral health status, oral health-related behaviours and oral health impact.

Results Dentally anxious children were more likely to have active decay and decay experience. Parents of children with dental anxiety were more likely to report that the child's oral health had a negative effect on family life. Highly anxious children were less likely to attend the dentist or engage in oral health-related behaviours.

Conclusions Dentally anxious children have more dental disease and their parents express that the child's oral health has a greater impact on their family's quality of life.

Introduction

Dental fear and anxiety in children often impedes their effective treatment.¹ However, few studies have looked at the wider impact of dental phobia on oral health. Dental anxiety is defined as involving 'a feeling of dread that something will happen in relation to dentistry, combined with a sense of losing control'.² Dental phobia is defined by the *Diagnostic*

and Statistical Manual of Mental Disorders as a specific phobia that is: i) a severe and out of proportion fear within a certain context to the presence or anticipation of a specific object or situation; ii) the subject becomes immediately anxious following exposure to the stimulus. This may take the form of a situationally-bound or situationally-predisposed panic attack; iii) the person is able to understand that the reaction is out of proportion; iv) the subject avoids the situation or endures it with intense distress; v) the subject's reaction to the fearful stimulus interferes significantly with the person's everyday life.³

However, dental anxiety and phobia may well be inextricably linked with factors such as the child only attending in pain, resulting in uncomfortable procedures.² Therefore, it may not be possible to view dental phobia as a singular disorder, but rather a symptom

of a wider disorder where anxiety and other factors such as poor oral health are closely interrelated. The reported prevalence of dental fear in children varies widely. For example, a review of studies between 1982 and 2006 by Klingsberg and Broberg⁴ suggested around 9% of children said they had a dental fear. These patients were from populations in Australia, Canada, Europe and the USA. Other more recent studies have quoted higher figures. For instance, a sample of over 2,000 six-year-olds from a low to medium low socioeconomic status reported a prevalence of dental fear of 22%.⁴ Most studies suggest that females show a higher level of dental fear than males.

Although the 2013 Child Dental Health Survey (CDHS) in the UK reported on children's anxiety levels (21% of five-year-olds and 17% of eight-year-olds suffered from moderate to severe anxiety),⁵ there

¹Faculty of Dentistry, Oral & Craniofacial Sciences, King's College London; ²Paediatric Dentistry Centre of Oral Clinical and Translational Science Faculty of Dentistry, Oral & Craniofacial Sciences King's College London
Correspondence to: James Coxon
Email: jcoxon@kcl.ac.uk

Received Paper:
Accepted 19 November 2018
DOI:10.1038/s41415-019-0148-3

was no in-depth look at the relationships between dental anxiety and oral health status, oral health-related behaviours and oral health-related quality of life. Most research undertaken has concentrated on adults.^{6,7,8} A few studies have looked at the effect of dental phobia on the child's quality of life,⁹ while others have sought to gain more knowledge through qualitative research.¹⁰

This research wishes to complete a descriptive analysis of the relationship between dental anxiety in younger children and variables relating to oral health and oral health-related behaviour, utilising the considerable data set gathered from the CDHS.

Materials and methods

Data were taken from the 2013 CDHS, commissioned by the Health and Social Care Information Centre. The children surveyed were five, eight, twelve and fifteen years of age. The full methodology of the survey can be found in the technical report.¹¹

Grouping of patients in relation to the parent's report of the child's anxiety levels

The five- and eight-year-olds were categorised via a questionnaire, filled in by the parent, that asked them to rate their child's anxiety in general terms. This was on a scale ranging from one (not at all anxious) to ten (extremely anxious). For this study, the participants were divided into three categories: VAS scores of 1–3 ($n = 1,789$, 78%), VAS scores of 4–6 ($n = 305$, 13%) and VAS scores of 7–10 ($n = 195$, 8%).

Data analysis

The variables deemed relevant were selected and tabulated. These included clinical variables, parental-reported child's oral health status, parental-reported child's oral health behaviours and the impact of the child's oral health on the family. Using SPSS (version 25), a simple statistical analysis was conducted using cross tabulation and a chi-squared test. To judge if results were deemed significant, a Bonferroni correction was applied. This was to allow for the increased chance of a rare event leading to incorrectly rejecting the null hypothesis as multiple hypotheses were being tested. Following this correction, the result was deemed significant if $P \leq 0.002$. The following variables were extracted from the data set to see if there is a relationship between the three different groups.

Socio-demographic

1. Gender
2. Free school dinner eligibility. The CDHS used this as a measure of poor socio-economic status. Parents can claim free school dinners for their children if they claim unemployment benefits, an income-related support allowance or due to immigration status.

Variables found at clinical examination

1. Number of sound, missed, filled teeth (decay experience). This was scored in the CDHS by the 2003 criteria which states 'All teeth with cavitated or visual dentine caries, restorations with cavitated or visual dentine caries, teeth with filled decay (otherwise sound) and teeth extracted due to caries. Excludes teeth with enamel caries present. The term obvious decay experience relates to teeth with dental cavities, missing teeth and filled teeth in the DMFT dental decay index'.¹² To allow statistical testing, this was grouped into no decay experience and decay experience
2. Active decay
3. The measure used from the data set scored both cavitated and non-cavitated carious lesions. Again, this was grouped into two groups; no decay present and decay present
4. Indications of soft tissues lesions: ulceration, fistula or abscess (PUFA). This was used as measure of clinical consequences of untreated dental caries. The PUFA index records the presence of severely decayed teeth with visible pulpal involvement, ulceration due to tooth fragments, fistula and abscess. The results were grouped into: no PUFA lesion seen and PUFA lesion seen.

Parental report of child's oral health status

- Parent-reported child had toothache in last six months. Grouped into yes or no.

Parental report of the impact of child's oral health on family life

- Impact on family life of child's dental health in last six months. This information was gathered via seven questions taken from the Family Impact Scale.¹³

Parental report of child's behaviour related to oral health

1. Frequency of brushing teeth. This was grouped into children who brushed twice a day, as recommended, and those who brushed less than twice a day

2. Use of different oral hygiene product. For example, manual toothbrush, electric toothbrush, dental floss. This was grouped into if the child used the product or not
3. Usual dental attendance. This was grouped into children who attended for regular check-ups and children who only attended when in pain/never at all
4. Parent-reported child had general anaesthetic for dental treatment. Grouped into yes or no
5. Parent-reported child had sedation for dental treatment. Grouped into yes or no.

To calculate the size of the difference between the three population groups, Cohen's η^2 was used to establish if the difference was meaningful.¹⁴

Results

In the three categories, VAS scores 1–3 had 1,789 children (78%), VAS scores of 4–6 had 305 children (13%) and VAS scores of 7–10 had 195 children (8%). The socio-demographic variables are shown in Table 1. The percentages indicate the proportion of participants in each group. For example, in the group VAS score 1–3, 49% were male and 51% were female. There was no significant difference in terms of gender or eligibility for free school meals.

The variables related to the clinical examination of the participants (Table 2) showed that children who had higher VAS scores were more likely to have active decay, fillings in permanent teeth and evidence of previous decay experience. However, they were not more likely to have had primary teeth filled, or have teeth extracted due to decay. There was a suggestion that more anxious children have more signs of untreated dental disease (using the PUFA index) but this was not deemed as significant ($P = 0.005$).

The parent's report of the child's oral health status is reported in Table 3. Children who scored higher on the VAS were more likely to report having toothache in the last six months. Furthermore, the parent report of the impact of child's oral health on the family are shown in Table 4. It is noticeable that children whose parents rated them as dentally anxious also reported a significant impact on family life caused by the child's oral health.

The variables relating to oral health-related behaviour are shown in Table 5. Parents who reported that their children were dentally anxious were less likely to brush more than

Table 1 Socio-demographic features

		VAS score 1–3	VAS score 4–6	VAS score 7–10	χ^2	P value
Gender	Male	877 (49%)	147 (48%)	94 (48%)	0.1	0.949
	Female	912 (51%)	158 (52%)	101 (52%)		
Free school dinner eligibility	Yes	251 (14%)	48 (16%)	32 (17%)	1.5	0.479
	No	1,490 (86%)	251 (84%)	153 (83%)		

Table 2 Variables reported following clinical examination

Variable		VAS score 1–3	VAS score 4–6	VAS score 7–10	χ^2	P value
Number of teeth with active decay	0	1,277 (71%)	181 (59%)	107 (55%)	35.418	<0.002
	1 +	512 (29%)	124 (41%)	88 (45%)		
Number of permanent teeth filled	0	1,752 (98%)	289 (95%)	185 (95%)	16.1	<0.002
	1 +	37 (2%)	16 (5%)	10 (5%)		
Number of deciduous teeth filled	0	1,546 (86%)	234 (77%)	158 (81%)	0.7	0.419
	1 +	243 (14%)	71 (23%)	37 (29%)		
Number of teeth extracted due to decay	0	1,769 (99%)	299 (98%)	190 (97%)	3.7	0.154
	1 +	20 (1%)	6 (2%)	5 (3%)		
PUFA	No	1,652 (96%)	269 (91%)	177 (94%)	10.5	0.005
	Yes	72 (4%)	25 (9%)	11 (6%)		
Any decay experience	No	1,159 (65%)	147 (48%)	89 (46%)	51.1	<0.002
	Yes	630 (35%)	158 (52%)	106 (54%)		

Table 3 Parental report of child's oral health status

Variable		VAS score 1–3	VAS score 4–6	VAS score 7–10	χ^2	P value
Reported toothache in the last six months	Not mentioned	1,573 (88%)	276 (90%)	161 (83%)	18.5	<0.002
	No	216 (12%)	29 (10%)	34 (17%)		

Table 4 Affect of oral health of quality of life

Variable		VAS score 1–3	VAS score 4–6	VAS score 7–10	χ^2	P value
Has child's oral health impacted on family life?	No impact	1,439 (81%)	201 (67%)	106 (55%)	89.665	<0.002
	Some impact	331 (19%)	100 (33%)	87 (45%)		

twice a day or use fluoridated toothpaste in the last year. Children in the more anxious groups were also more likely to only attend when in trouble or not at all. Parents also reported that anxious children were more likely to have had a general anaesthetic for dental reasons. The same applies for children having sedation for dental reasons, although the cases were few.

For results deemed as statistically significant, Cohen's h was used to establish the size of the difference between the population groups (VAS score 1–3, VAS score 4–6, VAS score 7–10). Table 6 shows these results. The difference can be described as small if $h = 0.20$, medium if $h = 0.50$, and large if $h = 0.80$. Population groups were compared in pairs. While a number of comparisons showed a small effect size, only the impact of the child's oral health on family life in children with no, or mild, anxiety versus children with severe anxiety yielded a medium effect size.

Discussion

The results of this research suggest that dentally anxious children are more likely to have experienced more dental decay, attend the dentist infrequently and have treatment that carries more risk, such as a general anaesthetic. By analysing effect size, it is demonstrated that the oral health of dentally anxious children impacts far more on their family life compared to children with little dental anxiety.

However, the results of this study must be viewed with caution. The measures used to rate the child's anxiety have some major drawbacks. Firstly, grouping dental anxiety via the VAS method has less validation compared to other methods, such as a validated assessment or clinical judgement. Despite there being some evidence to support its use,¹⁵ other studies suggest that parents cannot accurately measure a child's anxiety.¹⁶ Indeed, there is some evidence to suggest that parents often rate their child's anxiety higher than the child does.¹⁷ In addition, much of the other data gathered is by proxy reports, but to some extent this is inevitable when gathering data from young children.

Previous research has highlighted a notable relationship between the child's and parent's dental anxiety levels, especially in the young age ranges examined here.¹⁸ The question should be raised that we may be measuring the parent's anxiety levels rather than the child. For example, the parent may misjudge the motivation behind the child's non-compliance, mirroring their

own anxiety on to the child. A young child's behaviour at the dentist is notably different to adults even if the child is not especially anxious. Additionally, there is also a suggested relationship between the child's oral health-related behaviours, such as toothbrushing, and the parent's own behaviour.^{18,19,20} As the child's caregiver is often in direct control of many of the factors listed here, such as dental attendance, sugar consumption and toothbrushing habits, future studies like the Child Dental Health Survey would greatly benefit from gathering data from the caregiver on their dental anxiety and oral health-related behaviours to establish if the child's oral health and oral health behaviour mirrors that of the caregiver.

The relationship between gender and dental anxiety has been documented before.^{8,18} However, this difference was not present in these young children. This may reflect: 1) emerging differences in gender relating to dental anxiety and age; and 2) the lack of an effective anxiety measure relating to the younger age groups.

Previous studies examining adults with dental anxiety suggest that higher dental anxiety is seen in patients of a lower socio-economic background.⁸ However, this is not demonstrated in this data analysis. Hieldari *et al.* also suggested that dental phobics are more likely to follow preventative regimes to avoid the need for dental treatment.⁸ This was not the case in our data analysis. However, the findings of the previous study are related to the use of mouthwash, which most children do not use universally as an oral hygiene measure.

This study does support previous literature that suggests the dentally anxious children are more likely to have tooth decay. It can be hypothesised that anxious children experience a higher rate of dental disease due to three factors. Firstly, differences may be due to a third factor related to dental anxiety and oral health. For example, dentally anxious children are less likely to brush their teeth more than once a day, leading to tooth decay, or use fluoridated toothpaste, suggesting that some children do not brush at all.

Secondly, there are differences in treatment approaches for phobic and non-phobic children. For example, practitioners may choose not to attempt to restore a tooth of a nervous child and elect for a preventative approach or wait until the child reports pain. Clinically, it is more difficult to adequately restore the teeth of children who suffer with dental anxiety, leading to extractions under

Table 5 Oral health-related behaviour

Variable		VAS score 1–3	VAS score 4–6	VAS score 7–10	χ^2	P value
Frequency of brushing teeth	Twice a day	1,507 (86%)	240 (79%)	142 (77%)	15.9	<0.002
	Once a day or less	253 (14%)	63 (21%)	43 (23%)		
Used manual brush in last year	No	195 (11%)	28 (9%)	34 (17%)	9.016	0.011
	Yes	1,594 (89%)	277 (91%)	161 (83%)		
Used electric brush in last year	No	981 (55%)	166 (54%)	113 (58%)	0.7	0.690
	Yes	808 (45%)	139 (46%)	82 (42%)		
Used toothpaste in the last year	No	55 (3%)	10 (3%)	20 (10%)	25.5	<0.002
	Yes	1,734 (97%)	295 (97%)	175 (90%)		
Used fluoride drops in last year	No	1,772 (99%)	303 (99%)	194 (99%)	0.6	0.748
	Yes	17 (1%)	1 (1%)	1 (1%)		
Used mouthwash in the last year	No	11,023 (57%)	175 (57%)	127 (65%)	4.6	0.101
	Yes	766 (43%)	130 (43%)	68 (35%)		
Used floss in the last year	No	1,676 (94%)	282 (92%)	187 (96%)	2.4	0.302
	Yes	113 (6%)	23 (8%)	8 (4%)		
Used disclosing tablets in last year	No	1,685 (94%)	289 (95%)	180 (92%)	1.4	0.50
	Yes	104 (6%)	16 (5%)	15 (8%)		
Used sugar free chewing gum in the last year	No	1,497 (84%)	246 (81%)	156 (80%)	3.0	0.222
	Yes	292 (16%)	59 (19%)	39 (20%)		
Pattern of attendance at dentist	For regular check ups	1,749 (98%)	287 (94%)	178 (92%)	30.4	<0.002
	Only when trouble/never	34 (2%)	17 (6%)	15 (8%)		
Reported that child had a general anaesthetic for dentistry	Yes	90 (5%)	29 (10%)	34 (17%)	47.881	<0.002
	No	1,699 (95%)	276 (90%)	161 (83%)		
Reported that child had sedation for dentistry	Yes	57 (3%)	22 (7%)	6 (3%)	12.060	0.002
	No	1,732 (97%)	283 (93%)	189 (97%)		

general anaesthesia. This is backed up by our data analysis, suggesting nervous children are more likely to have had dental treatment under general anaesthetic. Previous research has suggested methods to help the profession to fully engage with non-pharmacological

methods to help the nervous child cope with dental treatment.¹⁹ In addition, research by the authors of this paper has identified that the profession in general has a poor understanding of behavioural psychology principles.²⁰ Therefore, identifying effective

Table 6 Calculation of effect size using Cohen's h

Variable	Cohen's h VAS score 1–3 vs VAS score 4–6	Cohen's h VAS score 4–6 vs VAS score 7–10	Cohen's h VAS score 1–3 vs VAS score 7–10
Number of teeth with active decay	0.25	0.08	0.33
Number of teeth with permanent teeth filled	0.17	0	0.17
Any decay experience	0.34	0.04	0.38
Reported toothache in last 6 months	0.06	0.21	0.14
Impact of oral health on family life	0.32	0.25	0.57
Toothbrushing frequency	0.19	0.05	0.23
Used toothpaste in last year	0	0.3	0.3
Reported that child had a general anaesthetic for dentistry	0.19	0.20	0.40

non-pharmacological management techniques such as applied behavioural analysis could help benefit patients by allowing them to be treated without pharmacological interventions and thus have the benefits of restorative dentistry.

Thirdly, the difference in children's dental attendance pattern. Children in this study presented less regularly if they had reported dental anxiety. Previous research has highlighted that adult dental phobics tend to attend more irregularly.^{20,21} In this study, one would presume that the parents or caregivers are responsible for the child attending. Sadly, the data prevents us from drawing any firm conclusions about the reasons behind this. It may be due to a lack of knowledge about the importance of oral health and the need for regular check-ups, a preconceived belief about the inevitability of tooth decay or the parent avoiding the dentist due to their own dental anxiety. Further research is needed to fully explore these theories.

Conclusion

This study has helped to highlight some of the more obvious relationships between dental anxiety in children and factors relating to oral

health. It also highlights some of the differences between children and adults in this regard. As this work demonstrates, it may not be possible to simply look at dental phobia as a disease entity by itself. The links between poor oral health, pain only attendance and other factors needs to be fully explored via further statistical analysis to gain a true understanding of what the term 'dental phobia' fully means, rather than the simplified definition given in the *Diagnostic and Statistical Manual of Mental Disorders*. Further research in this field will help the dental profession gain a valuable insight into the nature of dental anxiety and related factors, and how the profession can aid these patients.

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Chapter 5 - The impact of dental anxiety on the oral health of children aged 5 and 8 years: A regression analysis of the Child Dental Health Survey 2013.

Submitted and Accepted for publication in the British Dental Journal.

Authors J.D. Coxon, M.T. Hosey and J.T. Newton

Title

The impact of dental anxiety on the oral health of children aged 5 and 8 years: A regression analysis of the Child Dental Health Survey 2013.

Abstract

Introduction. Dental anxiety and fear is widely prevalent in the population, including children. This research is a further analysis of the Child Dental Health Survey 2013, to explore the impact of dental anxiety on factors relating to oral health

Aim. To explore the relationship between dental anxiety and oral health and the impact dental anxiety has on the quality of family life.

Design. Regression analysis of data of 4916 children aged 5 years and 8 years who participated in the Child Dental Health Survey 2013.

Setting. National Epidemiological Survey in schools in the UK.

Materials and Methods. A series of logistic regression analyses was carried out for markers of oral health and impact of the child's oral health on the family's quality of life. The variables entered as predictors in the models included dental anxiety, socio demographic status and oral health related behaviours.

Results. Dental anxiety was associated with poorer oral health on nearly all measures (decay experience $p < 0.001$, active decay $p < 0.001$, primary tooth being restored $p = 0.010$, signs of oral infection $p = 0.007$) and had a greater impact on their family's quality of life ($p < 0.001$).

Conclusions. Dentally anxious children have more dental disease and this has a greater impact on their family's quality of life.

Introduction

Dental anxiety, dental fear and the more severe form, dental phobia, in children is well documented in the literature,⁽¹⁾ with a reported prevalence of dental fear ranging from 5.7% to 20.6%⁽²⁾ in children and adolescents. The management of this population group represents a sizeable challenge for the profession. However, unlike the adult population,^(3,4) only a few studies have been completed into the effect dental anxiety has on children's oral health and the impact this has on their families' day to day life⁽⁵⁾.

Dental fear and anxiety is defined as a feeling of dread and anticipation that something will happen, combined with a sense of losing control in relation to dentistry.⁽¹⁷⁾ Dental phobia is described as a more severe form that leads to an out of proportion reaction. This phobia interferes with daily life.⁽¹⁸⁾ For the purposes of this paper, the single term of dental anxiety will be used throughout to describe dental fear, anxiety or phobia.

Previous research has described the negative effect dental anxiety can have on the oral health of children^(19,20,21) and the effect it can have on family life.⁽²²⁾ The resultant poor oral health can often lead to distressing consequences such as frequent pain from untreated dental decay⁽²³⁾ and inevitable tooth removal.⁽²¹⁾

The data collected from the Child Dental Health Survey 2013(CDHS) presents a unique chance to further research the relationship between dental anxiety and factors relating to oral health. The CDHS takes place every ten years in the UK and has well established methodology and features a large sample size.

