Designing for Distress in Pediatric Optometry Exams using a Mixed Methods Case Study and Human-Centered Design

By: Ronal Infante

A Thesis Submitted in Partial Fulfillment

of the Requirements for the Degree of

Master of Science in Industrial Design

at the

University of Houston

Houston, Texas

May 2020

Thesis Committee:

EunSook Kwon, Ph.D.

Gordon Vos, Ph.D.

Ruth E Manny, O.D., Ph.D., FAAO

Muriel L Martinez, O.D., FAAO

Designing for Distress in Pediatric Optometry Exams using a Mixed Methods Case Study and Human-Centered Design

Ronal Infante

Approved by
Committee Members:

Chair of the Committee
EunSook Kwon, Ph.D.
Professor, Director of Industrial Design Program
Industrial Design Program,
Gerald D. Hines College of Architecture and Design

Gordon Vos, Ph.D.
Lecturer
Industrial Design Program,
Gerald D. Hines College of Architecture and Design

Ruth E Manny, O.D., Ph.D., FAAO
Charles R. Stewart Professor
College of Optometry

Muriel L Martinez, O.D., FAAO
Clinical Assistant Professor
College of Optometry

ABSTRACT

Children can be difficult to examine because they may become noncompliant if their physical and emotional needs are not met. Previous studies show that the administration of eye drops used to dilate the eye during cycloplegia causes significant distress in children and that younger age groups experience more anxiety. Yet, there is a lack of studies that describe and measure anxiety throughout the entire length of an eye exam, provide qualitative themes about the exam, and investigate if physical and emotional factors and factors related to the exam are correlated with distress. To fill this gap, this thesis starts with a descriptive mixed methods case study that employs statistical analysis and theme analysis of survey responses, observations, and field notes collected at the University of Houston's University Eye Institute.

The study findings corroborate previous studies. There were significantly higher anxiety levels during dilation with cycloplegia when compared to the baseline and all other procedures, with the exception of tonometry, which did not show a significant difference compared to dilation. Also, the youngest age group had significantly higher anxiety levels throughout the entire exam compared to the other two older age groups.

However, the findings reveal that two otherwise overlooked procedures, tonometry and ophthalmoscope test, also showed significantly higher anxiety when compared to the baseline. Furthermore, factors not examined by previous studies, e.g. being new to the clinic, receiving an eye exam in the morning, and having a lower mood rating, showed significantly higher anxiety. Lastly, patient age, time since last nap, and number of eye exams showed strong negative correlations with anxiety level.

Eight key themes were frequently present in the observations: (1) administering cycloplegic drops was the most anxiety-inducing procedure within a single eye exam, (2) being restrained was anxiety-inducing, even before drops were administered, (3) having a parent restrain their child or sit the child on their lap occurred in most exams, (4) tools and tricks used to capture a child's attention incorporated color, movement, lights, and sounds, (5) children sought their parents during times of stress in most exams, (6) children were more anxious when doctors were present,

(7) children experienced anxiety even when doctors showed them their tools and explained the procedures, and (8) children squirmed when in anxious situations in most exams.

By collaborating with doctors and designers, this thesis subsequently translates the study's findings into key design heuristic principles used in the development of a design for an interventional product that aims to reduce distress during exams.

The proposed interventional product takes the form of glasses and features an adjustable body with two channels positioned directly in front of the eyes to deliver dilation drops in an agile manner and visual targets that snap into the body to distract a child and naturally open their eyes. This product is intended to be used while the child is sitting upright in a chair. It delivers drops quickly, is less prone to mistakes, and eliminates the need to restrict a child, thereby reducing anxiety.

The proposed interventional product is a culmination of a data-driven, human-centered research approach, fueled by the combination of traditional scientific research and applied design research methods, that has surfaced in several recent publications in the field of healthcare as a way to propose solutions to complex issues in a faster, more direct and empathetic manner. Such an approach has been discussed, yet not many examples exist. Thus, this thesis serves as an example of how to maximize empathy and include diverse perspectives by merging both traditional scientific research and applied design research methods when designing for healthcare.

