Original paper

Color perception and its relation to dental anxiety in children

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Abstract

Background. One of the major causes of dental anxiety in children is their first impression of the dental environment. Even minor details, such as the choice of color in a dental setting and the color of dental equipment, can positively influence a child's behavior.

Objectives. The aim of the study was to assess the relationship between the emotions in children and color combinations in a pediatric setting.

Material and methods. The study involved 200 children (99 boys and 101 girls) aged between 6 and 12 years who visited the dental clinics at the College of Dentistry, Jazan University, for the first time between November 2017 and January 2018. The participants were divided into 2 groups based on age. The younger children group included participants aged from 6 to 9 years, while the older children group included participants aged from 10 to 12 years. Anxiety levels were recorded using the Modified Dental Anxiety Scale. Colored pencils and images of emoticons were provided to all children, who were instructed to color the negative and positive emoticons with their preferred colors.

Results. The analysis of anxiety levels among children in both groups revealed statistically significant differences across sexes in the younger age group, with girls being more anxious than boys ($p = 0.003$). Additionally, a statistically significant difference was observed in the choice of colors by children of both sexes in 2 age groups ($p = 0.001$). Most children were inclined towards bright colors and used them to express their emotions.

Conclusions. The incorporation of colors in a dental setting could invoke positive emotions in children. Hence, the use of colors in the workplace has the potential to ease anxiety.

Keywords: emotions, anxiety, dental anxiety, anxiety scale, colors

Introduction

From the moment of their birth, humans have been subject to fear and emotions. Four causes of fear have been identified: non-associative perspective or direct stimulation; physiological differences; an innate predisposition; and conditioning.[1] For a long time, concerns have been raised regarding the reasoning behind dental anxiety in children. It remains a major obstacle in the field of dental care. Dental anxiety in children is attributed to a multitude of factors. Children may become anxious directly or through indirect learning or conditioning (from information or by modeling).[2] The overall comprehension of the dental environment is a notable cause of anxiety in children.[3] Shifting the perspective of society and parents could motivate pediatric dentists to develop a child-oriented environment to help children, especially when uncooperative and anxious.[4] Environmental aspects such as colors leave a positive imprint in the minds of children, which in turn reduces dental anxiety to a considerable extent. Thus, colors play a vital role in a child's life.[5,6]

For children, color preference is expressed through their belongings and surroundings, such as toys, clothing, lunch boxes, sportswear, and home accessories.[7] Research has demonstrated the relationship between the performance and behavior of a child and their color preferences.[6,8] Colors have been classified as warm or cool, based on their correlation with temperature.[9] Colors have 3 fundamental features, namely saturation, value and hue. The human eye is able to recognize colors through cones and rods. After the color passes into the eye via the retina, receptor cells absorb the hues, and the corresponding signal is sent to the brain for deciphering. Simultaneously, the hormone-regulating endocrine glands receive these brain impulses. Hence, color represents both psychological and physiological perceptions, triggering emotional responses.[10]

The results of numerous studies have demonstrated that children use colors as a medium to express their emotions. Moreover, the coordination between the brain, eyes and light creates a standard reaction to color.[5,11] Therefore, pediatric dentistry can utilize child-friendly colors to positively influence children's emotional status.[12] It has been observed that the choice of colors in a dental office and treatment room has a positive effect in addressing dental anxiety. The use of bright colors and colored equipment helps children maintain a calm composure during their dental visits.[3]

The present study aimed to assess 2 assumptions. The first assumption states that a significant association exists between color preference and emotions in children. The second assumption posits that there is a sex-based discrepancy in the level of anxiety among children. Accordingly, it is hypothesized that there is a correlation between the use of bright colors in a dental clinic and the level of dental anxiety among children. Also, there is a possibility of variation in the level of anxiety between males and females. Therefore, the present study focused on examining the relationship between children's age, sex and levels of anxiety before dental procedures, as well as testing the psychometric properties of the dental anxiety scale and identifying any differences in children's color preferences by age and sex when asked to color a happy or a sad emoticon.