A previous study, by the present authors, performed a secondary analysis on the data set⁽⁶⁾. This study suggested that children with high levels of dental anxiety were more likely to experience dental decay and have had treatment that carries more risk, such as a general anaesthetic. In terms of oral health related behaviour, dentally anxious children were more likely to attend irregularly and are less likely to brush their teeth twice a day. It was also noted that the dentally anxious child's oral health seemed to impact more on the quality of family life, compared to non-anxious children.

However, this study didn't take other variables which are known to predict poor oral health into account. For example, numerous studies have linked poor socio-economic status with poor oral health⁽⁷⁾ and failing to follow a recommended oral hygiene regime, brushing twice a day with fluoridated toothpaste, were also not controlled for.

The aim of this study was to explore the relationship between dental anxiety and oral health and the impact that dental anxiety has on the quality of family life.

Materials and Methods

Data source

Data was gathered from the CDHS 2013. This survey is commissioned by the Health and Social Care Information Centre and occurs every 10 years. The children surveyed were 5 years, 8 years, 12 years and 15 years of age. The full methodology of the survey can be found in the technical report here:

<https://files.digital.nhs.uk/publicationimport/pub17xxx/pub17137/cdhs2013-technical-report.pdf>.

For the purpose of this study, data analysis took place on information gathered from the 5 year and 8 year old age groups.

Outcomes

A number of variables were considered as indicators of oral health status for this analysis.

The first outcome measure was the decayed missing filled index teeth (DMFT). This was scored according to the 2003 criteria which states "All teeth with cavitated or visual dentine caries, restorations with cavitated or visual dentine caries, teeth with filled decay (otherwise sound) and teeth extracted due to caries. Excludes teeth with enamel caries present. The term obvious decay experience relates to teeth with dentinal cavities, missing teeth and filled teeth in the DMFT dental decay index."⁽⁸⁾ This was grouped into no decay experience and decay experience.

The second indicator of oral health was the presence of active decay. This included both cavitated and non cavitated carious lesions and was grouped into two groups; no decay present and decay present.

The third outcome measure was the presence of soft tissue lesions. This was taken as an indicator of the clinical consequences of untreated dental caries, where there is a visible pulpal lesion, ulceration, fistula or abscess (PUFA index). This variable was grouped into a binary value: no PUFA lesion seen vs. any PUFA lesion seen

Also included as outcome measures were restorations present in primary teeth and teeth extracted due to decay. These were again grouped into binary variables: restorations present or not present and teeth extracted due to decay or no teeth extracted due to decay

The final outcome variable examined involved the parental report of the impact of the child's oral health on family life. This information was gathered via seven questions taken from the Family Impact Scale,⁽⁹⁾ and grouped into two groups; not effected or effected.

Predictors

Predictors of the above outcome measures were divided into socio-demographic variables, dental anxiety, and variables concerning oral health related behaviours. These variables were chosen following a bivariate descriptive analysis of the CDHS to establish factors which may have a relationship with dental anxiety. ⁽⁶⁾

Socio-demographic variables examined included the child's age (5 years or 8 years old), their gender and their socio-economic status. The CDHS 2013 survey used free school dinner eligibility as a measure of poor socio-economic status. Children are eligible for free school dinners if the parents claim unemployment benefits, an income related support allowance or have immigration status.

In this age groups the CDHS scored dental anxiety via the completion of a visual analogue scale (VAS), which was filled in by the parent and asked them to rate their child's dental anxiety, on a scale ranging from 1 (not at all anxious) to 10 (extremely anxious). The participants were grouped into 2 categories: VAS scores below the median value and VAS scores above the median value.

The oral health related behaviours were reported by the parent. Included were the participant's frequency of tooth brushing , grouped into children that brushed twice a day or more, and children who brushed less than twice a day. Also included were the participant's use of oral hygiene products such as a manual toothbrush, toothpaste and mouthwash, grouped into children who used the product and those who did not.

The participant's dental attendance patterns were also examined and grouped into children who were only brought to the dentist in pain or when in trouble, and those who attended for regular appointments.

The final predictors looked at additional pharmacological methods such as the use of sedation and previous experience of general anaesthetic for dental treatment. These were grouped into children with previous experience of these measures and those without.

Analysis

Using SPSS (version 25) a series of logistic regression analyses was carried out for each stated outcome variable. The statistical significance was assessed at the five percent level. An odds ratio was also calculated, stated as Exp (B) in the results tables. Cox and Snell's R^2 calculation was used to establish the coefficient of determination and used to summarise the proportion of variance in the dependent variable associated with the predictor (independent) variables. ⁽⁹⁾

Results

Data from 4916 participants was analysed, comprising of 2549 5 year olds and 2367 8 year olds. In terms of gender, the data included, 2435 males and 2481 females. Participants' anxiety scores, reported by their parents, ranged from 1-10 (none to extreme anxiety), with a median score of 1 with 1304 (57%) below or equal to the median and 985 (43%) above it.

Oral health status.

Predictors of previous decay experience, active decay being present and signs of oral infection being present are shown in Table 1.

Dental anxiety served as a predictor for the child having decay experience ($p < 0.001$), active decay present ($p < 0.0001$) and signs of untreated oral infection ($p = 0.007$). In addition, eight year old children or children of poor socio-economic status were more likely to have previous or current decay and oral infection. In terms of oral health related behaviours, children who brushed infrequently, those who did not use toothpaste, and children who only attended when in trouble were also more likely to have previous or current dental decay. Irregular attendance also predicted oral infection being present. A history of being treated with additional pharmacological measures (under general anaesthetic or with the aid of sedation) served as a predictor of the child having decay experience and active decay

Table 1 - Predictors of a child having decay experience.

		Decay experience (R ² = 0.094)		Active decay present (R ² = 0.065)		Signs of oral infection present (R ² =0.025)	
Predictor	Binary groups	Sig.	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)
Age	5 vs 8 years	<0.001	1.259	<0.001	1.169	<0.001	1.442
Gender	Male vs Female	0.054	0.837	0.241	0.894	0.764	0.940
Free school meal eligibility.	Eligible vs not eligible.	<0.001	0.691	0.004	0.685	0.011	0.527
Dental anxiety	Below average vs above average	<0.001	1.649	<0.001	1.518	0.007	1.773
Frequency of brushing teeth.	Twice a day or more vs once a day or less	0.001	1.489	0.002	1.466	0.547	1.170
Used manual toothbrush in last year	No vs Yes	0.132	1.265	0.066	1.354	0.280	1.514
Used toothpaste in last year	No vs Yes	0.012	0.469	0.008	0.458	0.745	0.834
Used mouthwash in last year	No vs Yes	0.148	1.154	0.195	1.141	0.730	1.079
Dental attendance of child	For check ups vs only when in trouble/never	0.011	2.068	0.001	2.524	0.003	3.212
Ever had general anaesthetic before dental treatment	No vs Yes	<0.001	2.257	<0.001	2.083	0.156	0.532
Ever had sedation before dental treatment	No vs Yes	<0.001.	3.086	0.004	1.977	0.511	1.323

In terms of reported dental treatment received, dentally anxious children are more likely to have primary tooth restored ($P= 0.010$, Table 2), as were 8 year olds, those who did not adhere to recommended oral hygiene regimes and those who received their dental care under sedation. Dental anxiety was not a significant predictor of having a tooth extracted. Aside from the use of general anaesthetic to aid dental treatment, only the non-use of toothpaste served as a predictor.

Table 2 – Predictors of a primary tooth being restored, and a tooth extracted due to decay.

		Primary tooth restored (R ² = 0.050)		Tooth extracted due to decay (R ² = 0.028)	
Predictor	Binary groups	Sig.	Exp(B)	Sig.	Exp(B)
Age	5 vs 8 years	<0.001	1.294	0.566	0.924
Gender	Male vs Female	0.197	0.853	0.913	1.043
Free school meal eligibility.	Eligible vs not eligible.	0.309	0.843	0.635	0.798
Dental anxiety	Below average vs above average	0.010	1.380	0.962	1.019
Frequency of brushing teeth.	Twice a day or more vs once a day or less	0.009	1.500	0.517	0.687
Used manual toothbrush in last year	No vs Yes	0.631	0.910	0.995	1.004
Used toothpaste in last year	No vs Yes	0.007	0.419	0.006	0.136
Used mouthwash in last year	No vs Yes	0.010	1.403	0.764	0.881
Dental attendance of child	For check ups vs only when in trouble/never	0.451	1.281	0.894	1.123
Ever had general anaesthetic before dental treatment	No vs Yes	0.471	1.172	<0.001	22.263
Ever had sedation before dental treatment	No vs Yes	<0.001	2.612	0.539	1.471

Impact of child's oral health on the quality of family life

Table 3 shows predictors of the impact of the child's oral health on the quality of family life. As well as dental anxiety ($p < 0.001$), predictors were an 8 year old child, not using toothpaste, infrequently attending the dentist, and the child requiring additional pharmacological measures to aid dental treatment (GA and sedation).

Table 3– predictors of the impact of child's oral health on the quality of family life.

Predictor	Binary groups	Sig.	Exp(B)
Age	5 vs 8 years	0.002	1.127
Gender	Male vs Female	0.236	1.136
Free school meal eligibility.	Eligible vs not eligible.	0.401	1.139
Dental anxiety	Below average vs above average	<0.001	2.278
Frequency of brushing teeth.	Twice a day or more vs once a day or less	0.423	1.121
Used manual toothbrush in last year	No vs Yes	0.516	0.893
Used toothpaste in last year	No vs Yes	0.005	0.431
Used mouthwash in last year	No vs Yes	0.571	1.067
Dental attendance of child	For check ups vs only when in trouble/never	0.011	2.091
Ever had general anaesthetic before dental treatment	No vs Yes	<0.001	2.599
Ever had sedation before dental treatment	No vs Yes	0.009	1.898

$R^2 = 0.069$

Discussion

In these age groups, dental anxiety predicted poorer oral health in measures such as decay experience, the presence of active decay and the presence of untreated dental infection. The only exceptions were oral health outcomes related to having a permanent tooth restored or having teeth extracted due to decay. This exception is probably due to the newly erupted permanent teeth having relatively little time

exposed to the oral environment. Higher levels of dental anxiety also predicted that the child's oral health had a greater effect on the quality of family life.

These findings are in accordance with the broader themes found in the literature related to adult populations; people with dental anxiety are more likely to have worse oral health that impacts on their quality of life ⁽⁴⁾. However, there are subtle differences that require explanation. For example, 5 and 8 year old children with dental anxiety were not more likely to have had a tooth removed due to decay. This is understandable given that the teeth have not been erupted in the mouth for a long period of time. Although anxious children are more likely to have untreated decay, it has not resulted in pulpitis or pulp necrosis. However, our data analysis suggests dental anxiety is related to an increase chance of a child having a soft tissue lesion as a result of untreated dental decay (PUFA index). This may be due to the anxious child's caregiver being less likely to present the child for examination and treatment at a dental surgery, or the practitioner may have decided to not extract the tooth due to likely poor co-operation.

There is surprisingly scant research in the impact of dental fear on the oral health of children and the impact the child's oral health has on their quality of life and the quality of family life. What limited research there is suggests a relationship between dental anxiety and poor oral health ⁽¹¹⁾ and has a negative effect on the quality of the life of the individual and family ⁽¹²⁾.

This study has limitations, most notably in the measures used to assess the child's dental anxiety. As mentioned in our previous study⁽⁶⁾, parental reports of the child's dental anxiety are fraught with inaccuracies. These relate to over reporting of a child's anxiety⁽¹³⁾, failing to differentiate between "normal" fear of a novel situation, or proper dental anxiety ⁽¹⁴⁾, or the parent's report on the child's anxiety mirroring their own anxiety ⁽¹⁵⁾. In addition, as opposed to adult dental anxiety measures such as MDAS ^(27,28), a visual analogue scale of dental anxiety has no validated cut-off to identify whether or not an individual is phobic.

The use of a by proxy VAS scale is therefore not ideal in the measurement of child anxiety. However, previous research suggests there is no ideal measure currently in use.⁽¹⁶⁾As such, efforts should centre on the development and validation of an adequate dental anxiety measure prior to the 2023 Child Dental Health survey. It should also be noted that some of the questions asked in the survey may also lead to inaccurate reporting. For example, does the parent understand if the child has experienced sedation or a general anaesthetic?

It is noticeable that in this regression model, deprivation, as scored by free school meal eligibility, mirrored dental anxiety in predictors of poor oral health. Both had a significant relationship with previous decay experience, the presence of active decay and signs of oral infection. This finding would indicate the importance of ensuring areas of social deprivation should be able to access dental services to build rapport

with the child and parent from an early age, by schemes such as “Baby Teeth Do Matter”. ⁽²⁵⁾

The family has a central role in a child’s health and any illness is likely to impact on family life ⁽⁸⁾ The results of this analysis suggest a child’s dental anxiety results in a detrimental effect on the quality of family life.

It can also be hypothesised that this impact on the everyday life of the family will affect the treatment planning process, with parents opting for a general anaesthetic. This concept does not seem too farfetched, especially when considering poor dental attendance is also a significant predictor. A child who is dentally anxious and attends infrequently is more likely to have oral infection that effects family life. In such a scenario, a parent may be more likely to choose extractions over more complex work.

Indeed, the parent’s own dental anxiety and beliefs about dentistry may alter their decision making. Further work is needed to look at the relationship between the quality of family life, the parent’s decision making regarding the child’s treatment, and the decision making of the dentist. For example, is the dentist advising treatment that is in the best interest of the child or the caregivers?

Although this regression is modelled on variables found to be of significance in our descriptive analysis of dental anxiety ⁽⁶⁾, it is notable that preventative regimes such as infrequent brushing and not using toothpaste are still significant predictors of poor oral health and a consequential detrimental effect on family life. Although not related to the primary aim of this study, this finding highlights the importance of preventative measures and schemes for young children such as “Designed to Smile”. ⁽²⁶⁾

This study highlights that children’s dental anxiety, even at aged 5 and 8 years old, is linked with clear health problems and there is a clear effect on the family unit. As such this study highlights the importance to the profession in preventing dental anxiety, even in these age groups, by utilising prophylactic measures such as the use of latent inhibition, where previously pleasurable experiences of the dental environment can prevent long term anxiety when exposed to a negative experience. This is possible by ensuring any trip to the dentist is as rewarding as possible.

Equally this study stresses the importance of attempting to resolve dental anxiety when it presents in the child, even at a young age. Although radical treatment such as the use of general anaesthetic can improve a child’s quality of life, it does little to resolve dental fear ⁽²⁴⁾. Simple behavioural management techniques such as positive reinforcement of desirable behaviour may help resolve dental anxiety before it impacts on an individual and their family. Although challenging to the dental team, dental anxiety and other associated factors related to poor oral health should be viewed by the profession as an opportunity to re-engage with the individual and their caregivers to ensure a positive outcome.

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Chapter 6 The oral health of dentally phobic 12 and 15 year olds: A descriptive analysis of the 2013 Child Dental Health Survey. Accepted for publication British Dental Journal

Authors J.D Coxon, M.T.Hosey and J.T. Newton

RESEARCH

The oral health of dentally phobic 12- and 15-year-olds: a descriptive analysis of the 2013 Child Dental Health Survey

James D. Coxon,^{*1} Marie-Therese Hosey² and J. Tim Newton¹

Key points

Suggests dentally phobic adolescent children are more likely to have dental decay.

Describes how the oral health of children with a dental phobia is more likely to impact on their everyday life compared to non-dental phobic children.

Argues dentally phobic children are less likely to show behaviour related to the prevention of dental disease, such as attending the dentist for regular examinations or brushing twice a day.

Abstract

Introduction Dental anxiety has been shown to be related to poorer oral health. Limited data exist exploring the relationship between oral health status and dental anxiety in non-clinical populations in children.

Aim To compare the oral health of phobic and non-phobic children aged 12 and 15 years.

Design Secondary analysis of data from 12-year-old and 15-year-old children in the Child Dental Health Survey 2013.

Materials and methods Participants were grouped into non-phobic and phobic groups, depending on their self-reported dental anxiety (MDAS). Descriptive analyses compared the two groups on social demographic factors, clinical status, self-reported oral health status, oral health-related behaviours and oral health impact.

Results A total of 601 children were classed as dentally phobic with 4,144 classed as non-phobic. Dental phobic children were more likely to be female, had more active decay and untreated dental disease, and rated their dental health as poorer. Phobic children were more likely to report that their oral health had a negative effect on their everyday life. This group were less likely to brush their teeth regularly or attend the dentist for check-ups.

Conclusions Dentally phobic children have more dental disease and express greater impact on their everyday life.

Introduction

A fear of dental treatment is well documented in both the adult and child population.^{1,2} Dental fear is defined as a loss of control and the anticipation that something traumatic will happen in relation to dentistry.³ Dental phobia is defined as a severe and out of proportion fear of dentistry leading to avoidance and impacting on everyday life.⁴ Previous research has suggested that dental fear in adults impacts on their daily life,^{5,6,7} leading to psychological distress and even increased time on sick

leave.^{8,9} The research into children's dental anxiety and its effect on the child's oral health and oral health-related behaviour is sparser.

The reported prevalence of dental anxiety in children differs, depending on the study, from 9% to 22%.^{3,10} Qualitative studies to examine what the child perceives when faced with the dental environment have been undertaken,¹¹ suggesting that a cognitive behavioural therapy assessment model may be useful to understand childhood dental anxiety and gain some insight in to what children perceive as aversive when attending the dentist. There have also been small-scale studies that suggest the child's oral health-related quality of life is worse if the child is dentally anxious.¹²

In the UK, the 2013 Child Dental Health Survey (CDHS) resulted in the publication of a broad overview on dental anxiety prevalence and relationships. Participants aged 12- and 15-years-old were asked to self-rate their anxiety levels and reported that 62% of 12-year-olds and 54% of 15-year-olds stated

they had anxiety when attending the dentist; a further 14% of 12-year-olds and 10% of 15-year-olds stated they had extreme anxiety.¹³ There was no reported relationship between eligibility to free school meals, a marker of social deprivation, but there was a difference between the genders, with girls more likely to report extreme anxiety.

The aim of this paper is to use the data generated by the highly refined methodology of the CDHS to perform a descriptive analysis of relationships between dental anxiety and gender, social deprivation, oral health status, oral health-related behaviours and oral health-related quality of life.

Materials and methods

The study constituted an analysis of the data that were gathered during the 2013 CDHS. This was the fifth in a series of surveys, completed every ten years, to look at the dental health of children in England, Wales and Northern

¹Faculty of Dentistry, Oral & Craniofacial Sciences King's College London; ²Paediatric Dentistry Centre of Oral Clinical and Translational Science Faculty of Dentistry, Oral & Craniofacial Sciences King's College London, London, UK. Correspondence to: James Coxon Email: j.coxon@kcl.ac.uk

Revised Paper.
Accepted 19 November 2018
DOI:10.1038/s41415-019-0196-8

Ireland. Questionnaires also allowed an insight into the children's experience of dentistry and their oral health-related behaviours and attitudes. Further details on the methodology of the 2013 Child Dental Health Survey are available online.¹⁵

Assessment of fear

Participants, aged 12 and 15 years, were grouped into non-phobic and phobic groups depending on their self-reported dental anxiety. This was scored using the Modified Dental Anxiety Scale (MDAS).¹⁴ This scale asked the participants to score how they felt in different scenarios, such as having a local anaesthetic, ranging from not anxious to extremely anxious on a five-point scale. Scores were summed and those participants with a total of 19 or above were ranked as phobic ($n = 601$), based on the work and validation of numerous studies.^{15,16,17} Scores below were ranked as non-phobic ($n = 4,144$).

Data analysis

Social and demographic variables, variables found at clinical examination, the child's self-reported oral health status, behaviours that impact on oral health and oral health impact variables were tabulated (Table 1) and grouped according to whether the children were phobic or not and analysed using SPSS version 25. A simple statistical analysis was conducted using cross tabulation and a chi-squared test. As multiple hypotheses were being tested, a Bonferroni correction was applied to allow for the increased chance of a rare event leading to incorrectly rejecting the null hypothesis. Following this correction, the result was deemed significant if $P = <0.002$. The variables chosen are listed in the following sections.

Social and demographic

1. Gender
2. Free school dinner eligibility. This was used by the CDHS as a measure of poor socio-economic status. Parents can claim free school dinners for their children if they claim unemployment benefits, an income-related support allowance or help due to immigration status.