ACKNOWLEDGEMENTS

First and foremost, I owe so much of this work to my faculty sponsor and program director, Dr. EunSook Kwon, who has molded me from an engineer to a transdisciplinary designer. You have radically changed the way I think and inspired me to redefine my career goals. You believed in me when I applied to the program and have worked patiently with me in realizing the lofty goals I had for this thesis. You have been more than an educator; you have been a role model.

I want to thank Dr. Gordon Vos for being incredibly generous with his time. You took a significant amount of time out of your very busy schedule to mentor me and teach me how to tackle complicated data. I feel empowered by the data analysis skills I have gained and cannot wait to apply them again. Thank you for your influence.

This thesis absolutely could not have been possible without Dr. Ruth Manny and Dr. Muriel Martinez. You both took a chance with me, pulled many strings for me, and advocated for the study and me as a researcher. Along with fellow faculty members, Dr. Karen Fern, Dr. Debra Currie, Dr. Kassaundra Johnston, Dr. Beth Harper, and the UHCO Pediatric and Binocular Vision Service staff, residents, and student doctors, you have welcomed me into your world, let me be a part of your important work, and shared your amazing ideas. I am inspired by the impact your clinic has on the lives of your patients and I am beyond grateful.

For solidarity, inspiration, and stability I have my friends and fellow members of the graduate industrial design studio to thank. Special thanks to Cameron White and Megan Collins for your suggestions and connections and Kristi Bartlett and Andres Quintero, who I can always count on for good, honest advice.

I also want to thank the incredibly talented Rick Lowe, Catherine Davila, and Brent Reaney who have enriched my life with socially-engaged art, validated my efforts to draw attention to the needs of diverse users through human-centered design, and have encouraged me to see myself as an artist.

I dedicate this thesis to my parents, Vivian and Oscar, who have overcome insurmountable challenges bringing us to this country. Thank you for teaching me work ethic and how to dream. I owe you everything and I am so proud to be your son.

Les dedico esta tesis a mis padres, Vivian y Oscar, quienes han superado varios desafíos al traernos a este país. Gracias por enseñarme cómo trabajar duro y soñar. Les debo todo y estoy muy orgulloso de ser tu hijo.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1. INTRODUCTION

1.1. Issues Related to Early Eye Care in Pediatric Optometry.

For children, early eye care is very important. Eye exams can help identify vision problems, such as amblyopia (lazy eye), strabismus (cross-eye) and cataracts (clouding of the eye's lens). Amblyopia and some forms of strabismus are treatable with spectacles and outpatient procedures, while cataracts and other forms of strabismus require surgical intervention (Blaikie & Dutton, 2015).

Myopia (nearsightedness) is a condition where the eye elongates and causes light to focus anterior to the retina. Myopia has been called a global epidemic due to its increasing prevalence; global rates of myopia are increasing, especially in Asia (Seppa, 2013; Vitale, Sperduto, & Ferris, 2009). In addition to its increasing prevalence, myopia is alarming because high myopia has been associated with retinal detachment, glaucoma, cataracts, macular degeneration, visual impairment, and blindness (Prousali et al., 2017; Seppa, 2013; Rose, Smith, Morgan, & Mitchell, 2001; Zadnik et al., 2015). The refractive error caused by myopia is compensated in children by optical correction using spectacles or contact lenses. In adults when the myopia is stabilized, refractive surgery is a treatment option (Vitale, Sperduto, & Ferris, 2009). However, there exists no generally accepted strategy to decrease myopic progression (Prousali et al., 2017). Studies suggest that factors contributing to myopic progression include decreased exposure to natural light, genetics, and straining of the eyes due to increased amounts of near work (Seppa, 2013; Vitale, Sperduto, & Ferris, 2009; Prousali et al., 2017).