Material and methods

Study setting and participants

The study was conducted at the Pediatric Dental Clinic of the College of Dentistry (Jazan University, Saudi Arabia), and approved by the Ethics Committee of Jazan University (approval No. CODJU-1716I). The study participants were children between the ages of 6 and 12 years who were visiting the Pediatric Dental Clinic for the first time. Individuals who were not first-time visitors, undergoing psychiatric therapy, or suffering from generalized anxiety disorders were excluded from the study. The purpose and procedure of the study were explained to the children and their accompanying parents or guardians. Written consent was obtained from the parents or legal guardians of the study participants before the start of the study.

Sample size estimation

The sample size was calculated using the following formula (Equation 1):

$$N = (4pq)/d^2 \quad (1)$$

where:
N – sample size;
p – proportion of children with anxiety (66.7%);
q – 1–p;
d – precision of the study [%].

The sample size required for the present study was calculated to be 181,[13] with a precision of 7%.

Study design

This cross-sectional descriptive survey was conducted from November 2017 to January 2018. The children who participated in the study were divided into 2 groups based on age. The younger group consisted of children between the ages of 6 and 9, while the older group ranged between the ages of 10 and 12. The personal details of each child were recorded before the study and were kept confidential. An Arabic translation of the Modified Dental Anxiety Scale, which includes emoticons (sad and happy), was carried out.[14] A validation test for the dental anxiety scale

based on the study by Humphris et al. was conducted before the study.[15] While the dependent variable was the level of anxiety among children on account of dental procedures, the independent variables included age, sex and color preferences on the level of anxiety.

Arabic validation of the anxiety scale

A dental intern fluent in Arabic had initially translated the questions that form part of the Modified Dental Anxiety Scale from English to Arabic (available on request from the corresponding author).[16] This was followed by a reverse translation conducted by a bilingual dentist. Minor errors were corrected through mutual coordination. Additionally, a biostatician was consulted to validate the questions and assess the intended outcome (single global construct). Experts were responsible for rationally analyzing the questionnaire by focusing on clarity, comprehensiveness, readability, and the level of agreement using the Likert Scale. To assess the reliability of the Arabic version of the Modified Dental Anxiety Scale, test–retest reliability and internal consistency were calculated using Cronbach's alpha coefficient. It was stated that the Arabic version would be internally consistent if the alpha coefficient had a minimum value of 0.70.[16] Furthermore, if the value obtained for the intraclass correlation (ICC) agreement calculated using Pearson's r was 0.80 or more, the questionnaire would be considered reliable (excellent).[17] Confirmatory factor analysis corroborated the validity of the child anxiety questionnaire. It was established that each item in the model must contribute to and correlate with the single global construct.[18,19]

Analysis of variables

The present study evaluated 3 variables: demographics; the dental anxiety scale; and the choice of color for emoticons. A single examiner was responsible for recording the readings in order to ensure uniformity. The Arabic version of the Modified Dental Anxiety Scale employed in the present study consisted of a series of 5 questions presented to the participants for the purpose of rating their level of anxiety in relation to a specific dental situation according to their own perception. The questionnaire was completed by the participants during their visit to the dental clinic, with the assistance of their parents or guardians when necessary. The responses were evaluated on a five-point Likert Scale ranging from 1 (no anxiety) to 5 (extreme anxiety). Therefore, the total scores ranged from 5 to 25. A score below 15 was indicative of a lack of anxiety, while a score of 15 or above was indicative of anxiety. This classification was adapted from the study by Annamary et al.[16] To identify any potential associations between color and pain perception, a set of 8 colored pencils (black, white, pink, orange, green, blue, yellow, and red) was given to each child. The participants were required to color 2 emoticons, representing happiness and sadness, with the color of their choice from the provided set. The recorded data was then tabulated and analyzed.