Clinical findings

1. Number of decayed, missing, filled teeth (DMFT or decay experience), according to the 2003 criteria which states 'All teeth with cavitated or visual dentine caries, restorations with cavitated or visual dentine

Table 1 Social and demographic features of participants

Variable		12 year and 15 year age group: non-phobic	12 year and 15 year age group: phobic	χ^2	P value
Gender	Male	2,107 (51%)	181 (30%)	90.3	<0.002
	Female	2,037 (49%)	420 (70%)		
Free school dinner eligibility	Yes	938 (24%)	149 (27%)	1.8	0.179
	No	2,970 (76%)	411 (73%)		

Table 2 Clinical findings

Variable		12 year and 15 year age group: non-phobic	12 year and 15 year age group: phobic	χ^2	P value
Number of teeth with active caries	0 teeth	2,959 (71%)	375 (62%)	20.4	<0.002
	1+	1,185 (29%)	226 (38%)		
Number of permanent teeth filled	0 teeth	2,655 (64%)	377 (63%)	0.4	0.523
	1 + teeth	1,489 (36%)	224 (37%)		
Number of primary teeth filled	0 teeth	4,051 (98%)	587 (98%)	0.2	0.895
	1 + teeth	93 (2%)	14 (2%)		
Number of teeth extracted due to caries	0	3,853 (93%)	536 (89%)	10.9	<0.002
	1+	291 (7%)	65 (11%)		
PUFA	Yes	106 (3%)	33 (6%)	16.2	<0.002
	No	4,016 (97%)	561 (94%)		
Any decay experience	Yes	2,207 (53%)	242 (40%)	8.9	0.03
	No	1,937 (47%)	359 (60%)		

caries, teeth with filled decay (otherwise sound) and teeth extracted due to caries. Excludes teeth with enamel caries present. The term obvious decay experience relates to teeth with dentinal cavities, missing teeth and filled teeth in the DMFT dental decay index.¹⁸ This was grouped into two groups: no decay experience; and decay experience

2. Active decay present in the mouth. This included caries with cavitation and caries with no cavitation. This was grouped into two groups of no decay present and decay present
3. Indications of soft tissue lesions: ulceration, fistula or abscess (PUFA). This was used as

a measure of the clinical consequences of untreated dental caries, with the results grouped into: a) no soft tissue lesion seen; and b) soft tissue lesion seen.

Variables related to the child's own reported oral health status

These measures were gathered via a questionnaire given to the child:

1. Child's self-rated dental health, scored on a scale of one to five, rating from very good to very poor. The variable was divided into two groups: 'very good/good' and 'fair/worse'

- Child's self-rated general health, scored on a scale of one to five, rating from very good to very poor. The variable was divided into two groups: 'very good/good' and 'fair/worse'
- Child reported toothache in the last three months, scored 'yes' or 'no' and grouped accordingly
- Child reported sensitive tooth in the last three months, scored 'yes' or 'no' and grouped accordingly
- Child reported bleeding or swollen gums in the last three months, scored 'yes' or 'no' and grouped accordingly
- Child reported broken tooth in the last three months, scored 'yes' or 'no' and grouped accordingly
- Child reported mouth ulcers in the last three months, scored 'yes' or 'no' and grouped accordingly
- Child reported bad breath in the last three months, scored 'yes' or 'no' and grouped accordingly

Variables related to oral health-related quality of life

CHILD-OIDP, an oral health-related quality of life index for children.⁴⁹ This was broken down into eight aspects:

- Child reports difficulty eating in last three months
- Child reports difficulty speaking in last three months
- Child reports difficulty cleaning teeth in last three months
- Child reports difficulty relaxing or sleeping in last three months
- Child reports that they felt different in last three months
- Child reports difficulty smiling, laughing, showing teeth in last three months
- Child reports difficulty doing schoolwork in last three months
- Child reports difficulty enjoying being with people in last three months.

An overall score was then calculated.

Variables related to behaviours impacting on oral health

- Child reported frequency of toothbrushing. Data were divided into two groups: those who said that they brushed the recommended two times daily and those who said that they brushed once daily or less
- Child reported usual dental attendance. Data were divided into two groups: those who

Table 3 Child's self-reported oral health status

Variable		12 year and 15 year age group: non-phobic	12 year and 15 year age group: phobic	χ^2	P value
Self-rated dental health	Very good/good	2,947 (71%)	351 (59%)	38.6	<0.002
	Fair/worse	1,175 (29%)	244 (41%)		
Self-rated general health	Very good/good	3,599 (87%)	471 (79%)	28.7	<0.002
	Fair/worse	526 (23%)	124 (31%)		
Reported toothache in the last three months	Not mentioned	3,467 (84%)	482 (80%)	4.2	0.04
	Mentioned	676 (16%)	118 (20%)		
Reported sensitive tooth in the last three months	Not mentioned	2,789 (67%)	381 (64%)	3.3	0.071
	Mentioned	1,347 (33%)	217 (36%)		
Reported swollen or bleeding gums in the last three months	Not mentioned	3,416 (86%)	470 (78%)	6.2	0.013
	Mentioned	724 (14%)	130 (22%)		
Reported broken tooth in the last three months	Not mentioned	3,848 (93%)	545 (91%)	3.3	0.070
	Mentioned	294 (7%)	55 (9%)		
Reported mouth ulcers in the last three months	Not mentioned	3,306 (80%)	473 (79%)	0.4	0.519
	Mentioned	835 (20%)	128 (21%)		
Reported bad breath in the last three months	Not mentioned	3,403 (82%)	459 (76%)	12.1	<0.002
	Mentioned	743 (18%)	142 (24%)		

attended regularly for dental examinations and those who only attended when they had 'trouble with their teeth' or never attended

- Child reported consumption of sugary food, grouped into two groups: four or more times in a day and less than four times a day
- Child reported consumption of sugary drinks, grouped into two groups: four or more times in a day and less than four times a day
- Self-reported orthodontic treatment. Previous research has highlighted that children who have experienced orthodontic treatment tend to be less anxious.¹² Children were asked to report if they were having orthodontic treatment, if they have previously had orthodontic treatment or if teeth had been extracted for orthodontic

reasons previously.

Results

A total of 601 12- and 15-year-olds were classified as dentally phobic (12.7%) with 4,144 children classified as non-phobic (87.3%). Mean 12.43, SD 4.9. The socio-demographic variables are shown in Table 1. Girls were more likely to be classed as dentally phobic. Eligibility for free school meals, used as an indicator of socio-economic status, indicated that there was no association with dental phobia. The percentages stated refer to the proportion of participants in either the non-phobic or phobic group. For example, 51% of non-phobic children were male and 49% were female. In the phobic group 30% were male and 70% were female.

Table 4 Oral health-related behaviour

Variable		12 year and 15 year age group: non-phobic	12 year and 15 year age group: phobic	χ^2	P value
Frequency of brushing teeth	Twice a day	3,218 (78%)	413 (70%)	21.1	<0.002
	Once a day or less	889 (22%)	178 (30%)		
Pattern of attendance at dentist	For a check-up	3,439 (84%)	445 (74%)	33.9	<0.002
	Only when trouble/never	669 (16%)	156 (26%)		
Frequency of eating sugary food	Four times or more a day	2,624 (64%)	376 (63%)	0.2	0.631
	Less than four times a day	1,463 (36%)	219 (37%)		
Frequency of having sugary drink	Four times or more a day	1,296 (32%)	194 (34%)	0.5	0.469
	Less than four times a day	2,711 (68%)	379 (66%)		
Undergoing orthodontic treatment at time of survey	Yes	586 (14%)	68 (11%)	3.585	0.058
	No	3,544 (86%)	532 (89%)		
Appliance worn in past	Yes	359 (9%)	40 (8%)	3.325	0.68
	No	3,122 (90%)	477 (82%)		
Any teeth extracted for orthodontic reasons?	No	3,718 (90%)	543 (9%)	0.227	0.634
	Yes	426 (10%)	58 (9%)		

The variables found during the clinical examination are shown in Table 2. Phobic patients were more likely to have: i) active decay; ii) teeth extracted due to decay; and iii) a higher PUFA score. The reported oral health status of phobic versus non-phobic groups is reported in Table 3. Phobic children were more likely to have lower self-rated dental and general health, and self-reported bad breath.

Regarding the variables relating to quality of life, the phobic children reported more difficulty eating, cleaning teeth, and reported that they felt different and had difficulty smiling, laughing and showing teeth without embarrassment as well as difficulty enjoying being with people. A sum of the scores given for the questions related to oral health affecting quality of life (Child ODP) were analysed with Student's t-test and showed a significant difference in means between the phobic and non-phobic groups ($p = 0.001$).

The variables relating to oral health-related behaviour are shown in Table 4. Phobic children were more likely to brush less than twice a day and attend when only in trouble or not at all.

There was no demonstrable relationship between dental phobia and sugar consumption.

Discussion

The aim of this study was to assess the relationship of dental phobia and variables related to oral health. This study is among the first to assess this and utilised the data gathered from the well-planned 2013 Child Dental Health Survey. However, the use of MDAS as an anxiety measure may not have been ideal. The threshold value used to determine extreme dental anxiety has been validated on adult populations and may not be appropriate for use on the adolescent population group studied here.²⁰ However, some authors suggest there is no definitive anxiety measure for use with children.²¹

The overall picture described by the data is that dentally phobic children in these age groups are more likely to have dental-related disease. In addition, these data clearly suggest that the child's oral health impacts on their

quality of life, with phobic children reporting that they were more likely to have physical (eating, cleaning their teeth) and psychological (feeling different, embarrassed) difficulties. The prevalence of dental phobia in this population group is in line with the previous research. The relationship of dental anxiety and gender has been noted before,²² and previous research has highlighted that females are more likely to be dentally phobic.^{3,7}

There was no significant difference between the phobic and non-phobic children in relation to treated caries such as primary or permanent teeth filled. There was a difference between the DMFT of non-phobic versus phobic patients, but this was not deemed as significant ($p = 0.03$). There was no demonstrable relationship between orthodontic treatment and dental phobia.

These data clearly suggest that there is an impact of the child's oral health on their quality of life. Phobic children reported that they were more likely to have physical (eating, cleaning their teeth) and psychological difficulties (feeling different, embarrassed) due to their oral health. This is in keeping with other studies' findings on adults.^{5,23} Self-esteem generally decreases during adolescence,²⁴ but the impact of poor oral health on a child's self-esteem may lead to a greater effect on development over time. Further work needs to be undertaken to assess this.

Previous research has suggested that dentally phobic adults actively undertake preventative measures by using mouthwash.⁷ This does not seem to apply to these children, but children are less likely to use mouthwash compared to adults; indeed, in the UK children would not be able to purchase mouthwashes containing alcohol without assistance from a caregiver.

There is a demonstrable link between caries experience and dental phobia in this and other research.¹² It can be hypothesised that phobic children experience a higher rate of dental disease due to three possible factors. Firstly, the differences are due to a third factor related to phobia and oral health. For example, social class, which previous studies have shown a relationship between poorer oral health and an increased chance of dental phobia. However, this study showed no significant relationship between social class and phobia.

Secondly, there are differences in treatment approaches for phobic and non-phobic children. For example, dental phobics are more likely to choose a tooth extraction over

extensive oral rehabilitation. These data may support this hypothesis, with phobic children being more likely to have teeth extracted due to decay but no more likely to have teeth restored despite having more active decay or signs of untreated disease. Dentists may feel that there are fewer restorative options for phobic children, due to behavioural management problems. Recent research suggests that the level of behavioural knowledge of the profession is poor.²⁵ Improving the application of non-pharmacological behavioural management may allow more conservative treatment on this phobic population group.

Finally, the differences in attendance are a result of fear. The link between irregular attendance and dental phobia is well supported and it has been postulated that this is due to escape/avoidance behaviour leading to the patient being negatively reinforced, resulting in greater avoidance of the dentist in the future.^{26,27} However, with this age range the parents or caregiver are responsible for the child's attendance. We therefore must consider why the parent does not bring a child in need of treatment to the dentist. This may well be due to the parent not prioritising the child's oral health, a lack of knowledge about the importance of regular check-ups, or the parent avoiding the dental environment due to their own dental fear or fear of the dentist's criticism. Sadly, no data was available to analyse how the parent's anxiety affected the findings in this study. Further research is needed to fully investigate the reasons parents do not bring children to the dentist.

Conclusion

This research helps to provide a greater understanding of the oral health of dental phobics and demonstrates the need for the profession to investigate more fully the challenges faced by this population group. However, the amount of theories postulated above demonstrates that this simple descriptive

analysis has notable limitations. Therefore, there is a need to perform a multivariate analysis to fully understand the true relationships that we have touched upon here.

It is our opinion that this research demonstrates this population group face significant challenges due to dental anxiety, poor oral health and the significant impact this has on their self-esteem. Given the increasing evidence that behavioural therapies can lead to a long-term change in a person's beliefs about dentistry, this seems to be a sizeable tragedy.^{28,29} These interventions can lead to a long-term benefit for both the patient's health and the future economic burden on both the individual and the state.

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Chapter 7 - How does dental anxiety affect the oral health of adolescent? A regression analysis of the Child Dental Health Survey 2013.

Submitted and accepted for publication in the British Dental Journal

Authors J.D. Coxon, M.T. Hosey and J.T. Newton

Title

How does dental anxiety affect the oral health of adolescent? A regression analysis of the Child Dental Health Survey 2013.

Abstract

Introduction. Dental phobia has been widely studied but there is limited research on the effect of dental phobia on oral health. This research is an analysis of the 2013 Child Dental Health Survey, to explore the impact of dental anxiety on factors relating to oral health in the adolescents.

Aim. To examine if dental anxiety predicts poor oral health in 12 and 15 year olds.

Design. Regression analysis of data from 4950 children aged 12 years and 15 years who participated in the Child Dental Health Survey 2013.

Setting. National epidemiological survey of UK schools.

Materials and Methods. A series of logistic regression was carried out to examine if dental anxiety, socio demographic factors and oral health related behaviour could predict for oral health status, the impact of the child's oral health on their own quality of life and the impact of their oral health on the family's quality of life. Additional outcomes examined were self-perceived dental health and general health.

Results. Dental anxiety was not a predictor of poor oral health but did predict a greater impact of the child's oral health on everyday life. Adolescents with dental anxiety had negative thoughts regarding their dental and general health.

Conclusions. Dental anxiety effects the everyday life and psychological wellbeing of adolescents.

Introduction

Dental anxiety is wide spread, with a reported prevalence ranging from 5.7% to 20.6%.^(1,2) Unlike the adult population,^(3,4) there is little research into the effect dental anxiety has on children's oral health or the impact on their daily life. Dental phobia, is a more severe form of dental anxiety and classed according to the Diagnostic and Statistical Manual of Mental Disorders 5th Edition as "(i) a severe and out of proportion fear within a certain context to the presence or anticipation of a specific object or situation, (ii) the subject becomes immediately anxious following exposure to the stimuli. This may take the form of a situationally bound or situationally predisposed panic attack, (iii) the person is able to understand that the reaction is out of proportion, (iv) the subject avoids the situation or endures it with intense distress. (v) the subject's reaction to the fearful stimulus interferes significantly with the person's everyday life."⁽⁵⁾

There is evidence to suggest that individuals with dental phobia suffer from worse health than non-phobics. Epidemiological studies demonstrate a relationship between poor health and dental phobia,^(8,) although this is not as marked as in clinical studies.^(6,7,) A recent regression analysis of the adult dental health survey from the UK, showed a significant relationship between poor oral health and dental phobia.⁽⁴⁾ Studies in adults suggest that dental phobics often perceive their oral health to be worse than non-phobics.^(9,10) However, these subjective measures are often inaccurate, with individuals often over rating their dental need.⁽¹¹⁾ This may be due to the anxious participant's negative cognitions.

The psychological impact of poor oral health on daily life has been suggested in other studies including our own simple descriptive analysis of UK epidemiological data⁽¹²⁾ This has been noted previously in the adult population, with dental phobics reporting an effect on their emotional reactions, daily life and socialising.⁽¹²⁾ Small-scale studies also suggest that dentally anxious children's quality of life suffers as a result of their oral health.⁽¹⁴⁾

Our previous descriptive analysis (in press) highlighted that dentally phobic children were more likely to have dental disease, and their oral health impacted on their quality of life.⁽¹⁵⁾ However, this study failed to control for variables which are known to predict poor oral health. For example, the intake of cariogenic food, socio-economic status, and use of fluoride toothpaste. The aim of this study was therefore to conduct a regression analysis to examine if dental phobia was a predictor of poor oral health and the impact the child's oral health-on their quality of life.

Materials and Methods

Data source

Data was gathered from the CDHS 2013. This epidemiological survey occurs every 10 years in the UK, with children aged 5 years, 8 years, 12 years and 15 years surveyed. The full methodology of the survey can be found in the technical report here: <https://files.digital.nhs.uk/publicationimport/pub17xxx/pub17137/cdhs2013-technical-report.pdf>.

This study examined data gathered from the 12 year and 15 year old age groups.

Outcomes

Indicators of oral health status included the decayed, missing and filled teeth index (DMFT), the presence of active decay, previous treatment received and the presence of untreated infection.

The DMFT index was scored to the 2003 criteria which states “All teeth with cavitated or visual dentine caries, restorations with cavitated or visual dentine caries, teeth with filled decay (otherwise sound) and teeth extracted due to caries. Excludes teeth with enamel caries present. The term obvious decay experience relates to teeth with dentinal cavities, missing teeth and filled teeth in the DMFT dental decay index.”⁽¹⁶⁾ This was grouped into no decay experience and decay experience.

Active decay scoring included both cavitated and non cavitated carious lesions and grouped into two groups; no decay present and decay present. Other outcomes grouped into present and not present were restorations in permanent teeth, teeth extracted due to decay and signs of ulceration, fistula or abscess (PUFA). This PUFA index was used as an indicator of the clinical consequences of untreated dental caries.

Also included in the analysis were the participant’s report of their oral health related quality of life which utilising the Child Oral Impacts on Daily Performances,⁽¹⁷⁾ which has been validated for use in the UK. This measured the effect of oral health on eight aspects of daily life over the past three months, including problems eating; problems speaking; problems cleaning teeth; not being able to relax; feeling different; embarrassment smiling or laughing; trouble completing schoolwork; and difficulty appreciating being with people. These were grouped into two groups; not affected and affected.

The child’s self-rated dental health and self-rated general health was also analysed. This was scored on a scale of one to five rating and the variable was divided into two groups; very good/good and fair/worse

The final outcome measure was the parent’s report of the impact of child’s oral health on family life. This information was gathered via seven questions taken from the Family Impact Scale.⁽¹⁶⁾

Predictors

The predictors used were classified as socio-demographic, self rated dental anxiety, and oral health related behaviours.

Socio-demographic predictors where the participants age (grouped into 12 years or 15 years old), participant’s gender, and the socio-economic status of participant by utilizing free school dinner eligibility as a measure of poor socio-economic status. Children were eligible for free school dinners if the parents claim an income related support allowance, unemployment benefits, or due to immigration status.

The participant’s self rated score for dental anxiety was grouped into non-phobic and phobic groups using the Modified Dental Anxiety Scale (MDAS). This scale asked the participants to score how they felt in different scenarios on a five point scale. For example, having a local anaesthetic. Scores were then summed. Based on previous studies, participants with a total of

19 or above were ranked as phobic (n= 601) while scores below were ranked as non-phobic (n = 4144).

Predictors related to oral health related behaviours included the participant's frequency of tooth brushing, as reported by the participant were grouped into those that brushed twice a day or more, and those who brushed less than twice a day.

Also included were the participant's use of oral hygiene products such as manual toothbrush and mouthwash and their use of toothpaste in the last year. as reported by the parent. This was grouped into those who used the product and those who did not.

The self-reported dental attendance patterns were grouped into participants who were only brought to the dentist in pain or when in trouble, and those who attended for regular appointments.

Predictors incorporating additional pharmacological measures to aid treatment included previous experience of general anaesthetic and previous experience of sedation, grouped into children who had experienced these measures and those who had not. This data was gathered from parental reporting.

The intake of cariogenic food and drink was also used as a predictor. This was grouped into those who consumed sugary food and drink more than four times daily and those who did not.

Analysis

A logistic regression was carried out for each stated outcome variable using SPSS (version 25). This type of regression was deemed appropriate as the dependent variable is dichotomous (binary). The statistical significance was assessed at the 5% level. An odds ratio was also calculated, stated as Exp (B) in the results tables. To establish the coefficient of determination, Cox and Snell's R^2 calculation was used to summarise the proportion of variance in the dependent variable associated with the predictor (independent) variables.

Results

Data from 4950 participant's data was analysed, comprising of 2532 12 year olds and 2418 15 year olds. In terms of gender, the data included, 2377 males and 2573 females. Participants were grouped into a non-phobic group (4144, 87.3%) and a phobic group (601, 12.1%).

Oral health status.

Table 1 shows predictors of children who have had previous decay (decay experience), active decay and for signs of a dental infection (PUFA).

Dental anxiety was not a significant predictor for previous dental decay. ($p=0.925$). Children of lower socio-economic status were more likely to have experienced dental decay. In addition, children who had experienced decay were less likely to brush twice daily, did not use toothpaste in the last year and routinely had used a manual toothbrush. They were also more likely to have experienced pharmacological measures to aid dental treatment (sedation/general anaesthetic).

Dental anxiety was not a predictor for active decay ($p=0.612$). Variables deemed as significant were social deprivation and brushing infrequently. Having had a general anaesthetic for dental treatment predicted for active decay being present. Dental anxiety did not predict the presence of untreated dental infection ($p=0.493$)

Table 1 – predictors for previous decay experience, active decay present, and signs of untreated dental infection.