Given the possibility that parents may miss symptoms and that a young child may be unable to communicate their symptoms, children should have their first comprehensive eye exam at 6 months, then again at age 3, and every 2 years thereafter (Irving et al., 2016; Scheiman et al., 2002). If left untreated, these problems can progress and become more difficult to treat with age. Furthermore, if a child has a vision problem that affects their visual acuity, their ability to learn may be impacted (Garzia et al., 2008; Wood, Black, Hopkins, & White, 2018).

Higher rates of myopia coincide with technological advances, a more industrialized society, shifts in culture that feature more screen-based activities, and longer periods of near-work, via screens or paper, due to more time in classrooms and a higher demand for advanced skills and trades. Logically, it follows to say that children will be seeking eye exams more often due to the increased prevalence of habits that cause poor visual acuity. Therefore, it is more important than ever to ensure that eye exams are well designed for kids. Be that as it may, there are hurdles to overcome.

1.2. Research Problem & Significance of Study.

Children can be difficult to examine by clinicians because they may become noncompliant if their physical and emotional needs are not met (Blaikie & Dutton, 2015). As one might imagine, the emotional needs of children are complex, relate to their physical needs (such as eating and sleeping), and may involve other factors (as discussed in later sections). Moreover, a crying child, or one throwing a tantrum due to distress, can impede optometrists from assessing eye health during an examination (Blaikie & Dutton, 2015; Hirji, Jones, & Thompson, 2012; Sujuan, Handa, Perera, & Chia, 2015).

Yet, there is a gap in the literature characterizing the emotional state of children during eye exams. As discussed further in the following section, only the administration of medicated drops used to dilate the eyes to facilitate cycloplegic refraction is well-characterized as a cause of distress. Cycloplegic refraction is a key procedure in comprehensive eye exams and dilation of the pupil facilitates this procedure. Common dilation drops include cyclopentolate, tropicamide, phenylephrine, and proparacaine (an anesthetic) used at varying concentrations depending on the patient's age, medical history and suspected ocular conditions. Cycloplegic refraction is unsurprisingly uncomfortable because the drop solutions have a low pH and sting the eyes. The pain causes crying and other signs of distress such as squirming that may make examinations difficult for clinicians. Surprisingly, not much qualitative data is available to further describe this procedure. It may be possible that other unknown factors present during this procedure, such as being restrained by clinicians and having their eyelids opened, cause children to experience anxiety more than the drops themselves. It may also be a possibility that earlier procedures build up anxiety prior to drop administration. Perhaps other physical and emotional factors contribute

to anxiety as well. A study that examines anxiety throughout an eye exam and identifies additional factors, procedures, and tools that correlate with distress may be the first step in closing the gap in the literature.

This thesis aims to capture a holistic view of the anxiety experienced by children during an eye exam by examining data that has not been obtained in previous studies. This additional context could have numerous clinical applications, one of which being an input to the design of a tool to help reduce anxiety. As such, this thesis also aims to use the study's findings as an input to the research and development of a product to help reduce distress.

1.3. Research Questions.

1. *Are there differences between the anxiety scores for each of the exam procedures?*

Previous studies only evaluate anxiety at either 2 or 4 points and some do not use an appropriate clinical tool. Hirji, Jones, & Thompson (2012) examined anxiety "At home," "on arrival in the department," "on receiving cyclopentolate drops," and "on seeing the doctor" using a scale from 1 to 10. A year later, Syrimi, Jones, & Thompson (2013) compared anxiety caused by drops to that of a spray alternative "at home," "on arrival at the department," "on dilation," and "on examination" using that same scale. Sujuan, Handa, Perera, & Chia (2015) merely examined anxiety before and after drop administration. They reported that 25.8% of children had pre-drop anxiety but did not provide data for that period. In summary, none of these studies provided information between the arrival of the patient and drop administration. There is currently no data to compare the anxiety level of the administration of drops to that of other exam procedures. It is of interest to examine the impact of each procedure on anxiety to better understand the pre-drop period and to see if a procedure other than drop administration is anxiety inducing.