Statistical analysis

The IBM SPSS Statistics for Windows software, v. 24.0 (IBM Corp., Armonk, USA), was used for the statistical analysis. The data was first entered into an Excel spreadsheet and subsequently transferred to the IBM SPSS Statistics for Windows software dataset. The relationships between the dependent and independent variables were analyzed using the χ^2 test. The significance level was set at $p < 0.05$.

Results

The results of the validation test demonstrated that there were no notable discrepancies in the test–retest reliability. An ICC value of 0.81 was obtained using Pearson's r, which demonstrated the questionnaire's excellent reliability (Table 1). The results of the factor analysis are shown in Table 2. The 5 items included in the questionnaire made a significant contribution to the single global construct, thereby increasing the credibility of the tool in assessing anxiety levels among children.

A total of 200 children were included in the study. Of the participants, 99 (49.5%) were male and 101 (50.5%) were female. The younger group consisted of 79 children, 35 of whom were male and 44 of whom were female. The older group comprised 121 children (64 boys and 57 girls). Overall, based on the Modified Dental Anxiety Scale, 35 children were anxious and 165 children were non-anxious. The study revealed statistically significant differences between the boys and girls in the younger age group, with a p-value of 0.003. However, no statistically significant difference was observed in the older age group. In both age groups, girls exhibited greater levels of anxiety than boys (Table 3).

Table 1. Test–retest reliability of the Arabic version of the Modified Dental Anxiety Scale

Instrument	ICC	Cronbach's alpha
Arabic version of the Modified Dental Anxiety Scale	0.81 ±0.08	0.75

ICC – intraclass correlation.

Table 2. Confirmatory factor analysis of the Arabic version of the Modified Dental Anxiety Scale

Item	Item 1	Item 2	Item 3	Item 4	Item 5
Item 1	1.00	–	–	–	–
Item 2	0.89	1.00	–	–	–
Item 3	0.86	0.91	1.00	–	–
Item 4	0.90	0.83	0.85	1.00	–
Item 5	0.91	0.83	0.90	0.89	1.00

Table 4 shows the results of the comparative analysis conducted to assess the relationship between color preferences related to anxiety levels and positive emotions. The results revealed no statistically significant differences in color preferences between boys and girls in both age groups. Blue, pink and yellow colors were preferred by both anxious and non-anxious younger children. In the older group, children exhibiting anxiety symptoms preferred pink to other colors, while the non-anxious participants preferred blue, yellow and pink over other colors. None of the children chose the color black to express their emotions.

A similar comparative analysis was conducted to assess color preferences in relation to anxiety levels and negative emotions (Table 5). The findings show that the anxious children belonging to the younger age group preferred black and red to express negative emotions, while the non-anxious children belonging to the same age group preferred red, black and yellow over other colors. Among the older participants, those exhibiting anxiety symptoms preferred black, whereas the non-anxious children preferred red, black and yellow over other colors.

Our study also analyzed the association of colors with both positive and negative emotions among children of both sexes across 2 age groups. In the older children group, boys preferred blue and yellow when expressing positive emotions, while girls exhibited a preference for pink and yellow. In the younger group, however, the male participants chose yellow, blue and green, whereas the female participants selected pink, red and blue to express positive emotions. Both boys and girls demonstrated similarities in ignoring the color white. A statistically significant difference in the choice of colors by children of both sexes was observed in 2 age groups, with a *p*-value of 0.001 (Table 6), thereby providing evidence to reject the null hypothesis and accept the alternative hypothesis. Consequently, it can be concluded that the use of bright colors decreases the level of anxiety among children.

In expressing negative emotions, children in the older age category preferred black and red over other colors, with white being among the least preferred colors. Among the younger children, while the majority of boys expressed their emotions through black and red, girls preferred black, red and yellow (Table 7). Therefore, it can be inferred that the use of bright colors has a positive impact on reducing dental anxiety in children.