		Previous decay experience (R²= 0.068)		Active decay present (R²= 0.026)		Signs of untreated dental infection (R² = 0.016)	
Predictor	Binary groups	Sig.	Exp(B)	Sig	Exp(B)	Sig	Exp(B)
Age	12 vs 15 years	<0.001	1.189	0.272	0.956	0.003	0.537
Gender	Male vs Female	0.096	1.199	0.173	1.189	0.816	0.907
Free school meal eligibility.	Eligible vs not eligible.	0.01	0.588	0.003	0.622	0.323	0.612
Used manual toothbrush in last year	No v Yes	0.024	1.431	0.702	1.074	0.600	1.481
Used toothpaste in last year.	No vs Yes	0.033	0.566	0.051	0.572	0.997	19480190.265
Used mouthwash in last year	No vs Yes	0.458	1.089	0.214	1.184	0.242	1.750
Ever had general anaesthetic before dental treatment	No vs Yes	<0.001	2.558	0.027	1.467	0.422	0.544
Ever had sedation before dental treatment	No vs Yes	0.001	1.587	0.335	1.168	0.693	0.781

Table 1continued

		Previous decay experience (R ² = 0.068)		Active decay present (R ² = 0.026)		Signs of untreated dental infection (R ² = 0.016)	
Predictor	Binary groups	Sig.	Exp(B)	Sig	Exp(B)	Sig	Exp(B)
Dental anxiety levels	Non phobic vs phobic	0.925	0.984	0.612	1.104	0.493	1.485
Eats sugary food and drinks 4 times or more in a day	Yes vs No	0.778	0.970	0.160	0.835	0.872	0.934
Frequency of brushing teeth	Twice a day or more vs Once a day or less	0.018	1.392	0.011	1.478	0.120	1.990
Self reported dental attendance	Attended for check ups vs only attend when in trouble/never	0.871	1.032	0.084	1.423	0.688	1.304

Table 2 shows predictors for a child having had a restoration placed in a permanent molar and having had a tooth extracted due to decay.

Again, dental anxiety was not a significant predictor($p=0.397$). Female, 15 year old participants who were eligible for free school meals were more likely to have had a tooth filled. Adolescents were more likely to have teeth filled if they had experienced sedation or a general anaesthetic for dental treatment.

Dental anxiety was not a predictor of an individual having a tooth extracted due to decay ($p=0.316$). The analysis suggests that this was more likely to occur if the child is 15 years and attend infrequently and have had experienced general anaesthetic and sedation.

Table 2 – predictors of a restoration being placed in a permanent molar and tooth extraction due to decay.

		Restoration being placed in a permanent molar (R2 = 0.087)		Tooth extracted due to decay (R2 = -0.056)	
Predictor	Binary groups	Sig.	Exp(B)	Sig	Exp(B)
Age	12 vs 15 years	<0.001	1.384	<0.001	1.384
Gender	Male vs Female	0.022	1.315	0.022	1.315
Free school meal eligibility.	Eligible vs not eligible.	0.047	0.723	0.047	0.723
Used manual toothbrush in last year	No v Yes	0.251	1.222	0.251	1.222
Used toothpaste in last year.	No vs Yes	0.366	0.770	0.366	0.770
Used mouthwash in last year	No vs Yes	0.499	1.090	0.499	1.090
Ever had general anaesthetic before dental treatment	No vs Yes	<0.001	2.365	<0.001	2.365
Ever had sedation before dental treatment	No vs Yes	<0.001	1.872	<0.001	1.872
Dental anxiety levels	Non phobic vs phobic	0.397	0.850	0.397	0.850
Eats sugary food and drinks 4 times or more in a day	Yes vs No	0.452	1.093	0.452	1.093
Frequency of brushing teeth	Twice a day or more vs Once a day or less	0.352	1.153	0.352	1.153
Self reported dental attendance	Attended for check ups vs only attend when in trouble/never	0.0301	0.805	0.301	0.805

Impact of the adolescent's self-rated oral health on their quality of life and effect on quality of family life

Dental anxiety served as a significant predictor for the child's oral health effecting their quality of life ($p=0.020$). Table 3 shows other significant predictors were children who brushed infrequently, attended infrequently, and who had received sedation for dental treatment before.

In contrast to the negative effect dental anxiety has on an individual's quality of life, dental anxiety does not seem to impact on the quality of family life, as reported by the parent ($p=0.981$). Variables which were deemed significant were using mouthwash, not attending frequently, consuming cariogenic food and drink frequently and attending for a general anaesthetic and sedation.

Table 3– predictors of the child’s oral health impacting on their quality of life.

		Child’s oral health impacting on their quality of life (R² = 0.026)		Child’s oral health impacting on family quality of life (R² = 0.035)	
Predictor	Binary groups	Sig.	Exp(B)	Sig	Exp(B)
Age	12 vs 15 years	0.156	0.942	0.813	1.009
Gender	Male vs Female	0.156	1.202	0.658	1.052
Free school meal eligibility.	Eligible vs not eligible.	0.130	0.773	0.349	1.161
Used manual toothbrush in last year	No v Yes	0.255	0.814	0.953	1.010
Used toothpaste in last year.	No vs Yes	0.499	1.246	0.652	0.880
Used mouthwash in last year	No vs Yes	0.898	0.983	0.005	1.416
Ever had general anaesthetic before dental treatment	No vs Yes	0.200	0.929	0.023	1.451
Ever had sedation before dental treatment	No vs Yes	0.014	1.477	<0.001	2.005
Dental anxiety levels	Non phobic vs phobic	0.020	1.554	0.746	1.060
Eats sugary food and drinks 4 times or more in a day	Yes vs No	0.673	0.947	0.017	0.759
Frequency of brushing teeth	Twice a day or more vs Once a day or less	0.019	1.446	0.238	0.838
Self reported dental attendance	Attended for check ups vs only attend when in trouble/never	0.001	1.936	0.042	1.486

Predictors of self-rated dental health and general health.

Table 4 shows predictors of self-perceived dental and general health,. Dental anxiety was a significant predictor of poor self-rated dental health($p=0.012$). Lower ratings were associated with being younger, being male, and infrequently brushing teeth. Adolescents attending infrequently were three times more likely to report poor dental health.

Dentally anxious children were nearly twice as likely to rate themselves as having poor general health ($p= 0.004$). Brushing less than twice a day was also deemed as significant.

Table 4 – predictors of self-rated poor dental health and general health.

		Self rated poor dental health (R²=0.078)		Self rated poor general health (R² = 0.031)	
Predictor	Binary groups	Sig.	Exp(B)	Sig	Exp(B)
Age	12 vs 15 years	0.015	0.902	0.433	0.957
Gender	Male vs Female	<0.001	0.620	0.676	0.929
Free school meal eligibility.	Eligible vs not eligible.	0.205	0.803	0.176	0.741
Used manual toothbrush in last year	No v Yes	0.144	0.772	0.404	0.815
Used toothpaste in last year.	No vs Yes	0.416	1.288	0.462	1.401
Used mouthwash in last year	No vs Yes	0.093	0.801	0.921	0.982
Ever had general anaesthetic before dental treatment	No vs Yes	0.448	1.150	0.536	1.160
Ever had sedation before dental treatment	No vs Yes	0.155	1.265	0.855	1.042
Dental anxiety levels	Non phobic vs phobic	0.012	1.629	0.004	1.975
Eats sugary food and drinks 4 times or more in a day	Yes vs No	0.888	0.982	0.687	0.932
Frequency of brushing teeth	Twice a day or more vs Once a day or less	<0.001	2.506	<0.001	2.721
Self reported dental attendance	Attended for check ups vs only attend when in trouble/never	<0.001	3.077	0.123	1.494

Discussion

This analysis shows that higher levels of reported dental anxiety predicted that the oral health of the child impacted on their quality of life and predicted lower self-perceived dental health and general health. Dental anxiety did not predict poorer oral health on any of the variables measured here.

This study does have limitations, most notably related to the MDAS measure used to rate dental anxiety levels. This measure is well supported for use with adults but has not been validated on children and adolescents. In particular, the threshold value of 19 or above which is used to classify an individual as phobic has only been validated in the adult population ^(18,19).

Epidemiological surveys often tend to underreport the true effect of dental anxiety on oral health compared to clinical studies. ⁽²⁰⁾ The CDHS required positive consent from individuals and their caregivers to participate. Therefore, participants may not have consented to take part in this dental survey if they suffered with extreme dental anxiety, which led to data not being captured from this group.

In some areas, the results confirm the literature regarding children in other cultures ⁽¹⁴⁾ and in adult population. i.e. dental phobics state that their oral health impacts their daily life, affecting their function and social interactions. In addition, the relationship between dental anxiety and lower self perceived dental health shown here, echoes the findings in the literature on the adult population. ⁽¹¹⁾ As per the adult population, the socio-economic status of these adolescents also predicts the oral health status, with poorer children suffering from worse oral health.

The findings of this study, in relation to dental anxiety and oral health, contrast with previous studies in adult populations, which suggests poor oral health is associated with dental anxiety and phobia. This has been demonstrated in a wide range of studies. No measures of oral health analysed here demonstrated this relationship and also contrasts with similar studies in the paediatric population ^(26,2). Indeed, the findings of this regression analysis, with regards to oral health, contradict our own results from the secondary analysis of the data. ⁽¹²⁾ This highlights the importance of this regression analysis, where the effects of known predictors of poor oral health, like socio-economic status, are mediated.

Possible explanations for this finding may be

- 1) there has been insufficient time for the manifestations of dental phobia, such as avoiding the dentist, to show. Signs of poor oral health such as dental caries and infection associated with teeth occur over a relatively long period of time
- 2) Parent's and caregivers are, to a large extent, in control of their children's access to dental care. While there is qualitative evidence that suggests dentally anxious children place considerable pressure on their parents to not take them to the dentist ⁽²⁷⁾, we may not see the vastly different attendance patterns of phobic and non phobic population groups compared to adults.
- 3) As mentioned previously, the likely selection bias of an epidemiological study requiring positive consent may lead to an under reporting of dental phobia and poor oral health.

The dissonance between an individual's actual oral health and perceived dental health is in keeping with the negative thoughts, feelings and resultant physical symptoms of dentally anxious children found in qualitative research. ⁽²⁷⁾.

The overall picture this research paints is that dentally phobic children's everyday life is impacted by their perception of poor dental health. This may well lead to actual poor oral health in adulthood. The "Vicious cycle model" is well supported, with an individual's fear and anxiety leading to avoidance of dental treatment, leading to poor oral health, leading to feelings of shame and embarrassment. This continues in a downwards spiral. ⁽⁶⁾ The results shown here demonstrate the start of this cycle, where perceived poor dental health is leading to a negative impact on self-esteem ^(21,22).

As such, this study shows the importance of interventions to treat dental anxiety prior to the detrimental effect this causes on oral health in adulthood. Interventions can vary from simple techniques such as habituation via "tell-show-do", enhancing perceived control via stop signals and positive reinforcement of desirable behaviour ⁽²³⁾. For more severe cases of dental phobia, cognitive behavioural therapy has a good evidence base in the adult population and has increasing scientific support for its utilization with children ^(24, 25)

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Part 2 –The potential of ABA to help manage the behaviour of the paediatric dental patient.

Chapter 8 A review of the use of applied behavioural analysis related to paediatric dentistry

Reprint of publication in the Journal of Disability and Oral Health

Authors J.D Coxon, M.T.Hosey and J.T. Newton

8.1 Supplementary information

8.1.1 Overview of the chapter

As stated in the previous chapter's supplementary information, having established that dental anxiety is a significant problem for children and adolescents in the population of England, Wales and Northern Ireland, one can now look to see if ABA has the potential to help in its management and resolution in the dental environment.

As there has never been a review of studies involving ABA and paediatric dentistry, the first step was to conduct a structured review on the topic. This was completed and published in the Journal of Disability and Oral Health in June 2019.

8.1.2 Detailed methodology

Although the methodology is outlined in brief in the following paper, there is a need to expand on certain areas to allow replication in the future. The terms used in the electronic searches were agreed between Prof Tim Newton and myself to ensure that any literature that may have utilised ABA was likely to be included. Following these electronic searches papers not relating to paediatric dentistry (i.e. participants aged over the age of 16 years) were excluded. Papers were identified for inclusion following an independent review by Prof Newton and myself. There was no disagreement on what article should be included.

8.1.3 Findings of the literature review.

The total number of studies found in this structured review appeared to be low in number considering

- a) A number of behavioural interventions being advocated by BSPD and AAPD to manage paediatric patients in the dental chair.
- b) The range of studies relating to paediatric health care (section 1.4.3).

As in keeping with ABA methodology, most studies were single subject or consisted of a very small group. The participants were mostly under the age of 9, suggesting that ABA interventions may have a particular relevance to children who have yet to reach a particular stage of cognitive development.

All studies were conducted in the USA with the exception of Sanders and Jones' (1990) study in the management of anxiety associated with injections and Van Houten and Rolider's (1984) study on response prevention and nocturnal thumbsucking. Despite all the studies emanating from Western cultures similar to the UK, it is disappointing that no studies emanated from this country.

Although not included with in the following article, these papers were critiqued by making use of the "Evaluative Method", an assessment tool developed for use with single-subject experimental designs (Reichow et al 2008). This device uses quality indicators such as the ability to replicate methodology, results that can demonstrate experimental control, and an assessment of the studies' social validity. The results of this assessment are then entered into a formula that allows the study to be characterised as strong, moderate or weak.

The results of this critique are shown in table form in Appendix A. Overall, the majority of studies are rated as of 'adequate' quality with the most common shortcomings being the lack of blinding of outcome raters and the testing of the fidelity of the intervention. This probably reflects the very applied nature of the studies which seek to test interventions based in the environment which the behaviour occurs and are closely tied to clinical practice. In addition, in studies relating to disruptive behaviour in the dental chair, the dependent variable was not generally stable, either in the baseline phase or after the intervention was

introduced. This is likely to be due to some of the treatments (for example, injections) being more challenging than others. As such, many studies also reported an average dependent variable figure for baseline and intervention phases.

The majority of the studies described their methodology in a detailed manner to allow replication and were able to demonstrate experimental control. Most studies paid attention to the social validity of the outcomes, suggesting an attention to the value of the goals which the intervention sought to achieve.

8.1.4 Limitations of the literature review

This structured review does have limitations. It was notable when reviewing the papers chosen for inclusion that there were some referenced papers that would have been suitable for inclusion but published prior to the cut off date of 1984. A future review should consider the inclusion of papers from an earlier date if they are deemed relevant to the topic.

The exclusion of papers not presented in the English language may have also led to a narrowing of available studies in what already was a narrow field. However, this was not deemed to be a major limitation as this thesis was concerned about the possible use of ABA in the UK, so it made sense to only include studies which took place in cultures vaguely similar to the UK.

A future review should consider the inclusion of papers that are relevant to the challenges faced by the paediatric dental profession, although not labelled as paediatric dentistry. There are many areas of interest that may aid the oral health of children, such as ABA studies into dietary preference, behaviours related to good health and the keeping of appointments.

8.1.5 The place of this paper in the thesis narrative.

This literature review has demonstrated that although only numbering 19 papers, ABA has been utilised to resolve some undesired behaviours that are detrimental to oral health. This includes a number of studies that looked at interventions aiming to resolve the uncooperative behaviour of young patients undergoing dental treatment.

In some areas the quality of the studies could be improved. A number of papers used methodology that was not capable of establishing if there was a functional relationship between the dependent and independent variable. For example, the A-B study design of McMullen et al (2017).

Although present in the studies related to bruxism and digit sucking, the other papers did not utilise a functional analysis to establish what stimulus is likely to be maintaining the undesired behaviour. A functional analysis is highly recommended by many ABA authorities to allow a more targeted choice of intervention (Horner 1994).

When one reviews the interventions named in the review article and compares them to the guidelines listed by British and American paediatric dental bodies there are some clear omissions and indicate some areas that are ready for research in the future. These include interventions based on habituation (for example, tell-show-do and systematic desensitisation) and access to social reinforcement dependent on behaviour (parental presence). With regards to uncooperative behaviour in the dental chair, no studies named examined the use of positive punishment or negative reinforcement, as utilised in voice control and hand over mouth technique. However, the use of interventions such as these are controversial and many in the profession would, understandably, feel there is unethical.

A review of the use of Applied Behavioural Analysis related to paediatric dentistry

J Coxon,¹ M T Hosey² and J T Newton³

1. Senior Dentist, Porth Dental Teaching Unit, Qwm Taf Morgannwg University Health Board. 2. Professor of Paediatric Dentistry, Centre for Oral, Clinical and Translational Science, Faculty of Dentistry, Oral and Craniofacial Sciences, King's College London. 3. Professor of Psychology as Applied to Dentistry/ Honorary Consultant Health Psychologist, Faculty of Dentistry, Oral & Craniofacial Sciences, King's College London.

Abstract

Aim: To review and summarise published reports of the application of Applied Behaviour Analysis (ABA) in Dental Settings.

Methods: Search of Electronic Databases Medline and PsychInfo 1984 - October 2018 using specific keywords. Reviews and book chapters and reports of any study not adopting an ABA methodology were excluded. In addition a hand search was conducted of issues of the *Journal of Applied Behaviour Analysis* in this date range. Finally citations quoted in the reviewed papers were examined for articles deemed as suitable.

Findings: 19 reports of the application of ABA in dental settings were found. There were 12 multiple baseline designs, 4 reversible design and 3 A-B design. The targets for intervention were varied, with disruptive behaviour being the most commonly targeted. Other target behaviours of relevance to the paediatric dentist included bruxism and digit sucking. The most commonly adopted interventions included the use of reinforcement and punishment.

Conclusions: ABA has not been widely used in the dental setting despite the potential for the technique to demonstrate the efficacy of behavioural interventions. The available evidence demonstrates that a range of behavioural approaches are effective in changing potentially challenging behaviours.

Date Manuscript Received: 06/11/2018

Date Manuscript Accepted: 20/05/2019

Doi: 10.443/JDOH/Coxon/10

Introduction

Applied Behaviour Analysis (ABA) is defined as *"The science in which the analysis of behavior is applied systematically to improve socially significant behavior, and in which experimentation is used to identify the variables responsible for change in behavior"* (Cooper et al., 1987). We have previously described the science of Applied Behavioural Analysis (ABA: Coxon et al., 2019) and outlined the methods that it encompasses as well as the range of interventions which are commonly used within this framework. We have argued that ABA provides a valuable technique for the evaluation of interventions to encourage behaviour change at the level of

the individual client. This article will review published reports of the use of ABA in paediatric dentistry and discuss the implications of these findings for the future use of ABA.

Method

Two parallel electronic searches of PubMed and PsychInfo databases were undertaken for the period January 1984 to October 2018. The search terms for PsychInfo were (numbers in brackets indicate the number of manuscripts found):

- 1 dent*.mp. (14662)
- 2 exp Behavior Modification/ or exp Behavior Analysis/ or exp Behavior Therapy/ or applied behavior analysis.mp. (55893)
- 3 multiple baseline.mp. (4930)
- 4 reversal design.mp. (674)
- 5 exp Differential Reinforcement/ or changing criterion.mp. (1535)
- 6 2 or 3 or 4 or 5 (61029)
- 7 1 and 6 (229)
- 8 limit 7 to (human and english language and yr="1984 - Current") (137)

The Search Terms for Medline were (numbers in brackets indicate the number of manuscripts found):

- 1 dent*.mp. (511601)
- 2 Behavior Therapy/ or Applied behaviour analysis.mp. (26412)
- 3 multiple baseline.mp. (1562)
- 4 reversal design.mp. (288)
- 5 changing criterion.mp. (52)
- 6 2 or 3 or 4 or 5 (27714)
- 7 1 and 6 (809)
- 8 limit 7 to (english language and humans and yr="1984 - Current") (541).

A review of the titles and abstracts for the studies identified was undertaken by two authors (JC and JTN).

Following this initial review, a hand search of issues of the *Journal of Applied Behaviour Analysis* in the before mentioned date range was undertaken to scrutinise any articles that related to paediatric dentistry. Finally, the citations in the selected papers were examined to establish if any studies were suitable for review. Manuscripts which were reviews or book chapters, or which reported studies that did not adopt one of the ABA methodological designs were excluded. *Figure 1* shows the number of manuscripts identified at each stage of the review process.

Review

The review of the literature revealed 19 studies that could be said to research applied behaviour analysis related to paediatric dentistry (*Table 1*).