2. *What factors are correlated with pediatric distress?*

Hirji, Jones, & Thompson (2012) found differences in anxiety between 3 age groups: under 4 years, 4 - 7 years, and 7 - 10 years of age. The 2 younger age groups experienced more anxiety across all 4 evaluation points and on receiving drops, most so in the youngest age group. Furthermore, the

2 younger age groups had significantly more patients that were deemed "difficult to examine" and "unexaminable," with a large proportion of these patients belonging to the youngest age group. Syrimi, Jones, & Thompson (2013) examined the same age groups and found differences in anxiety between drops and spray methods for the 2 younger age groups and no differences between "naive" and "experienced" patients at all 3 age groups. Sujuan, Handa, Perera, & Chia (2015) examined "cooperativeness" between multiple factors—age group, sex, race, rank of child in family, general level of anxiety, personality type, experience with eyedrops, predictions and the perception of the child by doctors, nurses, and optometrists, and anxiety assessed by the child's guardian. They report that it took longer to administer drops and perform refraction on uncooperative children and that these children tended to be younger, male, have had previous negative eyedrop experience, were more anxious, and were described as demanding and aggressive by their parents. Findings from all of these studies are discussed in detail in the next section.

However, there is more to examine. None of these studies examined the impact of physical and emotional factors, such as sleep, meals, and mood, or factors related to the exam, such as length, experience of the clinician, time of day, etc. It is of interest to examine the impact of additional factors on anxiety and to corroborate the results of previous studies. Furthermore, none of these studies provide qualitative themes that describe what occurs during drop administration.

3. *How do optometrists calm down distressed children?*

Sujuan, Handa, Perera, & Chia (2015) reported that 25.6% of uncooperative children were soothed by rewards such as sweets or stickers. However, no studies provide qualitative themes that describe what occurs when children are rewarded, nor do they describe other ways children are soothed if these rewards are not given.

4. *How do children behave between exam procedures?*

No studies exist that provide qualitative data on the behaviors that occur between the procedures of an eye exam.

5. *How might we use this knowledge as an input to human-centered design?*

Although human-centered design is not new, it has become popular in healthcare recently. As discussed in the next section, there is interest in exploring novel ways to merge scientific research methods with applied design research methods to improve how we design healthcare products.

1.4. Theoretical Framework for a Descriptive Mixed Methods Case Study.

Creswell & Creswell (2014) advise that researchers should outline their approach to research when planning a study. According to them, an approach to research should discuss the philosophical worldview or paradigm that best aligns with the researcher, how it relates to the research design, and through which specific methods of research will the approach be translated into practice. Figure 1 displays a theoretical framework that outlines the research approach of this thesis.