Table 3. Anxiety levels among boys and girls in younger and older age groups

Age group	Sex	Level of anxiety		Total	*p*-value
		anxious	non-anxious		
Younger children	male	6 (17.1)	29 (82.9)	35 (44.3)	0.003*
	female	13 (29.5)	31 (70.5)	44 (55.7)	
Older children	male	6 (9.4)	58 (90.6)	64 (52.9)	0.180
	female	10 (17.5)	47 (82.5)	57 (47.1)	

* statistically significant ($p < 0.05$, χ^2 test, degrees of freedom (df) = 1). Data presented as frequency (percentage) (n (%)).

Table 4. Comparative analysis of color preferences in relation to the level of anxiety and positive emotions across 2 age groups

Age group	Level of anxiety	Positive emotions (happy face)							*p*-value
		red	blue	green	pink	white	yellow	black	
Younger children	anxious (n = 19)	3 (15.8)	4 (21.1)	3 (15.8)	4 (21.1)	1 (5.3)	4 (21.1)	0 (0.0)	0.370
	non-anxious (n = 60)	10 (16.7)	12 (20.0)	10 (16.7)	14 (23.3)	3 (5.0)	11 (18.3)	0 (0.0)	
Older children	anxious (n = 16)	3 (18.8)	3 (18.8)	2 (12.5)	5 (31.3)	1 (6.3)	2 (12.5)	0 (0.0)	0.510
	non-anxious (n = 105)	10 (9.52)	34 (32.4)	9 (8.6)	23 (21.9)	2 (1.9)	27 (25.7)	0 (0.0)	

* statistically significant ($p < 0.05$, χ^2 test, df = 6). Data presented as n (%).

Table 5. Comparative analysis of color preferences in relation to the level of anxiety and negative emotions across 2 age groups

Age group	Level of anxiety	Positive emotions (happy face)							*p*-value
		red	blue	green	pink	white	yellow	black	
Younger children	anxious (n = 19)	5 (26.3)	7 (36.8)	0 (0.0)	4 (21.1)	1 (5.3)	0 (0.0)	2 (10.5)	0.370
	non-anxious (n = 60)	15 (25.0)	15 (25.0)	4 (6.7)	5 (8.3)	3 (5.0)	3 (5.0)	15 (25.0)	
Older children	anxious (n = 16)	2 (12.5)	7 (43.8)	1 (6.3)	1 (6.3)	1 (6.3)	3 (18.8)	1 (6.3)	0.130
	non-anxious (n = 105)	29 (27.6)	19 (18.1)	9 (8.6)	14 (13.3)	8 (7.6)	7 (6.7)	19 (18.1)	

* statistically significant ($p < 0.05$, χ^2 test, df = 6). Data presented as n (%).

Table 6. Comparative analysis of color preferences associated with positive emotions among boys and girls in 2 age groups

Age group	Sex	Positive emotions (happy face)							*p*-value
		red	blue	green	pink	white	yellow	black	
Younger children	male (*n* = 35)	4 (11.4)	9 (25.7)	9 (25.7)	0 (0.0)	2 (5.7)	11 (31.4)	0 (0.0)	0.001*
	female (*n* = 44)	9 (20.5)	7 (15.9)	4 (9.1)	18 (40.9)	2 (4.5)	4 (9.1)	0 (0.0)	
Older children	male (*n* = 64)	10 (15.6)	28 (43.8)	7 (10.9)	1 (1.6)	1 (1.6)	17 (26.6)	0 (0.0)	0.001*
	female (*n* = 57)	3 (5.3)	9 (15.8)	4 (7.0)	27 (47.4)	2 (3.5)	12 (21.1)	0 (0.0)	

* statistically significant ($p < 0.05$, χ^2 test, $df = 6$). Data presented as *n* (%).