Study designs

The majority of the studies involved children under the age of seven years and the most common study design utilised multiple baselines across subjects. These studies are capable of demonstrating a functional relationship between an intervention and the chosen behaviour without the need to withdraw the intervention to see if there is a relapse. For example, this type of design has been used to demonstrate that the use of rewards can be used to decrease plaque levels by encouraging more efficient interproximal cleaning

Figure 1: Flowchart of electronic literature search

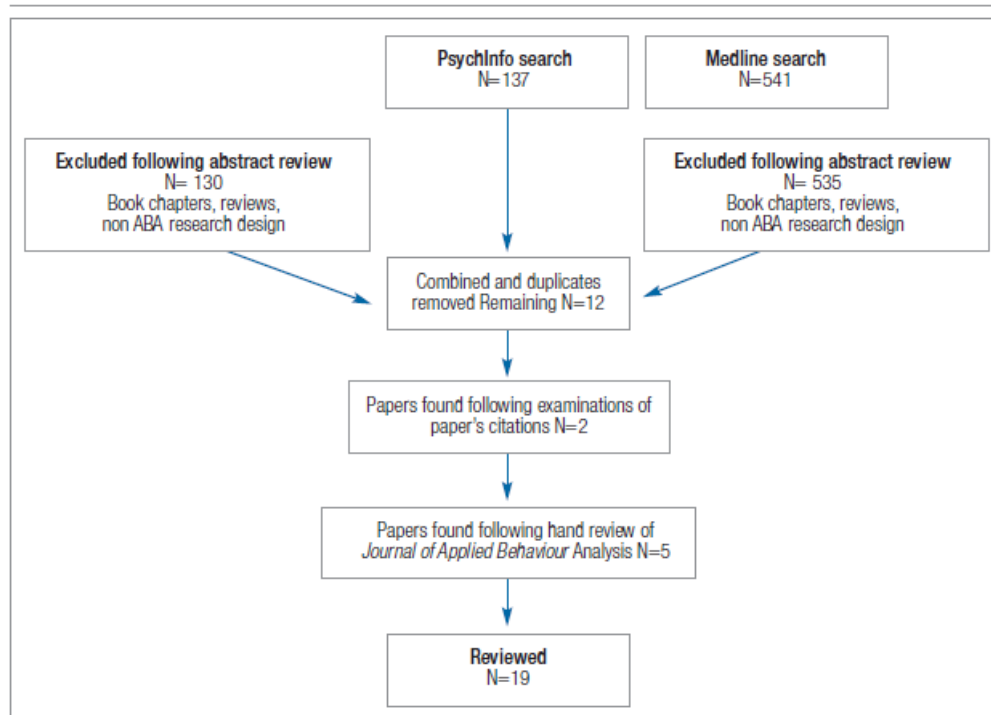


Table 1

Authors	Study Design	Target Behaviour (Dependent Variable)	Intervention (Independent variable)	Summary of results	Study Limitations
Long et al., (2013) Functional Analysis and Treatment of Diurnal Bruxism	1 Functional analysis of a five year old child with autism 2 Multiple baseline study across different settings	Bruxism	Differential reinforcement of an incompatible behaviour (saying therapist name). Positive reinforcement was via social interaction.	Functional analysis demonstrated social attention was maintaining the bruxism. Decrease in bruxism from 17% to 2% (the percentage of 10 second interval where bruxism occurred) with a continued decrease to 1% when measured 3 weeks later.	– Single case report of 5 year old boy but decrease seen when intervention introduced in each different setting. – The continuous reinforcement schedule may make implantation impractical. – Does not assess or state if intervention was effective in natural setting.
Armstrong et al., (2014) Functional Analysis and Treatment of the Diurnal Bruxism of a 16 year old girl with autism.	1 Functional analysis of a 16 year old child with autism 2 Alternating treatment design combined with a reversal design (ABAB)	Bruxism	Positive punishment constituting of: a Verbal reprimand b Physical punishment (3 seconds of downward pressure on jaw) c Combined verbal and physical punishment	Functional analysis indicated that behaviour maintained by automatic reinforcement. Decrease in bruxism in all 3 types of interventions. Some evidence of generalisation as there was a decrease in behaviour seen with different therapists.	– Single case report of 16 year old girl but decrease seen each time intervention introduced. – No stated figure on level of reduction although clearly visible of graph. – Does not discuss the inherent problems of using positive punishment – Does not assess or state if intervention was effective in natural setting.
Barnoy et al., (2009) Evaluation of multicomponent intervention for diurnal bruxism in a young child with autism.	1 Indirect functional analysis of a 6 year old child with autism. 2 Reversal design (BACB)	–	Two interventions: 1 Combined cue - verbal cue followed by positive physical punishment (3 seconds of downward pressure on jaw). 2 Verbal cue only.	Functional analysis indicated that behaviour maintained by automatic reinforcement. Decrease in bruxism during implementation of combined cue only.	– Indirect functional assessment which relied on the report of caregivers. – Not possible to say in physical punishment or verbal cue was responsible for decrease in behaviour. – Does not discuss the possible fall out of interventions based on positive punishment. – Lack of initial baseline measures led to a decrease in the ability to demonstrate a functional relationship between dependent and independent variables.
Van Houten and Rolider (1984) The use of response prevention to eliminate nocturnal thumb sucking	Experiment 1: Multiple baseline design across two children aged 9 and 7 years	Nocturnal thumb sucking	Response prevention (boxing glove faded to absorbent cotton bandage followed by fingertip bandage) with positive reinforcement and negative punishment	Decrease in thumb sucking to zero percent in all but one interval measured. Thumb sucking remained at zero percent throughout the fading of the prevention measures and during the two year follow up	– Observers parents whose scores were compared to give inter-observer reliability ratings, which may raise questions over their independence – Investigators stated that response prevention led to the minimum use of negative punishment but maximised the chances of using positive reinforcement – Stated limitation is that these findings cannot be generalised to daytime thumb sucking.
	Experiment 2: Multiple baseline design across three children, one aged 4 years and the two children aged six years.	Nocturnal thumb sucking	Two interventions a) Positive reinforcement via token economy. b) Response prevention and positive reinforcement via token economy	Positive reinforcement had a varied effect on thumb sucking behaviour with a marked decrease in one participant but little to no effect in the other two. Adding response prevention led to an almost complete elimination of thumb sucking behaviour which continued 6 months following the withdrawal of the intervention	
	Experiment 3: Multiple baseline design across three subjects aged 8, 7 and 4 years old.	Nocturnal thumb sucking	Response prevention (absorbent cotton restraint faded to fingertip bandage) and positive reinforcement via token economy	Implementation of the intervention led to an almost total elimination of thumbsucking which continued following the withdrawal of the intervention.	

Table 1 (...continued...)

Authors	Study Design	Target Behaviour (Dependent Variable)	Intervention (Independent variable)	Summary of results	Study Limitations
	Experiment 4: Multiple baseline across two children aged seven and four years.	Nocturnal thumb sucking	Response prevention (absorbent cotton restraint) and positive reinforcement via token economy	Implementation of the intervention led to a total decrease in thumbsucking, but this behaviour returned in one the subjects following the intervention withdrawal.	
Ellingson <i>et al.</i> , (2000) Analysis and treatment of finger sucking	1 Functional analysis 2 Multiple baseline across two children (7 year old and 10 year old).	Finger sucking.	Two interventions 1 Response prevention (glove faded by gradually cutting back fingertips) 2 Positive punishment via a loud noise contingent on the finger being placed in the mouth by use of an awareness enhancement device (for one participant only).	Functional analysis suggested that finger sucking was maintained via automatic consequences of oral and digital sensory feedback. The use of response prevention led to an almost total decrease in one participant through extinction. The use of response prevention resulted in only a moderate suppression in the second participant but the addition of positive punishment resulted in a total suppression in the long term.	– Not possible to draw concrete conclusion on the effectiveness of positive punishment due to the use of a treatment package involving response prevention first. – No discussion on the possible side effects of positive punishment.
Stricker <i>et al.</i> , (2001) Evaluation of an awareness enhancement device for the treatment of thumb sucking in children.	1 Functional analysis 2 Reversal design on two subjects with attention deficit hyperactivity disorder aged 7 and 14 years.	Thumb sucking	Positive punishment via a loud noise from an awareness enhancement device	Functional analysis suggested that behaviour is maintained via automatic reinforcement. The positive punishment intervention resulted in a total elimination of the thumb sucking behaviour	– The results do not indicate if the cessation of thumb sucking continued once the intervention had been withdrawn or if generalisation occurred in different environments. – No discussion as the possible side effects of punishment based measures.
Allen <i>et al.</i> , (1988) Reinforced practice of children's co-operative behaviour during restorative dental treatment	Multiple baseline design across two 3 year old children.	Co-operative behaviour in the dental chair	Two stages 1 During "practice appointments" ; a) negative reinforcement via escape contingent on the child remaining still for the required length of time.b) positive reinforcement via stickers placed on card on dental lamp during treatment 2 During treatment with the dentist; shaping via positive reinforcement (inexpensive toy) contingent on a 15 percent improvement from previous visit or if there was less than 30% disruptive behaviour	Baseline measurements showed disruptive behaviour to be almost 100% which reduced to levels less than 30% following the introduction of positive reinforcement. If the participant did not meet criteria for reinforcement during treatment their desirable behaviour increased during the next visit.	– Dentist not blind to procedure although their rating of the child's behaviour correlated with the direct observations recorded. – No follow up following withdrawal of the intervention although comments from the patient's family dentist stated children more co-operative but still a question if the behaviour generalised.

Table 1 (...continued...)

Authors	Study Design	Target Behaviour (Dependent Variable)	Intervention (Independent variable)	Summary of results	Study Limitations
Blount and Stokes (1984) Contingent public posting of photographs to reinforce dental hygiene	Multiple baseline across subjects in the two school class groups (A and B) of approximately 7 years old.	Effective tooth brushing	Two interventions 1 Instruction given to where plaque was still present and verbal praise if plaque levels low 2 Instruction and reinforcement via the public postings of their photograph at the front of the class room.	In class room A reduction in plaque scores from a mean of 2.0 (scored from the simplified oral hygiene index) to 1.8 during the instruction intervention, with a large decrease in plaque scores to 1.1 once the reinforcement intervention introduced. In class room B a reduction in plaque scores from a mean of 2.0 to 1.8 during the instruction intervention followed by a large decrease to 1.2 on the implementation of the reinforcement based intervention	- Noted that teachers stated this intervention may not be practical without additional assistance. - No evidence that the child toothbrushing behaviour continued following the removal of the intervention.
Allen and Stokes (1987) Use of escape and reward in the management of young children during dental treatment	Multiple baseline study across five children aged between 3 and 6 years.	Disruptive behaviour.	Negative reinforcement of desired behaviour (lying still in presence of scary stimuli) to shape desired behaviour during practice sessions. Positive reinforcement with changing criterion to shape desired behaviours.	Each participant showed a reduction in disruptive behaviour following the introduction of the intervention. For example, one child decreased from 88% disruptive behaviour to only 6%. All children showed at or below 15% level of disruptive behaviour by the time the dental treatment was completed.	- Noted that behavioural change may be due to habituation but argued that patients generally become sensitised to treatment over time. - How feasible would this intervention be in a busy practice? - The baseline measures included an element of positive reinforcement contingent of desirable behaviour being shown. This was deemed as ineffective but how salient was the reinforcer and was the reinforcer presented quickly after the desirable behaviour occurred?
O'Callaghan PM, Allen KD, Powell S, Salama F. (2006) The efficacy of non contingent escape for decreasing children's disruptive behaviour during dental treatment.	Multiple baseline across five children aged between 4 and 7 years old.	Disruptive behaviour	Operant extinction via non contingent escape from dental treatment to shape co-operative behaviour for 1 minute	Four children showed a marked decrease in disruptive behaviour following the introduction of non-contingent escape by on average 56%. One child showed only a minor difference in disruptive behaviour following the introduction of the intervention. However, this child did show a decrease in physically disruptive behaviour (from 43% to 5%) from baseline to treatment phase. The child's verbal disruption increased in the treatment phase.	- This led to a dramatic decrease in the need to restrain patients. - The dentist used positive reinforcement in the form of praise and this may have interacted with the negative reinforcement. - No systematic approach to thinning the schedule of reinforcement.
Allen, KD, Loiben T, Allen S, and Stanley RT (1992) Dentist implemented contingent escape for the management of disruptive child behaviour	Multiple baseline across four children aged between 3 and 7 years	Disruptive behaviour	Contingent negative reinforcement via escape from dental treatment contingent on co operative behaviour to shape co-operative behaviour that last 10s-20s	Decrease in disruptive behaviour especially where dentist followed the approximate escape contingency from a mean of 75% to 15.3%.	- The dentist involved found it difficult to keep to criterion and often fell back on traditional management techniques. - There could be safety issues on the need to not allowing escape while the child is very disruptive.
Strark <i>et al.</i> , (1989) Distraction: it's utilization and efficacy with children undergoing dental treatment	Multiple baseline across four children aged between 4 and 7 years.	Disruptive behaviour	Distraction stimuli (audiotaped story that related to colourful poster) with positive reinforcement for paying attention to distraction stimuli	Immediate decrease in disruptive behaviour by an average of 34.25% but with increase in disruptive behaviour in the two children who required further treatment despite distraction.	- Failure of intervention in the long term may be due to the patient being able to show distractive behaviour whilst paying enough attention to story to gain the "prize". - Following the interventions initial use, had the distraction become a conditioned stimuli to an aversive event.

Table 1 (...continued...)

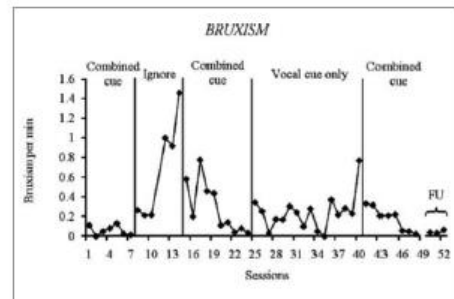
Authors	Study Design	Target Behaviour (Dependent Variable)	Intervention (Independent variable)	Summary of results	Study Limitations
Dahlquist LM and Gil KM (1986) Using parents to maintain improved dental flossing skills in children.	Multiple baseline across four children aged seven and eleven years.	Improved flossing technique to remove interproximal plaque	Instruction on correct flossing technique Positive reinforcement to shape optimal flossing technique. With prompts, and self-monitoring.	Significant long term decrease in interproximal plaque levels following intervention, from mean baseline measures of 75% to 94% down to 28% to 59% during the treatment phase. During the follow up assessment scores remained low (ranging from 23% to 54%).	– Due to nature of recruitment, participants parents may have been more conscious of dental health than average and easier to motivate. – The package intervention is time consuming and complicated. – No use of gingival inflammation as a measure, so possible subject just flossed more effectively before experimenter visited
Dahlquist <i>et al.</i> , (1984) The effects of Behavioural Intervention on Dental Flossing Skills in Children	Multiple baseline across three children aged nine years.	Improved flossing technique to remove interproximal plaque	Instruction on correct flossing technique Visual prompts Rewards for saving used floss Positive reinforcement to shape optimal flossing technique	Best results were obtained by shaping optimal flossing technique by positive reinforcement. A decrease was seen from the 58% to 73% plaque levels seen at baseline, down to 12% to 25% once the criterion based reinforcement intervention was introduced.	– Specifically reinforcing the desired behaviour (the removal of plaque rather than just using floss) showed the largest improvement. – Package intervention (corrective feedback and criterion based reinforcement) makes it difficult to assess what specific intervention caused the behaviour to change.
Kiesges <i>et al.</i> , (1984) The effects of graded exposure and parental modelling on the dental phobias of a four year old girl and her mother	Single case non reversible design on a four year old child.	Used subjective units of discomfort scale to measure anxiety	Graded exposure and parental modelling	Large reduction in child's dental anxiety, from a mean of 77 to 6 using the subjective units of discomfort scale (SUDS) and from 4.36 to 2.45 using the Dental Fear Survey Schedule. The mother's dental anxiety also improved despite minimal active intervention	– Not possible to demonstrate functional relationship due to nature of design. – No direct measurement of behaviour, just mother's assessment of her child's discomfort.
Sanders, MR Jones, L. (1990) Behavioural treatment of injection, dental and medical phobias in adolescents: A case study.	Multiple baseline across settings for a 13 year old child.	Number of hierarchy steps completed whilst participant stayed relaxed.	Systematic Desensitisation and counter conditioning using reinforcement of an incompatible behaviour	Functional relationship demonstrated between ability to tolerate dental and medical treatment and systematic DSCC	– Procedure did not generalise well from one setting to another.
Pal, K (1986) Children's dental diet. The short-term effects of a behaviour modification program.	Six phase reversal design	Diet	Instruction Positive reinforcement.	Positive reinforcement intervention decreased the consumption of cariogenic food.	– Findings match well supported theories that information on its own does not result in behavioural change due to confused message and a delayed consequence.
Cipes <i>et al.</i> , (1986) Monitoring and reinforcement to eliminate thumb sucking	Single subject AB design	Thumb sucking	Positive reinforcement with sticker chart and verbal praise 50% of parents also chose to give further reinforcement if reached criteria.	Decline in thumb sucking	– AB design not possible to demonstrate a functional relationship.
McMullen <i>et al.</i> , (2017) Using Prediction and Desensitization Techniques to Treat Dental Anxiety: A Case Example.	Single subject A-B design with a 5 year old child with Down's syndrome.	Co-operation during dental examination	Desensitisation	Increase in co-operative behaviour from zero percent during baseline measurement to 71% during the last treatment visit post intervention.	– AB design not possible to demonstrate a functional relationship

(Dahlquist and Gil, 1986). Figure 2 shows how plaque scores decreased following the intervention. This consisted of a) training the children to floss their teeth via modelling and corrective feedback b) Providing cues to help remind the participant to floss their teeth c) Rewarding the participant for using the floss and achieving certain plaque score. The criteria for reinforcement changed over time to help shape an effective flossing technique. As is shown, the plaque levels decrease every time the oral hygiene intervention is introduced at different times for each participant.

Other studies utilised a reversal design, such as Barnoy *et al.*, (2009) which examined the effectiveness of verbal cues and positive punishment via physically pressing down on the child's chin for a short duration of time if the child ground their teeth (Figure 3).

In this study an informal functional analysis had established that the 6-year-old child's bruxism was automatically reinforced; the behaviour was maintained by the natural reinforcement of the child grinding and not due to gaining social attention or to escape from a demand placed on them. As can be seen, the combined intervention of a verbal cue and physically pressing down on the child jaw led to a decrease in bruxism. However, this returned once the first intervention had been withdrawn. Reimplementing the intervention led to decrease to previous levels. A second intervention was then added, in this case just the verbal cue. This led to an increase over time, possibly due to the verbal cue no longer being associated with the physical punishment.

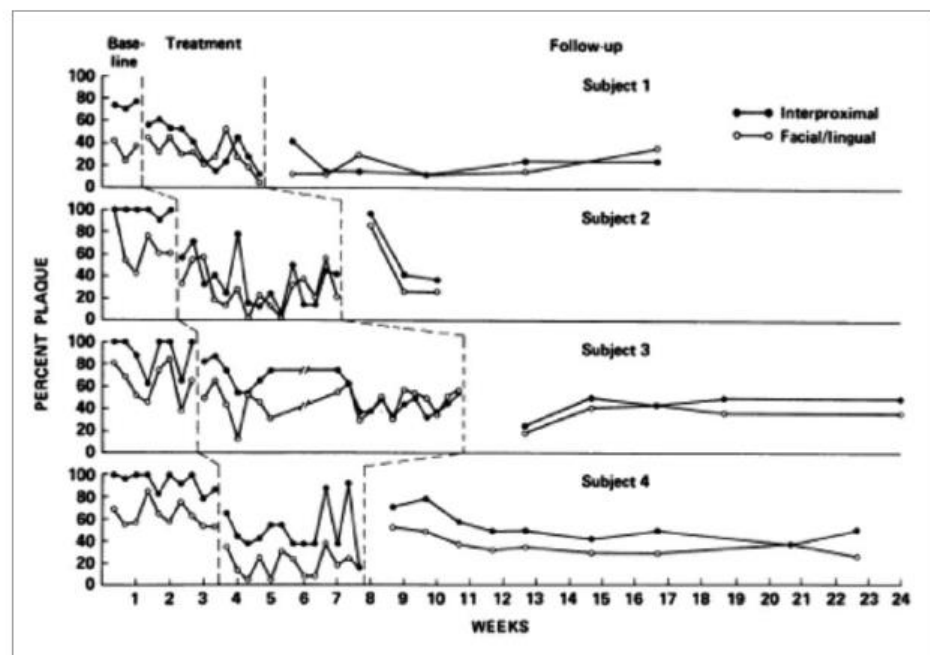
Figure 3: Example of a BABCB reversal design; Bruxism per minute for a 6 year old child with autism during the combined cue intervention (B), baseline(A), combined cue intervention(B), vocal cue only intervention(C), combined cue intervention(B) and follow up (taken from Barnoy *et al.*, 2009).



In classical conditioning this is termed extinction. Finally, reimplementing the combined intervention led a decrease to previous low levels.

Some of the other studies designs were not able to demonstrate a functional relationship between the intervention and the chosen behaviour. For example, Klesges *et al.*, (1984) used a non reversible design to study dental anxiety of a 4-year-old by graded exposure and modelling.

Figure 2: Experimenter assessed Interproximal and facial/lingual percentage plaque across baseline, treatment and follow up (taken from Dahlquist and Gil 1986).



After baseline measures were taken, the interventions were introduced and the effects noted. Any conclusions drawn from the results must be tempered by the multiple threats to validity (for example, Hawthorne effect) and the lack of information on the natural progression of the behaviour under study (Gast and Hammond, 2010). For example, the 4-year-old participant may have become habituated to the dental environment without any intervention needed.

Behaviour studied

Although some studies look at cognitive measures such as anxiety, the prime purpose of ABA is to study measurable behaviour. One of the main areas of research undertaken in this field relates to disruptive behaviour in the dental chair while undergoing treatment. Examples of interventions have included the reinforcement of non disruptive behaviour (Stokes and Kennedy, 1980), the use of distraction techniques (Stark *et al.*, 1989).

Other behaviours of interest to the paediatric dentist have been considered, such as bruxism (for example Lang *et al.*, 2013), digit sucking (Cipes *et al.*, 1986) and improving oral hygiene (Dahlquist *et al.*, 1984).

In terms of socially significant behaviours, there does seem to be some omissions. The literature review found no studies that looked at interventions to increase the attendance of paediatric patients at dental clinics, and only one intervention related to the intake of cariogenic food (Pal, 1986) although a wider search non-dental related to these areas is likely to have yielded further studies.

Type of intervention

The ABA interventions were defined under the principles of learning theory. The majority of the interventions could be described as contingency management i.e. the addition of an appetitive or aversive stimulus following the presentation of a defined behaviour. For example, Pal (1986) used positive reinforcement via pre-negotiated rewards to change the dietary intake of six children. It should be noted that effective positive reinforcement requires the threat of removing the anticipated reward (negative punishment).

There was a surprising number of interventions that could be described as positive punishment; that is the addition of an aversive stimuli that results in future decrease in the target behaviour. Examples of this include treating diurnal bruxism via verbal reprimand and therapist pressing physically downwards on the child's chin (for example Barnoy, 2009). In addition, other studies that examined digit sucking utilised positive punishment via the use of an electronic device that emitted a loud aversive noise if the child hand approached their mouth. There are obvious ethical concerns with such approaches. Previous research has highlighted that positive punishment is likely to give rise to many unintended and detrimental consequences if applied incorrectly (Axelrod, 2013).

Behaviours which were deemed to be maintained by automatic reinforcement, such as nocturnal digit sucking, were often treated with response prevention measure to decrease the likelihood of a child displaying the undesired behaviour. In the case of nocturnal thumb sucking, a glove

was often used which was then faded over time to a small finger bandage. This served two purposes. Firstly, it placed the behaviour on extinction, by breaking the association between behaviour and reinforcement. Secondly, it allowed the child to be reinforced and rewarded at a higher frequency for going through the night without sucking their thumb.

There were a number of studies on negative reinforcement (the removal of an aversive stimulus). Focused on disruptive behaviour, studies by Allen and Stokes (1987) and Allen *et al.*, (1992) have looked to shape desirable behaviour through

Figure 4: Percentage of 15 second intervals containing disruptive behaviour per 3 minute intervals. Dashed lines indicate a separate visit to the surgery. Shaded areas indicate the mean disruptive behaviour per visit (taken from Allen *et al.*, 1992).

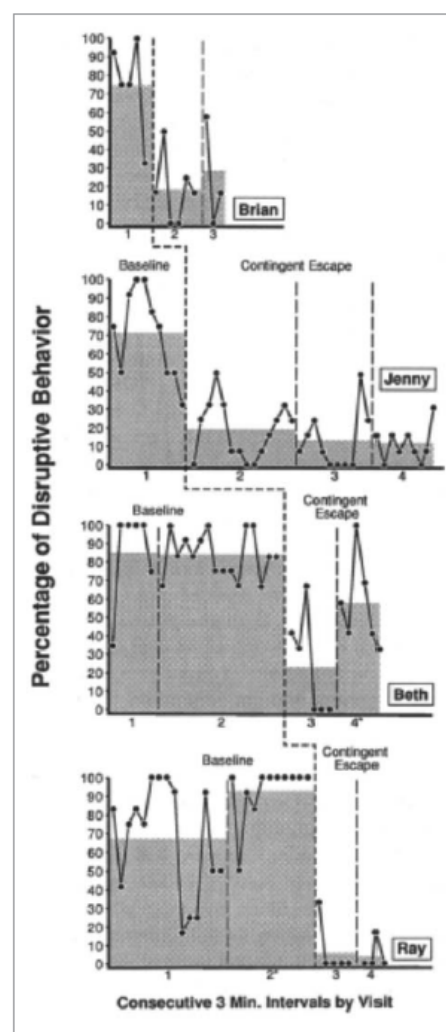
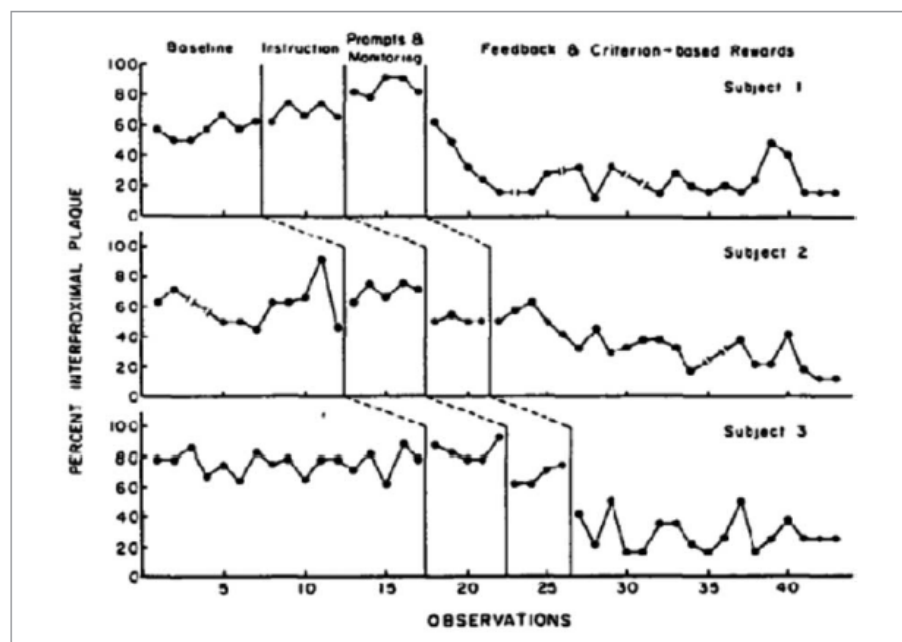


Figure 5: Percentage interproximal plaque across treatment conditions (Dahlquist et al., 1985)



the contingent or non-contingent use of escape from the aversive dental stimulus. The stated advantages of such an intervention involve easy implementation, cost-effective and non-cumbersome and effectiveness (Iwata, 1987).

Allen et al., (1992) demonstrated how contingent escape decreased the disruptive behaviour of four children. In this study, children were initially taught that the aversive dental stimulus would be withdrawn only if they showed cooperative behaviour for progressively longer periods of time. As Figure 4 shows, the implementation of the intervention led to a marked decrease in disruptive behaviour in all the participants.

O'Callaghan et al., (2006) also studied the use of escape to decrease disruptive behaviour in the dental chair. However, the child's escape was not contingent on any behaviour. The intervention therefore utilised a principle known as operant extinction. Previously the child had learnt that disruptive behaviour led to the dental treatment stopping. By letting the child rest at intervals when they were not disruptive, the previous learned association between disruption and the negative reinforcement of the operator discontinuing the dental treatment is weakened.

Many of the studies reviewed had multiple types of interventions, making it difficult to draw conclusions on the effectiveness of a single one. For example, Allen and Stokes (1987) used both negative reinforcement and positive reinforcement to decrease the disruptive behaviour of young dental patients. Some studies attempt to clarify the effect of each individual intervention by introducing them separately.

For example, as Figure 5 illustrates, the study of Dahlquist et al., (1985) into the effects of instruction, prompting and criteria based rewards on oral hygiene, implemented the interventions sequentially.

There will always however be speculation that even with this design the effects of interventions will be cumulative.

Conclusions

Behavioural psychology plays a vital role in the effective delivery of oral hygiene education and paediatric dental care. In comparison to controlled studies, applied behavioural analysis is a less cumbersome tool that can be used to support techniques to modify problematic behaviours in our patient group.

The bulk of the studies found in this literature review concentrated on allowing a dentist to perform treatment on young children. This research is of immediate benefit to the dentist and reflects the move away from pharmaceutical methods of behaviour control (American Academy of Pediatric Dentistry, 2011).

There are, however, gaps in the knowledge, both in terms of interventions and the behaviour studied. There is, for example, little research in token economy schemes or methods to promote generalisation of an intervention. With the increasing push towards caries prevention through fluoride application and dietary change there is a notable research hole in areas such as adherence to preventative advice.

Address for correspondence:

Dr J Coxon
Porth Dental Teaching Unit, Leith House, Pontypridd Rd, Porth CF39 9PH
Email: jcoxonabc@gmail.com

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Chapter 9 - Knowledge of behavioural management principles amongst specialist paediatric dental practitioners in the United Kingdom

Authors J.D. Coxon, M.T. Hosey and J.T. Newton

Published in Behavioural and Cognitive Psychotherapy 2017

9.1 Supplementary information

9.1.1 Overview of the chapter.

The previous chapter's published literature review has highlighted areas where ABA has been used in the past with regards to paediatric dentistry. This literature review has also shown areas where further research is needed in the future. For example, the use of a functional analysis for uncooperative behaviour in the dental chair and further research into interventions such as positive reinforcement for desirable behaviour.

However, the potential use of ABA in paediatric dentistry assumes that the profession has the prerequisite knowledge of behavioural psychology to fully implement ABA methods and principles. Except for one study which looked at the level of knowledge of behavioural principles among specialists in special care dentistry in the UK (Humza Bin Saeed 2012), there is no previous research on this topic.

Therefore, the following article describes our research examining specialist paediatric dentists' knowledge on principles of behavioural psychology. Their familiarity and confidence in using these techniques was also reported.

9.1.2 Limitations

This research only looked at the specialist paediatric dentists in the United Kingdom. Therefore, the study's findings can only be related to that geographic area and group of practitioners in the dental profession. Further research should be conducted in other countries to see if the results of this study generalise to other areas. In addition, the knowledge of other dental professionals involved in paediatric dental care should also be assessed.

The assessment tool used, the Knowledge of Behavioural Principles as Applied to Children (KBPAC), may be perceived as dated, being constructed by O'Dell et al in 1979. However, it is the only validated tool of this type available. The methodology used in fabricating the original KBPAC was particularly impressive, making use of a broad range of opinions and was extensively piloted on different population groups. It was also validated for use in the UK (Sturmey et al 1987). There are other assessment tools available, such as the one utilised by Luiselli et al (2010), but were fairly ad hoc measures, which lack validation.

The use of the shortened version of KBPAC in our survey may have resulted in fewer questions on certain concepts compared to the original version of KBPAC. However, principles related to interventions recommended by BSPD and AAPD, such as positive reinforcement, are included within the shortened series of questions.

The main limitation of this study is that it only tests the participant's background knowledge of the subject. This limitation is stated by both O'Dell et al (1979) when he drew up the assessment tool and by Sturmey et al (1987) when he validated the questionnaire's use in the UK. Clearly, the next step for research in this topic would

be an observational study to see if practitioners demonstrate an effective use of behavioural principles in their practical management of children.

Knowledge of behavioural management principles amongst specialist paediatric dental practitioners in the United Kingdom

James Coxon, Marie Therese Hosey and J. Tim Newton

King's College London

Background: Paediatric specialist dental practitioners are often faced with the challenge of disruptive behaviour or refusal to comply with treatment. Behaviour management skills are an essential component of their role. However, little is known of the confidence or competence of practitioners in these approaches. **Aim:** To identify paediatric dentists' knowledge of behavioural management principles as applied to paediatric dentistry. **Method:** Postal questionnaire survey of all specialists in Paediatric Dentistry on the General Dental Council UK register ($n = 234$), using the Knowledge of Behavioural Principles as Applied to Children Questionnaire (KBPAQC; O'Dell, 1979) adapted for the dental setting. Information was also gathered on experience in using behavioural management techniques and demographics. **Results:** Responses were received from 105 practitioners (45%). Participants gave the correct answer, on average, to 38% of the items (range 0 to 75%). **Conclusion:** Knowledge of behavioural principles amongst paediatric dentists in the United Kingdom is poor, despite their widespread reported use of such techniques.

Keywords: Behaviour, paediatric.

Introduction

Paediatric patients frequently show undesirable behaviour that impacts on their oral health. These behaviours can range from digit sucking (Cipes et al., 1986) to showing disruptive behaviour in the dental chair (Roberts et al., 2010). Paediatric dentists are often required to instigate interventions to decrease the likelihood of these behaviours occurring, using the basic principles of behavioural psychology. The use of non-pharmacological techniques to change behaviour is widely supported throughout the international paediatric dental field (American Academy of Pediatric Dentistry, 2015).

Dentists undergoing specialist paediatric training should be able to describe non-pharmacological behaviour management techniques used in Paediatric Dentistry and to apply this knowledge in the management of anxiety and anxiety-related behaviour in the dental setting (RCS, 2009).

Correspondence to James Coxon, Social and Behavioural Sciences, Population and Patient Health, King's College London Dental Institute, Floor 18, Tower Wing, Guy's Hospital, London SE1 9RT, UK.
E-mail: james.coxon@kcl.ac.uk

Although behavioural interventions are widely researched outside of dentistry, there has been little research completed from the dental field. A systematic review found only 11 relevant studies on behavioural interventions related to paediatric dental patients (J.D. Coxon, J.T. Newton and M.T. Hosey, unpublished observations). A small number of studies have supported the use of behavioural interventions to improve oral hygiene measures (Dahlquist and Gil, 1986), decrease disruptive behaviours in the dental chair (Allen et al., 1992) and change dietary habits (Pal, 1986). In addition, little is known about the level of behavioural knowledge that specialist paediatric dentists possess, although one paper suggested that the level of behavioural knowledge was poor among members of the profession who specialized in treating patients with special needs (Humza Bin Saeed et al., 2012).

This study sought to identify paediatric dentists' knowledge of behavioural management principles as applied to paediatric dentistry.

Method

The study took the form of a cross-sectional postal survey of paediatric specialist dentists. All specialists in Paediatric Dentistry registered with the UK General Dental Council at the time of the study (January 2016) were eligible to participate ($n = 234$). Specific steps were taken to increase the response rate based on the recommendations of Dillman (1978) and Edwards et al. (2002). Following the initial mailing, subsequent mailings to non-respondents were posted 3 and 5 weeks later. Each follow-up package contained a reply paid envelope and a covering letter, stating that a questionnaire had already been sent but a reply had not been received.

Measures

The questionnaire comprised three sections:

Section A asked questions in relation to the dentists' experience and confidence in managing paediatric dental patients and their perceived familiarity with behavioural management techniques. Participants were asked specifically to rate the following:

- The number of paediatric patients they had treated on average per week over the previous 2 years.
- Their experience of using behavioural management techniques with paediatric patients using a four point scale: none at all; very little experience; some experience; extensive experience.
- Their confidence in using behaviour management techniques on a 10-point scale with anchors 0 = not confident at all, and 10 = very confident.
- Their familiarity with a range of specific behaviour management techniques. In order to control for social desirability responses, an additional fictional behavioural management technique was included in this section – termed 'reputation'. Participants were asked to make the same ratings for this technique as for all other techniques. Ratings were made on a three point scale: yes; no; not sure.
- How often they used each of the specific behaviour management techniques (including 'reputation') on a 5-point scale: never; very rarely; occasionally; frequently; very frequently.

Section B was modified from a questionnaire developed by O'Dell (1979) and validated by Sturmey et al. (1987), which was designed to assess parents' knowledge of behavioural

management principles as applied to children. This questionnaire consists of 16 questions to assess the dentists' knowledge of behavioural management principles as applied to children. Each question had four response options. A 'knowledge score' was obtained by summing the number of correct answers to the 16 questions. This was the main outcome measure for this study.

Section C consisted of questions regarding demographic details of the participants: age, sex, and year of dental qualification.

Analysis

Descriptive statistics (frequencies, measures of central tendency and dispersion) were calculated for the questions in sections A and C. For the Knowledge of Behavioural Principles questionnaire, a score was calculated by summing the total number of correct responses given by each participant. Relationships between the Knowledge score and demographic variables were explored using non-parametric statistics (Mann–Whitney *U* test or Kruskal–Wallis for categorical variables) or the Spearman correlation coefficient for continuous variables.

Results

Characteristics of the participants

A total of 104 questionnaires were returned from 234 possible participants (response rate = 44.4%). [Table 1](#) summarizes the characteristics of the respondents.

Experience of treating paediatric dental patients, confidence and familiarity with behaviour management techniques

The average number of patients seen a week by the participants was 38.02 (*SD* = 34.1; median 30, maximum 200, minimum 0). In terms of their overall rating of their experience of using behavioural techniques with paediatric dental patients one participant said they had 'none' (1.0%); five said 'some experience' (4.8%) and 98 participants (94.2%) rated their experience as 'extensive'. The average rating of confidence in using behaviour management techniques for the participants was 9.13 (*SD* = 0.99; median 9, maximum 10, minimum 5). For ratings of the participants' perceived familiarity with the techniques and frequency of use, see [Tables 2](#) and [3](#).

Knowledge of behavioural principles

The average knowledge score for the 'Knowledge of Behavioural Principles as Applied to Children Questionnaire' was 38.5% (*SD* = 14.2; median 37.5, maximum 75.0, minimum 0).

There was no significant difference in knowledge score between groups defined by gender ($p = .62$) or workplace ($p = .57$). The Spearman correlation coefficients for knowledge score were: for number of paediatric patients treated, $\rho = .09$ ($p = .38$); for self-rated confidence in behaviour management, $\rho = -.05$ ($p = .65$); for number of years since qualification, $\rho = .06$ ($p = -.54$).

Table 1. Characteristics of respondents

Characteristics (<i>n</i> = 104)	
Gender	
Male	26 (25.0%)
Female	74 (71.2%)
Missing data	4 (3.8%)
Age	
Mean	47.2
<i>SD</i>	10.1
Median	48
Minimum	29
Maximum	71
Time since qualification (years)	
Mean	24.6
<i>SD</i>	10.1
Median	26.0
Minimum	7
Maximum	48
Workplace setting	
General dental setting (primary care)	17 (16.3%)
Community dental service (primary care)	33 (31.7%)
Hospital dental service (secondary care)	78 (75.0%)
NB: participants may work in more than one setting; therefore totals do not equal 104	

Discussion

This survey of dental practitioners specializing in the treatment of children reveals that the practitioners express a high level of confidence in their ability to manage behaviour, and familiarity with a range of techniques that could be used in dental settings. However, there is a clear discrepancy between the reported confidence of specialist paediatric dentists using non-pharmacological behaviour modification techniques and their actual knowledge of the principles underlying the use of such techniques. For example, the vast majority of participants reported frequently using positive reinforcement, but a large proportion failed to demonstrate a knowledge of simple principles associated with positive reinforcement, such as the effect of variable reinforcement on resistance to extinction.

There are some limitations to the present study; in particular, the relationship between knowledge and practice may be weak. Future research should explore the effectiveness of behaviour management techniques practised by dental practitioners.

Any interpretation of the data should be tempered by consideration of some aspects of the methodology. Firstly, some 19 participants reported familiarity with a fictional behaviour management technique, with 18 participants reporting using the fictional technique to some degree, bringing into question the validity of their self-report. The average proportion of correct answers from the 16 questions was 38.5%. Each question had four response options, thus on average participants should obtain a score of 25% by chance. With 104 participants the

Table 2. Frequency of familiarity with behaviour management techniques

Technique	Yes		No		Not sure	
	Frequency	Per cent	Frequency	Per cent	Frequency	Per cent
Voice control	102	98.1	1	1.0	1	1.0
Tell-Show-Do	104	100	0	0	0	0
Positive reinforcement	104	100	0	0	0	0
Distraction	104	100	0	0	0	0
Non-verbal communication	103	99.0	0	0	1	1.0
Contingent escape	36	35.0	44	42.7	23	22.3
Modelling (missing = 1)	101	98.1	1	1.0	1	1.0
Non-contingent escape	24	23.1	46	44.2	34	32.7
Cognitive behavioural therapy	86	82.7	9	8.7	9	8.7
Reptation (missing = 3)	19	18.8	58	57.4	24	23.8
<i>In vivo</i> desensitization (missing = 1)	93	90.3	6	5.8	4	3.8

95% confidence limits of a proportion of 25% are $\pm 10\%$. A total of 39 participants (37.5%) scored below the limits of estimate for chance responding. Furthermore, it seems likely that knowledge levels among the population of specialist paediatric dentists may be even lower – since non-response may indicate poorer knowledge or experience.

The techniques which the participants report using most frequently are largely those advocated by the American Academy of Pediatric Dentistry (AAPD, 2008), such as Tell-Show-Do. There appears to be less familiarity with techniques founded in the tradition of Applied Behaviour Analysis (ABA). Studies identified in a review of the use of ABA support the use of these techniques which are based on sound behavioural psychology principles, such as contingency management, i.e. the addition of an appetitive or aversive stimulus following the presentation of a defined behaviour. For example, the use of negative reinforcement (the removal of an aversive stimulus) to decrease disruptive behaviour in the dental chair (Allen and Stokes, 1987; Allen et al., 1992; O'Callaghan et al., 2006).

One exception to the non-use of techniques based on Applied Behavioural Analysis principles were interventions that used positive reinforcement, which 97.1% of participants frequently used. The use of positive reinforcement is widely supported in the scientific community to aid behavioural change in multiple environments, including dentistry. For example, Pal (1986) used positive reinforcement via pre-negotiated rewards to change the dietary intake of six children. However, the participants' performance on the knowledge questionnaire related to positive reinforcement demonstrated that there was a clear lack of basic understanding about how to implement an effective intervention.