Table 7. Comparative analysis of color preferences associated with negative emotions among boys and girls in 2 age groups

Age group	Sex	Positive emotions (happy face)							*p*-value
		red	blue	green	pink	white	yellow	black	
Younger children	male (*n* = 35)	13 (37.1)	8 (22.9)	2 (5.7)	2 (5.7)	2 (5.7)	3 (8.6)	5 (14.3)	0.030*
	female (*n* = 44)	7 (15.9)	14 (31.8)	2 (4.5)	7 (15.9)	2 (4.5)	0 (0.0)	12 (27.3)	
Older children	male (*n* = 64)	17 (26.6)	11 (17.2)	6 (9.4)	7 (10.9)	9 (14.1)	7 (10.9)	7 (10.9)	0.080
	female (*n* = 57)	14 (24.6)	15 (26.3)	4 (7.0)	8 (14.0)	0 (0.0)	3 (5.3)	13 (22.8)	

* statistically significant ($p < 0.05$, χ^2 test, $df = 6$). Data presented as *n* (%).

Discussion

From the moment of birth, man is subject to anxiety and fear. These emotions have a multifactorial and complex physiological and psychological etiology in dental environments. Dental anxiety represents the most significant challenge and a major concern for pediatric dentists. Many dental procedures are either avoided or missed intentionally when children are anxious, largely due to the erroneous belief that the procedure will be excruciatingly painful. The avoidance of dental visits has a detrimental impact on children's oral health. The present study revealed that the dental environment plays an important role in reducing anxiety levels in children. Umamaheshwari et al. observed that the primary cause of dental anxiety is a negative perception of the dental environment by children.[3] Pediatric dentists must, therefore, create a calm and welcoming atmosphere in their clinics to address the concerns of young patients.

In the present study, non-anxious children from both groups preferred blue, pink and yellow when coloring a happy face. Younger anxious participants, however, preferred yellow, blue and pink, whereas older anxious children preferred pink, red and blue over other colors. This observation is in accordance with the study by Umamaheshwari et al., who observed that younger children associate yellow with positive emotions, while older children prefer blue to depict positive emotions.[3] Furthermore, the present study noted that younger anxious children preferred black and red to express negative emotions, while older children preferred black to express the same emotions. In the case of non-anxious participants, both groups selected red, black and yellow to represent negative emotions. In contrast with the results of the present study, Odom and Sholtz evaluated the impact of hue on mood tones. The findings indicated that blue had a calming effect, while yellow was perceived as both exciting and cheerful. While younger anxious children preferred black, older children preferred red for expressing negative emotions.[20]

The current study also noted that younger children with anxiety preferred the color black to depict negative emotions, while the older group preferred red and black. This finding aligns with the results of the study conducted by Boyatzis and Varghese, which observed a correlation between darker colors and negative emotions as well as lighter colors and positive emotions.[6] The hypothalamus controls the nerve centers, respiration and heart rate. It induces a physical reaction in children when they are exposed to light stimuli and different colors. Every energy and wavelength has a different impact on children. Specific colors have been observed to increase perspiration, cause a vascular reflex action, stimulate muscular reactions, and affect the eye blinking rate. Kurt and Osueke observed that both violet and blue can lower blood pressure, while yellow, red and orange evoke different responses.[21] With regard to the relationship between color temperature and children's reactions, it was observed that while cool or warm colors could calm one child, they may evoke a different response in another child.[20]

The *p*-value of 0.003 observed in the current study rejects the null hypothesis and accepts the alternative hypothesis, concluding that there was a sex variation in the anxiety levels among younger children. The present study indicates that the majority of boys in both groups preferred red and black to express negative emotions. With regard to positive emotions, younger girls chose pink, blue and red, while the older ones selected pink, blue and yellow. Pink was the leading color choice among girls. Both younger and older girls, 31.8% and 26.3%, respectively, picked black to express negative emotions. In both age groups, the boys selected yellow and blue to depict positive emotions. These results bear a resemblance to a previous study by Annamary et al.[16] Some experts believe that the cultural influences account for these preferences. Typically, parents raise boys in a blue environment and girls in a pink environment.[5]