Table 3. Frequency of reported use of behaviour management techniques

Technique	Never		Rarely		Occasionally		Frequently		Very frequently	
	Frequency	Per cent	Frequency	Per cent	Frequency	Per cent	Frequency	Per cent	Frequency	Per cent
Voice control	7	6.7	12	11.5	23	22.1	29	27.9	22	31.7
Tell-Show-Do	1	1.0	1	1.0	3	2.9	9	8.7	90	86.5
Positive reinforcement	1	1.0	0	0	2	1.9	15	14.4	86	82.7
Distraction	1	1.0	2	1.9	11	10.6	27	26.0	62	59.6
Non-verbal communication	3	2.9	2	2.9	7	6.7	19	18.3	72	69.2
Modelling	2	1.9	14	13.5	46	44.2	20	19.2	22	21.1
Contingent escape (missing = 12)	56	60.9	10	10.9	11	12.0	8	8.7	7	7.6
Non-contingent escape (missing = 17)	63	72.4	8	9.2	9	10.3	4	4.6	3	3.4
Cognitive behavioural therapy (missing = 3)	43	42.6	25	24.8	21	20.8	7	6.9	5	5.0
Reptation (missing = 22)	63	76.8	1	1.2	6	7.3	6	7.3	6	7.3
<i>In vivo</i> desensitization (missing = 2)	12	11.8	19	18.6	40	39.2	19	18.6	12	11.8

The techniques of ABA show great promise for use in dental settings but require a thorough understanding of the principles of behaviour management. The findings of the present study suggest that in order for ABA to be more widely adopted in dental settings, there is need for further training of dental practitioners (particularly those working in paediatric care settings) in the principles and practice of ABA.

Acknowledgements

The authors acknowledge King's College London.

Conflicts of interest: None.

Financial support: This study was supported by King's College London.

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Chapter 10- What reward does a child prefer for behaving well at the dentist?

Authors J.D. Coxon, M.T. Hosey and J.T. Newton

Published BDJ Open

10.1 Supplementary information.

10.1.1 Introduction

The previous chapters have established

- i) the importance of attempting to manage and resolve dental anxiety.
- ii) what ABA research that has already been conducted related to paediatric dentistry and areas where research is needed in the future.
- iii) the professions readiness to make effective use of principles of behavioural psychology to aid the anxious child's care.

This final published article describes a simple study which looked to challenge an established practice in dental practice in the UK; that stickers are a salient reward for young children attending dental treatment.

Positive reinforcement is listed in both the recommended non-pharmacological behavioural management techniques of the AAPD and BSPD. However, positive reinforcement is unlikely to be effective unless the child is motivated to gain the reinforcer. Despite this principle being widely accepted (for example, Shultz

2015), no previous study has looked at what a child desires as a reward for attending a dental practice for treatment.

10.1.2 Methodology.

Although the methodology is listed in brief in the article, some more detail is needed to enable possible replication in the future.

Firstly, the age grouping (4-5 years old, 6-7 years old and 8 years) and the list of suitable rewards were chosen through consultation with a group of parents and children in the South Wales Valleys area. Through this discussion it was deemed advisable to group the children into the different age groups to allow them to choose slightly different rewards. The parents and children both stated that this was necessary due to changing preferences with age. For example, a 4 year old is unlikely to prefer the same item as an 8 year old.

Participants were deemed suitable for inclusion were children attending the clinic for a dental examination or dental treatment, aged between 4 to 8 years, male or female and able to follow the instructions given by the researcher. Participants outside this age range and not able to follow instructions were excluded from the study.

The sample size was selected following consultation with the co-authors and the KCL statistics department. Every subject meeting the criteria of inclusion were selected until the required sample size was achieved. This consecutive sampling technique was chosen to control for sampling bias.

Once parental consent and child assent was obtained, the child was shown the possible rewards pinned to a large board. The child was asked to choose which

one they desired most for coming to the dentist. The parent was independently asked to guess which reward the child would choose. On the way out of the surgery, the child was given the chosen reward.

10.1.3 Limitations

This study took place in a general practice setting in the Welsh Valleys; an area of high deprivation. It is feasible that the results of this study would not generalise to other areas of different socio-economic status or culture. For example, this study found no association between the monetary value of a reward and how frequently it was chosen. This may differ with a group of children from a more affluent setting.

This study does not demonstrate that the child is more likely to co-operate for dental treatment when offered a salient reward. Although reward salience has been demonstrated to alter the efficacy of interventions based on positive reinforcement in other studies (for example, Mason et al 1989), there is clearly a need to demonstrate that this is true in the dental setting. An ABA type, multiple baseline study would appear to be ideal for investigating this in single subjects or small groups. The dependent variable investigated could be a rating of co-operation, such as the Anxious and Disruptive Behaviour Code (Stark 1989). A simpler measure would be the time it takes for a child to reach the dental chair from the waiting room, as utilised by Peretz and Gluck (2005) in their “Magic Trick” study.

In addition, the beneficial side-effects of reinforcement were not investigated in this study. Although not reported on, it was noticeable that many of the participants appeared happier to attend our surgery on subsequent visits and

seemed to cope better with even demanding treatment, such as extractions. Such a finding would be in keeping with latent inhibition theories, which suggest that a previous pleasant experience can immunise an individual to anxiety following an aversive event.

The study described in the article below did not ask the child or parent to rate the acceptability of using positive reinforcement as an intervention to gain co-operation, although it was notable that no parent or child refused to consent to take part. This may not be true if the study was repeated in different cultures and societies.

ARTICLE OPEN

What reward does a child prefer for behaving well at the dentist?

James Coxon¹, Marie Therese Hosey² and Jonathon Timothy Newton³

BACKGROUND: Paediatric dentists often report using positive reinforcement to encourage their young patients to show co-operative behaviour. For effective reinforcement to take place the reward should be salient to the individual. To date, there is little research into what reward a young patient will choose when attending the dentist.

AIM: To identify what reward children between the age of 4–8 years will choose when attending the dentist, and to determine the extent of agreement between children and caregivers in reward choice.

METHOD: Observational study. Fifty-two children from different age groups (4–5 years, 6–7 years and 8 years) attending a primary-care dental clinic were asked to choose between a range of different rewards. The caregiver attending with them was also asked to anticipate the child's preferred choice.

RESULTS: There was no clear favourite reward for children from both genders and different age group. However, no child chose the 'sticker' reward that is traditionally given out at the dentist. Overall carers agreed with the child's choice of toy on 18 occasions (34.6%), but there were significant differences across the age groups with carers of older children showing less agreement.

CONCLUSION: To ensure that rewards are salient, children should be given a choice of rewards when attending the dental clinic. Parents ability to predict their child's preferred rewards decreases as the child ages.

CLINICAL RELEVANCE: A child's motivation to co-operate during dental treatment can be increased by offering a range of rewards. Asking children to choose their reward from a limited range will increase the saliency of the reward for the child.

BDJOPEN (2017) 3, 17018; doi:10.1038/bdjopen.2017.18; published online 8 September 2017

INTRODUCTION

Paediatric patients frequently show undesirable behaviour that impacts on the ability of the dentist to treat them effectively,¹ and dentists working with children are often required to instigate interventions to decrease the likelihood of these behaviours occurring, using the basic principles of behavioural psychology. These non-pharmacological techniques are widely supported throughout the international paediatric dental field.^{2,3} Positive reinforcement is one of the main behavioural modification methods in current use today.⁴

To allow positive reinforcement to be delivered effectively, the reward should be salient to the individual.⁵ However, there has been little formal research reporting what reward a child would prefer when attending the dentist. Experience suggests that most dental clinics in primary care use stickers as a reward. However, previous research has suggested that dentists' knowledge of the principles underlying behavioural techniques including the use of reinforcement is moderate, at best.^{4,6} Humza Bin Saeed *et al.* 2012 and so it is possible that the use of stickers as a rewards may not be an optimal strategy.

This study sought to research what reward children between the age of 4–8 years would choose as a reward for successful completion of treatment when attending the dentist, and to determine the extent of agreement between children and caregivers in reward choice.

METHOD

Ethical approval was granted by the NRES Committee London—City Road & Hampstead (14/LO/0377). As the burden of participation was small, potential participants were informed of the study and asked to consent on the day of their attendance at the clinic, rather than before appointment. A patient information leaflet for both the child and the adult was given and written assent/consent taken.

A consecutive series of 52 children attending the Chief Investigator's dental surgery were shown 10 different small 'rewards' comprising toys and stickers (each costing less than £2.50 per unit, average cost per unit £1.53, 2016 prices). The rewards shown were different for each age group (4–5 years, 6–7 years and 8 years). The child was asked to indicate which of the 10 objects they would most like to be given after their dental visit. The child's response was then recorded and the child was given the object of their choice after the dental visit, regardless of their behaviour. Independently the child's parent or caregiver was asked to indicate which of the items they believe the child would choose (without knowing which the child chose).

For each adult-child pair the following demographic data were collected:

- Gender of child.
- Age of child.
- Gender of caregiver.
- Relationship of caregiver to child.

The analysis of the data comprised:

1. A frequency count of token choice by child and by caregiver.
2. Calculation of the degree of agreement in object selection by parent and child.

¹Porth Dental Teaching Unit, Porth, UK; ²Department of Paediatric Dentistry, King's College London Dental Institute, London, UK and ³Unit of Social and Behavioural Sciences, King's College London, London, UK.

Correspondence: J Coxon (jcoxonabc@gmail.com)

Received 27 March 2017; revised 27 May 2017; accepted 31 May 2017

Table 1. Gender of child participants by age group

	Male	Female
4–5 Years	13 (62%)	8 (38%)
6–7 Years	7 (41%)	10 (59%)
8 Years	11 (79%)	3 (21%)

Table 2. Reward choices shown broken down by age and child/carer

	Child choice	Carer choice
<i>Age 4–5 years</i>		
Sticker choice 1	0	0
Sticker choice 2	0	0
Teeth	1 (5%)	0
Finger tattoo	1 (5%)	2 (10%)
Bubbles	7 (33%)	7 (33%)
Princess badges	5 (24%)	4 (19%)
Princess figures	2 (10%)	4 (19%)
Butterfly glider	0	0
Pirate whistle	1 (5%)	1 (5%)
Dino glider	4 (19%)	3 (14%)
<i>Age 6–7 years</i>		
Sticker Choice 1	0	0
Sticker Choice 2	0	0
Teeth	0	0
Egg	3 (18%)	2 (12%)
Despicable Me stationery	0	2 (12%)
Disney button badge	1 (6%)	4 (24%)
Highlighter	8 (46%)	3 (18%)
Alien sling shot	3 (18%)	2 (12%)
Dino glider	0	1 (6%)
Mini markers	2 (12%)	3 (18%)
<i>Age 8 years</i>		
Sticker choice 1	0	0
Sticker choice 2	0	0
Despicable Me stationery	2 (14%)	5 (36%)
Dino egg	3 (21%)	3 (21%)
Magic set	0	1 (7%)
Wooden horse	0	0
Cat's cradle	2 (14%)	0
Plane model	0	1 (7%)
Marvel figure	5 (36%)	3 (21%)
Spy pen	2 (14%)	1 (7%)

RESULTS

Table 1 shows the number of children in each age group by gender. The difference in the gender distribution of the age groups was not significant. $\chi^2 = 4.54$, $P = 0.104$.

Reward choices

Table 2 shows the toy choices made by children and their primary caregivers broken down into the three age groups.

Agreement between child and carer in toy choice

Overall carers agreed with the child's choice of toy on 18 occasions (34.6%), but there were significant differences across the age groups with carers of older children showing less agreement (see Table 3, $\chi^2 = 11.63$, $P = 0.003$). Gender of the child had no effect on the degree of agreement (Table 4, $\chi^2 = 0.03$, $P = 0.56$).

Table 3. Extent of agreement between child and carer on toy choice, shown by age group

	No agreement	Agreement
4–5 Years	8 (32%)	13 (68%)
6–7 Years	14 (82%)	3 (18%)
8 Years	12 (86%)	2 (14%)

$\chi^2 = 11.63$, $P = 0.003$.

Table 4. Extent of agreement between child and carer on toy choice, shown by gender of child

	No agreement	Agreement
Male	20 (64%)	11 (36%)
Female	14 (67%)	7 (33%)

$\chi^2 = 0.03$, $P = 0.56$.

DISCUSSION

This study demonstrated that there was no clear favourite reward for each age group and each gender. Therefore, to ensure that the reward is salient, children need to be presented with a wide range of choices. In addition, novel rewards may be more salient,⁵ which further suggests children should have a wide range of reward choices.

It may be argued that giving out rewards will leave a financial burden on the dental practice. However, the rewards chosen were all low cost, particularly in comparison to the cost of clinical time. When the child is well motivated to be co-operative, clinical time will be saved and treatment costs decreased.

It is unclear why caregivers of the older children were less likely able to anticipate what reward their child would choose. One hypothesis may be that parents of older children often have less contact with their child and are less aware of their likes and dislikes.

Further research is needed to highlight the benefits of using positive reinforcement techniques to gain co-operation in these age groups. Although salience of the reward affects the efficacy of reinforcement techniques, timing of the reward also has a measurable effect.⁷ Further work is needed to establish the effect of salient and timely reinforcement on the co-operation of paediatric patients.

COMPETING INTERESTS

The authors declare no conflict of interest.

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Chapter 11 Discussion

This chapter provides an overview and discussion of the results of studies conducted as part of the thesis and how the implications of the findings for paediatric dentistry and dental care in the future.

11.1 The thesis findings in relation to the stated objectives.

This thesis sought to examine the potential of ABA to help manage and resolve the challenging behaviour of dentally anxious children.

The first part of this thesis aimed to assess if dental anxiety was a socially significant problem for children and their family. This was investigated by studying the impact of dental anxiety on children's oral health in the UK population at the age of 5, 8, 12 and 15 years via an analysis of data collected from the Child Dental Health Survey 2013. The results indicate that dentally anxious younger children (aged 5 and 8 years) had worse oral health than non-anxious children, and their oral health had a significant impact on their family's quality of life. Anxious adolescent children (aged 12 and 15 years) reported that their self-perceived poor oral health significantly affected their everyday life. These results suggest that children's dental anxiety in the UK population is a significant problem that the profession should attempt to manage and resolve.

The second part of this thesis concentrates on the potential of ABA to aid this group of dentally anxious children. To this end, a structured review was conducted of published literature which had adopted ABA methodology in this field. The review highlighted that in these papers ABA methodology had been used, in the

main, on children under the age of 9 years, mostly in the USA. The 19 studies included in this review had demonstrated the use of interventions such as negative reinforcement and operant extinction to help children cope with dental treatment. Measures such as response prevention had been utilised to decrease digit sucking and interventions based on punishment had been used to decrease bruxism. Some studies were deemed of low quality, mainly due to methodology issues which prevented one from drawing conclusions about the relationship between a behaviour and an intervention. Despite being heavily advocated, no studies related to disruptive behaviour used a functional assessment prior to the intervention phase. Future studies in this field should aim to include a functional analysis. The lack of studies investigating interventions, such as systematic desensitisation to dental treatment (Gomes et al 2018), give suggestions of where research can be conducted in the future.

For these behavioural interventions to be implemented effectively the profession should have a prerequisite knowledge of behavioural psychology. Our study looked to establish the level of knowledge of the principles of ABA among specialist paediatric dentists in the UK. On average this was deemed to be poor. This result indicates that individuals tasked with providing care for challenging paediatric patients should receive adequate training. This will help ensure they fully understand how to implement techniques such as positive reinforcement effectively.

The final part of this thesis was an ABA study to explore reward choice in dental settings. Reward salience is directly linked to motivation, which dramatically impacts on behaviour change. As stickers are almost universally judged by dental

teams as the reward of choice, this research examined the relative value of stickers to other rewards for children when attending the dentist. The results suggest that stickers were not children's reward of choice and they should be offered a wide range of possible rewards to ensure they are optimally motivated to co-operate.

11.2 Limitations of research and need for further studies

11.2.1 Dental anxiety in children.

The analysis of the Child Dental Health Survey made use of a well designed survey with a well-developed sampling method. However, as mentioned in the supplementary information to part 1 and the discussion sections of the related papers, interpretation of the results must be tempered by recognising the drawbacks of the CDHS design methodology and the measures used to score dental anxiety.

The CDHS sampling protocol was not designed to reflect the true level of dental anxiety in the population. For example, epidemiological surveys requiring positive consent is likely to lead to underreporting of dental anxiety due to non-participation. In addition, the CDHS actively looked to over recruit in areas of social deprivation and did not seek to correct for the effect of culture on dental anxiety.

As outlined in detail in the supplementary information, some of the variables utilised were also prone to misinterpretation by the parent or adolescent. The statistical necessity for binary grouping of variable responses may affected the analysis.

With regards to reported dental anxiety, in the younger age groups (5 and 8 year olds), the parent scored the child's dental anxiety. Such by proxy measures are often said to lack validity. Parental dental anxiety may be reflected in the assessment of the child, or the parent may be unable to distinguish if the child is anxious in the dental environment or just showing natural anxiety of a novel stimuli.

However, there appears to be no clear solution to this fundamental problem. It has been reported that children under the age of eight often give inaccurate self-reporting of anxiety (Porritt et al 2013). However, further questions in the parent's questionnaire in the Child Dental Health Survey may show if there is a relationship between the parent's anxiety and the by proxy report of the child's dental anxiety.

In the older age groups (12 and 15 year olds) the chosen self reported measure (MDAS) has some benefits, but also has notable drawbacks. It has high reliability with clear boundaries for non-phobics and phobics. However, this measure was developed for adults and the language used may be inappropriate for children. It has no reported validity with child participants, and there is no assessment of unhelpful thoughts or behaviours that may lead to further dental anxiety. Although this research was bound by the measure already used, a change to a more robust dental anxiety measure may further validate the findings of this research. A dental anxiety measure for children would ideally be short in length to aid quick completion, be suitable for a wide range of ages, explore a participants reaction to a wide variety of stimuli, and be developed with children to ensure age appropriateness. It should have demonstrated reliability and a clear cut off between phobic and non phobic. As no such measure exists at present, the

immediate aim of research prior to the Child Dental Survey 2023 would be to develop dental anxiety measures along the lines of the criteria before mentioned. The Children's Experience of Dental Anxiety Measure (CEDAM, Porritt et al 2018) is a reliable and valid measure which is relatively brief and appears to overcome the limitations of previous assessment measures, as such it may fill this need.

Our research suggests that a child's dental anxiety has a negative effect on everyday family life. What is not clear is if this influences the choice of dental treatment for the child, to an approach that is less demanding of the child, but possibly more invasive and carrying greater risk. For example, the choice of extraction under general anaesthetic compared to pulp therapy and stainless steel crowns. A child's treatment is chosen by the parent, often at the suggestion of the dentist. Further research should look at the effect of a child's dental anxiety on a parent's choice of treatment, or the treatment advocated by the dentist.

The effect of dental anxiety on quality of life in adolescents is demonstrated in both the descriptive analysis and the regression analysis. Our paper suggests that these feelings of shame and embarrassment may lead to a future avoidance of dental care leading to a downwards spiral in oral health. Future research should examine the relationship of dental anxiety in children and if this leads to poor oral health in adulthood.

11.2.2 The limitations of the structured review of ABA related to paediatric dentistry.

The structured literature review was the first of its type and highlighted the use of ABA methodology to decrease problematic behaviours encountered by paediatric dentists such as bruxism, digit sucking and uncooperative behaviour in the dental

chair. Although the majority of these studies were deemed to be adequate in quality, a few had methodology issues that did not allow one to draw conclusions about the effectiveness of the interventions.

The preface to chapter 7 highlights the limitations of this review. The main points raised related to studies being excluded due to being published prior to 1984 or not included as they were not specifically labelled as dental or dentistry. As such this review cannot be described as fully comprehensive having omitted some potential studies that may have been of use to people working in this field.

However, this review is still of immense value in evaluating the work already undertaken and suggests areas which require research in the future. ABA's value is being able to demonstrate a functional relationship between a chosen behaviour and an intervention in single cases or small group studies. The variables that lead to certain behaviours are highly individual, often too varied to be captured by the broad statements gleaned from randomised controlled trials. ABA is a delicate and precise tool that can be used to aid behavioural change of individuals and small groups and is therefore ideally suited for use in the dental practice, school class, or other settings.

11.2.3 Limitations of the research into the knowledge of behavioural principles amongst UK paediatric dental specialists.

To assess the future potential of ABA to the paediatric dental profession there was first a need to gauge if the profession had the requisite knowledge of ABA principles. This knowledge is required to select and implement an intervention as effectively as possible. In general, the specialist practitioners scored poorly, which was surprising considering many professional bodies recommended non-

pharmacological management techniques, such as positive reinforcement, anchored in ABA and behavioural psychology.