A study conducted by Jayakaran et al. in 50 randomly selected children aged 6–10 years aimed to determine the preferred aids that help them cope with their anxiety levels.[7] The authors observed that the most preferred aids were watching cartoons, listening to music, observing cartoon-painted walls, playing with toys, and the presence of parents. Implementing these aids and designing the pediatric clinics accordingly will ensure a child-friendly environment and thereby improve the quality of healthcare.[7]

In a study by Hotwani and Sharma, 100 children aged 9 years were assessed for their preference of local anesthesia and the impact of colors on their anxiety levels using the faces version of the Modified Child Dental Anxiety Scale.[22] In the study, the child was asked to match the emotions with the 6 colored injectors according to their preference. It was observed that a change in physical appearance and color helped to reduce anxiety levels, and thus could be considered a modality of behavior management. Goldstein had previously observed that specific colors can elicit an emotional response.[23] Other researchers have also stated that the choice of color used in children's artwork reflects their underlying emotional state.[23–25]

Based on the environment, parents can indirectly influence their children's color preferences. Furthermore, experiences and nationality can also influence color preferences.[23] The relationship between colors and their combination and emotions has been investigated in several studies.[26] The use of colors in a dental setting can contribute to a sense of calm for both staff and children. The use of colored equipment can further expand this benefit. It was agreed that 7 colors should be used in the study (black, red, white, yellow, green, blue, and pink). Blue, green, yellow, and red were chosen because they represent the 4 basic colors of the Munsell color system. Pink was selected as the color of bodily tissues, and black and white were selected because they are achromatic colors.[26] The emoticon set included sad and happy faces. Terwogt and Hoeksma found that the association between emotions and color preferences differed between age groups.[27] While children in the older age group displayed a lower correlation between emotions and colors, children in the younger age group demonstrated a stronger correlation.[27] This aligns with the finding that, depending upon personal experiences, as a person grows older, their choices and preferences vary.[27]

The dental environment plays a crucial role in children's behavior, particularly in their willingness to cooperate with treatment. The emotional state of the child is reflected in their physical health.[28] In their study on the use of color in pediatric dentistry, Park and Park showed that the use of child-friendly colors can positively impact emotional health.[12] Their findings indicated that girls exhibited greater preference for red and purple than boys. It was also observed that healthy children and pediatric patients preferred blue and green, with a lesser preference for white. The color red is associated with pain, while yellow is associated with the absence of pain, as observed among Turkish children by Altan et al.[29] Another longitudinal cohort study revealed an increased prevalence of dental fear and anxiety (DFA) among children between the ages of 7 and 9.[2] The development of new carious lesions, the experience of toothache and extractions were identified as the most significant risk factors for the development of DFA. According to the study, dental treatment should not only focus on dental care but also consider its psychological impact, thereby preventing painful and traumatic experiences.[2]

A reduction in anxiety levels would decrease the time required for dental procedures and would make the procedure less stressful for the patient. Therefore, the present study suggests that by determining the levels of anxiety and identifying child-friendly colors, it is possible to incorporate these colors into the healthcare environment. This could be helpful in reducing anxiety in children and facilitating dental procedures with better success rates. Furthermore, a dental environment free of anxiety would facilitate the expression of dental concerns by children.

Limitations

The present study evaluated only 2 emotions, happiness and sadness. Further prospective and longitudinal studies are required to evaluate a greater variety of emotions in a larger population.

Conclusions

The impact of color on feelings and emotions is contingent upon the color perspective, the overall environment and the type of emotional link experienced by the individuals. Based on the results of our study, it can be presumed that there is a significant correlation between color perceptions and emotions. These factors have a major impact on children, depending on their anxiety

level, sex and age. Hence, the implementation of a child-friendly environment in dental clinics would reduce anxiety levels and facilitate cooperation with pediatric patients.

Ethics approval and consent to participate

The study was approved by the Ethics Committee of Jazan University (approval No. CODJU-1716I). Written consent was obtained from the parents or legal guardians of the study participants before the start of the study.

Data availability

The datasets generated and/or analyzed during the current study are available from the corresponding author on reasonable request.

Consent for publication

Not applicable.

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