The low average knowledge score of 38% may imply that the questionnaire was too difficult. However, there was a wide spread of scores (ranging from 0 to 75%) showing a good variability of responses. As mentioned in the preface to chapter 8, despite the demonstrated lack of theoretical knowledge, it is possible that practitioners may be practically adept at behavioural management based on classical and operant conditioning. For instance, a cornerstone of applied behaviour management is the delivery of timely contingent reinforcement. In order to determine whether paediatric dental practitioners deliver timely positive conditioning via verbal praise at a variable rate of reinforcement, a further observational study of specialist practitioners in the surgery would be of interest. Such observations would be invaluable in the training and education of future paediatric specialist practitioners.

Once an educational intervention has taken place to educate the profession on behavioural psychology and ABA principles, research needs to be undertaken to a) establish if the training has led to an increase in theoretical knowledge in the profession b) establish if the training has led to a better patient outcome c) establish if the patient has led to decreased stress in the operating dentist.

11.2.4 Limitations on the research into reward choice and reward value

The study exploring reward choice, illustrated in chapter 9, indicated that children would prefer a novel item as a chosen reinforcer over the traditional sticker. As mentioned in preface to chapter 9, the major limitation to this study is that it did not show whether or not the salience of the reward alters the child's behaviour in

the dental environment. Future research should investigate if the salience of the reward has a significant effect on a child's behaviour in the dental chair. This could take the form of a simple measure such as timing the child's time to sit in the dental chair as demonstrated in Peretz's "Magic Trick" study (2005). A more in depth study should utilise ABA methodology to demonstrate a significant relationship between independent and dependent measures.

11.3 The relevance of ABA for paediatric dentistry and future service provision.

11.3.1 In the dental surgery

The behavioural management of young patients is a continuing problem for the dental profession. In the age range of 4 to 11 years, Klingberg et al (1994) suggested that the prevalence of dental behaviour management problems in the Swedish population was 10.5%, as judged by the dentist. In addition, dental anxiety, often the motivation underpinning disruptive behaviour, has been shown to be widespread in paediatric dental patients, including the UK population (Coxon et al 2019, Coxon et al 2019). Previously the profession has concentrated its research and teaching on pharmacological methods to allow treatment on non-compliant young children. For example, there are numerous reviews on the use of nitrous oxide to aid dental treatment in young children (see for example, Hosey 2002).

While there is no doubt that pharmacological methods will always have a place in paediatric dental treatment, there is little evidence to suggest that this leads to a long term change in the patient's behaviour and beliefs (Matharu and Ashley

2006). In addition, there is an increasing pressure for the profession to look to non pharmacological methods to allow young children to be treated in the dental chair (AAPD 2011, Campbell 2011). While there are some examples of ABA being used to judge the effectiveness of behavioural interventions (see Chapter 7) there are notable gaps in the knowledge. For example, systematic desensitisation and counterconditioning (DSCC) is widely used in the treatment of other forms of anxiety, such as a fear of showers (Love et al 1990) and a fear of dogs (Erfanian and Miltenberger 1990). DSCC has also been used to help adult individuals with dental phobia (Conyers et al 2004). ABA would be an ideal tool to assess the effectiveness of such an intervention with regards to dental anxiety in children.

Research into the effectiveness of behavioural interventions to help resolve dental anxiety is especially relevant given the relationship poor oral health has with a fear of the dentist in young children, as suggested by our regression analysis of the CDHS 2013. Even in dentally anxious older children, where dental anxiety did not predict poor oral health, there was a clear indication that the oral health impacted far more on the everyday life of dentally phobic adolescents compared to non phobics. The long term consequences of the demonstrated negative cognitions are not clear. In adults dental phobia is associated with poor oral health and lower self esteem in numerous studies, both in specialist clinics (Berggren and Meynert 1984) and in epidemiological studies (Hägglin et al 2001). A regression analysis, which utilised data from the Adult Dental Health Survey (2009) confirmed that even after taking confounders into account, dental anxiety was still a significant predictor of poor oral health and had a negative effect on quality of life (Heidari et

al 2017). Such findings are in keeping with theories of spiralling poor oral health as described by the vicious cycle model (Berggren and Meynert 1984). Behavioural modification methods, utilising ABA methodology, may be an ideal tool to break this negative cycle.

The use of ABA is not just limited to the investigation of behavioural techniques new to the dental field. Our research suggests that it should be used to investigate the effectiveness of traditional techniques utilised in the dental surgery. Stickers are universally used in dental clinics as a means of rewarding desired behaviour. However, our research questioned if this is the ideal means of primary reinforcement for young children in the dental chair. Positive reinforcement techniques rely on the salience of the reward to gain the required motivation to comply with the dentist's requests. Our study highlighted that when given a choice of low value rewards, stickers were unlikely to be chosen (Coxon et al 2017). By looking into the likely salience of a reward, this study mimics the functional analysis component of ABA, where relevant information is gathered prior to commencing a behavioural intervention.

However, positive reinforcement is greatly affected by the timing of the reward; ideally there should be a minimal delay between a behaviour occurring and the presentation of the reward (McDevitt and Williams 2001). This is termed temporal contiguity. In the dental setting this is technically difficult. For example, it is often not possible to stop treatment multiple times while the child is given a reward. One technique often advocated to overcome this barrier is the use of a conditioned reinforcer (Cooper et al 1987). Here a novel stimuli of no inherent value becomes associated with a primary reinforcer such as a toy, via classical conditioning.

Examples of conditioned reinforcers include tokens, plain stickers, or even a novel sound. These can be presented during the treatment session to improve the reward timing. An example of such a study protocol is included in appendix B

11.3.2 ABA and oral health promotion.

Health care policy and provision is traditionally centred on an economic approach, which is grounded in the assumption that its consumers are rational decision-makers who only require information to avoid making irrational choices and decisions (Hough 2013). However, there is an increasing realisation that many health problems, such as obesity, are created to a large extent, by the automatic decisions individuals make every day. The traditional method of health educational programmes has been shown to be of limited value in achieving a widespread behavioural change (Ariely 2008). This has led to the championing of a behaviour-focused approach to health care, which is part of a prudent healthcare strategy where the focus is on providing support and motivation for an individual to make correct decisions with regards to their health.

The majority of diseases faced in dentistry fit in well with this behaviour focussed health care model. Whether an individual develops dental decay is strongly related to their behaviour, or in the case of young children, the behaviour of their caregiver. Aside from fluoride provision, the traditional approach to preventing tooth decay has centred on delivering healthcare information. Our research highlighted only one study that examined a behavioural strategy to decrease the intake of cariogenic food (Pal 1986), despite a wealth of evidence that highlights the relationship of sugary drinks and food consumption and dental decay.

Other behaviours relating to oral health, such as toothbrushing, are also lacking from the review of published ABA studies relating to paediatric dentistry (Coxon et al 2019). Only one study focused on toothbrushing as the target behaviour (Blount and Stokes 1984), while a further two studies focused on the effective use of dental floss (Dahlquist and Gil 1986 and Dalhquist et al 1984). Our further analysis of the CDHS highlighted significant relationships between poor oral health and behaviours such as toothbrushing and the use of fluoridated products (Coxon et al 2019), indicating that further research should take place in this area.

With the change in how we approach healthcare provision, behavioural change is rapidly becoming the primary tool in the prevention and management of many of the major health problems. This is especially true of most of the dental diseases. ABA is a valuable tool to help provide evidence at a practice-based level about what behavioural interventions are effective.

However, although the time may be correct to encourage ABA methodology, its effective use requires a prerequisite knowledge of the principles of behavioural psychology. While behavioural management techniques are listed in the training curriculum for specialist training in the UK (Royal College of Surgeons 2009), our research suggests that there is a need to educate and train the profession in this field. This should not be confined to specialist training. The continuing emphasis on prevention of dental disease would imply that methods to help patients change their behaviours should be elevated in both undergraduate and postgraduate training priorities.

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Appendix A – Critique of articles included in ABA literature review

Study	Participant characteristics Age, gender provided	Independent variable information to allow replicable precision.	Dependent variable information to allow replicable precision and information collected at appropriate times.	Baseline condition comprising of at least three data points, was stable, and defined with replicable precision.	Visual Analysis. Data for each participant graphed, was stable, clear difference between conditions.	Experimental control demonstrated by three demonstrations of experimental effect at three different points in time.	Interobserver agreement collected on at least 20% of time and above 0.80.	Kappa calculated in 20% of sessions and above 0.60	Procedural and/or treatment fidelity measured and greater than 0.80	~~Raters~~ blind to treatment conditions of participants.	Generalisation demonstrated by data collection after the conclusion of the intervention	Social Validity of DV and intervention demonstrated.	Overall strength of research report.
O'Callaghan et al 2006 The Efficacy of Non-Contingent Escape	Yes	Yes	Yes	No* (not stable)	No* (not stable, 25% overlap of data points)	Yes	Yes	Not reported	Yes	No	No	Yes	Adequate
Stark et al 1989 Distraction: it's utilisation and efficacy with children undergoing dental treatment	Yes	Yes	Yes	No* (not stable)	No* (not stable and 25% overlap of data points)	Yes	Yes	Yes	No (not reported on)	No	No	Yes	Adequate
~~Dahlquist~~ et al. 1984 The effects of behavioural intervention on dental flossing	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Not reported	Not reported	No	No	Yes	Adequate

Study	Participant characteristics Age, gender provided	Independent variable information to allow replicable precision.	Dependent variable information to allow replicable precision and information collected at appropriate times.	Baseline condition comprising of at least three data points, was information stable, and defined with replicable precision.	Visual Analysis. Data for each participant graphed, was stable, clear difference between conditions.	Experimental control demonstrated by three demonstrations of experimental effect at three different points in time.	Interobserver agreement collected on at least 20% of time and above 0.80.	Kappa calculated in 20% of sessions and above 0.60	Procedural and/or treatment fidelity measured and greater than 0.80	Raters blind to treatment conditions of participants.	Generalisation demonstrated by data collection after the conclusion of the intervention	Social Validity of DV and intervention demonstrated.	Overall strength of research report.
~~Skuse et al~~ 1986. Using parents to maintain improved dental flossing skills in children	Yes	Yes	Yes	Yes	No * (not stable and 25% overlap of data points)	Yes	Yes	Not reported	Yes	No	Yes	No (authors noted time consuming and complicated)	Adequate
~~Skuse et al~~ 1984. The effects of graded exposure and parental modelling on the dental phobias of a four year old girl and her mother.	Yes	No (not able to reproduce methodology)	No (parental by proxy measure of child anxiety)	No (only one measure of data collected at one point)	No (relevant data not graphed, only two data points collected)	No (only one demonstration of experimental effect)	No (no independent observation)	Not applicable	No	No	Yes (although parental by proxy measure of child's anxiety at only one point in time, 6 months after)	No (unable to demonstrate behavioural change)	Weak

Study	Participant characteristics Age, gender provided	Independent variable information to allow replicable precision.	Dependent variable information to allow replicable precision and information collected at appropriate times.	Baseline condition comprising of at least three data points, was stable, and defined with replicable precision.	Visual Analysis. Data for each participant graphed, was stable, clear difference between conditions.	Experimental control demonstrated by three demonstrations of experimental effect at three different points in time.	Interobserver agreement collected on at least 20% of time and above 0.80.	Kappa calculated in 20% of sessions and above 0.60	Procedural and/or treatment fidelity measured and greater than 0.80	Blinded to treatment conditions of participants.	Generalisation demonstrated by data collection after the conclusion of the intervention	Social Validity of DV and intervention demonstrated.	Overall strength of research report.
Blount and Stokes (1984) Contingent Public Posting of Photographs to Reinforce Dental Hygiene.	Yes	Yes	Yes	Yes	Yes	No (although clear change in dependent variable the experimental effect only demonstrated in two groups and two different points in time)	Yes	Not recorded	No	No	No (limited follow up period)	Yes	Adequate
Allen et al (1992) Dentist-implemented contingent escape for management of disruptive child behavior.	Yes	Yes	Yes	No * (not stable)	No * (not stable, overlap of data points by 25%).	Yes	Yes	Not recorded	No	No	No	Yes	Adequate

Study	Participant characteristics Age, gender provided	Independent variable information to allow replicable precision.	Dependent variable information to allow replicable precision and information collected at appropriate times.	Baseline condition comprising of at least three data points, was stable, and defined replicable precision.	Visual Analysis. Data for each participant graphed, was stable, clear difference between conditions.	Experimental control demonstrated by three demonstrations of experimental effect at three different points in time.	Interobserver agreement collected on at least 20% of time and above 0.80.	Kappa calculated in 20% of sessions and above 0.60	Procedural and/or treatment fidelity measured and greater than 0.80	~~Raters~~ blind to treatment conditions of participants.	Generalisation demonstrated by data collection after the conclusion of the intervention	Social Validity of DV and intervention demonstrated.	Overall strength of research report.
Allen and Stokes (1987) Use of escape and reward in the management of young children during dental treatment	Yes	Yes	Yes	No * (not stable)	No * (not stable, overlap of data points by 25%)	Yes	Yes	Not recorded	No	No	No	Yes	Adequate
Sanders and Jones (1990) Behavioural Treatment of Injection, Dental and Medical Phobias in Adolescents: A case study	Yes	Yes	Yes	No (less than 3 data points collected during baseline)	Yes	Yes	Not reported	Not reported	No	No	Yes	Yes	Adequate
Armstrong et al (2014) Functional analysis and treatment of the diurnal bruxism of a 16-year-old girl with autism	Yes	Yes	Yes	No (not stable)	No (not stable, ~~overlap~~ of data points by 25%)	Yes	Yes	Not reported	No	No	Yes	Yes	Adequate

Study	Participant characteristics Age, gender provided	Independent variable information to allow replicable precision.	Dependent variable information to allow replicable precision and information collected at appropriate times.	Baseline condition comprising of at least three data points, was stable, and defined with replicable precision.	Visual Analysis. Data for each participant graphed, was stable, clear difference between conditions.	Experimental control demonstrated by three demonstrations of experimental effect at three different points in time.	Interobserver agreement collected on at least 20% of time and above 0.80.	Kappa calculated in 20% of sessions and above 0.50	Procedural and/or treatment fidelity measured and greater than 0.80	Raters blind to treatment conditions of participants.	Generalisation demonstrated by data collection after the conclusion of the intervention	Social Validity of DV and intervention demonstrated.	Overall strength of research report.
~~Barnes~~ et al (2009) Evaluation of a multicomponent intervention for diurnal bruxism in a young child with autism.	Yes	Yes	Yes	Yes (baseline phase consisted of existing intervention)	Yes	Yes	Yes	Not reported	No	No	Yes	Yes	Adequate
Lang et al (2013) Functional analysis and treatment of diurnal bruxism.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	Yes	Yes	Adequate
~~Van Houten~~ and ~~Bjorkler~~ (1984) The use of response prevention to eliminate nocturnal thumb sucking	Yes	Yes	Yes	No (not stable)	Yes	Yes	Yes	Not calculated	No	No	Yes	Yes	Adequate
Stricker et al (2001) Evaluation of an awareness enhancement device for the treatment of thumb sucking in children.	Yes	Yes	Yes	No (not stable for one of the two participants)	Yes	Yes	Yes	Not calculated	No	No	No	Yes	Adequate

Study	Participant characteristics Age, gender provided	Independent variable information to allow replicable precision.	Dependent variable information to allow replicable precision and information collected at appropriate times.	Baseline condition comprising of at least three data points, was stable, and defined with replicable precision.	Visual Analysis. Data for each participant graphed, was stable, clear difference between conditions.	Experimental control demonstrated by three demonstrations of experimental effect at three different points in time.	Interobserver agreement collected on at least 20% of time and above 0.80.	Kappa calculated in 20% of sessions and above 0.60	Procedural and/or treatment fidelity measured and greater than 0.80	~~Bates~~ blind to treatment conditions of participants.	Generalisation demonstrated by data collection after the conclusion of the intervention	Social Validity of DV and intervention demonstrated.	Overall strength of research report.
Ellingson et al (2000). Analysis and treatment of finger sucking	Yes	Yes	Yes	No (not stable)	Yes	Yes	Yes	Not reported	No	No	Yes	Yes	Adequate
Allen et al (1988) Reinforced practice of children's co- ~~operation~~ behaviour during restorative dental treatment	Yes	Yes	Yes	Yes	Yes	No * (not stable)	Yes	Not reported	Yes	No	No	Yes	Adequate
McMullen et al (2017) Using prediction and desensitization techniques to treat dental anxiety: a case example.	Yes	Yes	Yes	No (results not adequately reported)	No (not graphed)	No (less than three demonstrations of experimental control)	Yes	Not reported	No	No	No	No (not possible to draw conclusions on effect of intervention due to experimental design)	Weak

Study	Participant characteristics Age, gender provided	Independent variable information to allow replicable precision.	Dependent variable information to allow replicable precision and information collected at appropriate times.	Baseline condition comprising of at least three data points, was stable, and defined with replicable precision.	Visual Analysis. Data for each participant graphed, was stable, clear difference between conditions.	Experimental control demonstrated by three demonstrations of experimental effect at three different points in time.	Interobserver agreement collected on at least 20% of time and above 0.80.	Kappa calculated in 20% of sessions and above 0.60	Procedural and/or treatment fidelity measured and greater than 0.80	~~Rating~~ blind to treatment conditions of participants.	Generalisation demonstrated by data collection after the conclusion of the intervention	Social Validity of DV and intervention demonstrated.	Overall strength of research report.
~~Ciampi~~ et al, (1986) Monitoring and reinforcement to eliminate thumb sucking	Yes	Yes	Yes			No							Weak

Appendix B

Draft protocol of ABA study to review the effect of the use of a conditioned reinforcer on paediatric disruptive behaviour in the dental chair.

Design

Multiple baseline design across subjects (for example, Cooper, Heron and Heward. Applied Behaviour Analysis (Second Edition, London, Pearson 2004).

The design involves measuring the frequency of occurrence of behaviours (baseline recording) and then intervening and observing the effect on the rate of occurrence of the behaviour across a number of subjects.

The study will seek to observe until baseline measures are stable and intervene with the following target behaviours in the dental chair:

- The child laying still with hands on lap and head tilted up with mouth open to allow the dentist to inspect teeth with a dental mirror and dry teeth with a 3 in 1 syringe.
- The child laying still with hands on lap and head tilted up with mouth open while dentist places topical anaesthetic in the buccal sulcus and deposits local anaesthetic.
- The child laying still with hands on lap and head tilted up with mouth open while the cavity is prepared, or the anaesthetic of the tooth is checked with a probe prior to extraction.
- The child laying still with hands on lap and head tilted up with mouth open while the filling material or stainless steel crown placed or the tooth is extracted.

Participants

15 children aged between 4 and 8 year attending the Chief Investigator's clinic.

Inclusion criteria

- Between 4 and 8 years of age
- Able to follow verbal instructions.
- Require at least four visits for dental treatment including fissure sealants, simple restorations, and extractions.
- Previously demonstrate a failure to comply with any of the four target behaviours in a single visit.

Exclusion criteria

- In need of emergency dental care or experiencing acute pain.

Procedure

Prospective participants will be approached by letter at least one week prior to their dental visit. The letter will be sent to their primary caregiver together with an information sheet for the child and the caregiver. On the day of the first dental visit the Chief Investigator will go through the study information again and seek assent/consent from the both the child and the caregiver.

The first visits will comprise of baseline observations. During the baseline phase of the study, the children will be given the standard treatment procedures, including restorative work and simple extractions. The dentist will explain the procedures, show the child the instruments described using age appropriate terms and carry out the procedure. The child be requested to comply with the four target behaviours.

Once baseline data is stable, the intervention will be introduced. The child will be informed that they will be able to earn a prize if they cooperate during treatment, and asked to choose a prize from a list of rewards. They will also be shown a board listing the four things they have to do, with four boxes for each behaviour. They will be done while the child is in the waiting room. When the child enters the surgery the procedures will be explained as in the baseline phase and the patient will be told they need to earn four plain stickers to gain the chosen prize. Stickers will be placed on the cardboard board "good patient certificate" attached below the light.

One sticker will be given when the patient fulfils each of the following criteria:

- a) Lie still with hands on lap and head tilted up with mouth open to allow the dentist to inspect teeth with a dental mirror and dry teeth with a 3 in 1 syringe.
 - b) Lie still with hands on lap and head tilted up with mouth open while dentist places topical anaesthetic in the buccal sulcus and deposits local anaesthetic.
 - c) Lie still with hands on lap and head tilted up with mouth open while the cavity is prepared, or the anaesthetic of the tooth is checked with a probe prior to extraction.
 - d) Lie still with hands on lap and head tilted up with mouth open while the filling material or stainless steel crown placed or the tooth is extracted.
- Should the child get four stickers they will be given the reward (as initially chosen by the child) by the person in the waiting area who helped them choose the "reward".

Observational measures.

All four visits will be video recorded. The recording will be scored by two members of the research team using the following previously validated measures.

- a) Disruptive behaviour using the Anxious and Disruptive Behaviour Code (Stark 1989)
- b) Global rating of co-operation on a single item 10cm Visual Analogue Scale with anchors of not all cooperative to fully cooperative and the Co-operation Rating Scale (Stark 1989)

In addition, observes will be asked to score the frequency of verbal or physical reinforcement from the dentist and dental nurse during the procedure.