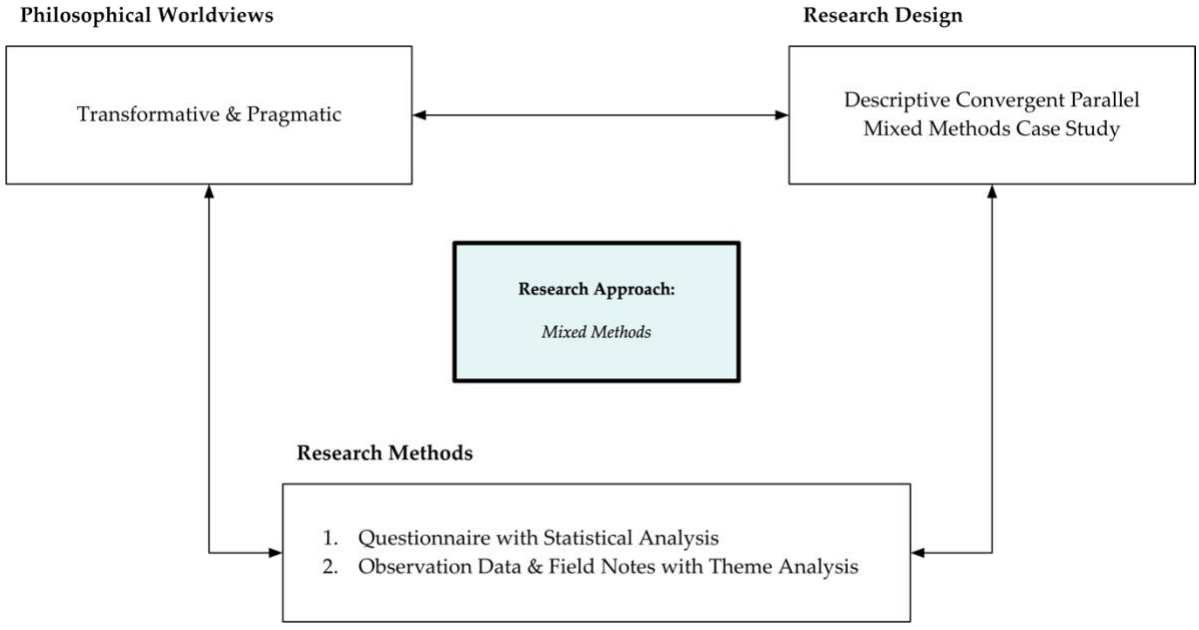


Figure 1. Theoretical framework for research—the interconnection of worldviews, research design, and research methods

Of the four main worldviews they provide that are relevant to the social sciences, this thesis aligns with that of both a transformative and a pragmatist worldview.

This thesis focuses on the interactions between children and optometrists to provide a more holistic understanding of anxiety throughout the entire length of a pediatric eye exam. Children are marginalized and their experiences are not as well-characterized as adult patients, due in part because children are more difficult to research and because adults make up the majority of cases. The findings of this research are intended to communicate the voice of the research participants and to describe their experiences as a way to advance an agenda that improves their experiences, reduces the marginalization of children, and changes the way cycloplegia is performed. To fully understand the case at hand, a collaborative approach is required to collect information from the study participants through self-disclosure and observation. The collaborative and change-oriented research approach of this thesis reflects qualities of a transformative worldview.

Moreover, this research is intended for a specific purpose—to inform the design of an interventional product. The research is grounded in real-world practice, assumes a clearly-defined context, and aims to reveal correlations between novel factors and anxiety, as well as to provide descriptive accounts of events that occur to provide the best understanding of the case. Since the target age group includes pre-verbal children and children that are too young to reliably communicate their experiences, the research must include descriptive observations of events and must use parents as a proxy to capture reliable information about their child's experiences. Since this research also has intrinsic problem-centered, pluralistic qualities and it centers around real-world practices, this research approach is also reflective of a pragmatist worldview.

As previously discussed, the research problem tackled by this thesis calls for both the identification of novel factors that are correlated with anxiety and descriptions of procedures and events that take place during eye exams to fill a research gap. A purely qualitative or quantitative approach would be insufficient to tackle this research problem. Thus, this research merits a mixed methods approach. Specifically, a descriptive convergent parallel mixed methods case study design addresses the research problem best. According to Creswell & Creswell (2014), case study

designs, which are often tied with transformative worldviews, are well-suited for situations that are clearly-defined by a time and activity and that require various methods of data collection over a period of time in order to provide a detailed analysis. Convergent parallel mixed methods designs, which are in-line with pragmatist worldviews, combine both qualitative and quantitative data collection roughly at the same time in support of a comprehensive analysis. As opposed to other mixed methods, a convergent parallel design collects data at a single stage of inquiry. When combined with a case study, this single-session research design becomes uniquely appropriate for a clinical setting where patients are usually seen once annually and for a study protocol that aims to recruit a convenience sample of study participants.

In order to tackle the aforementioned research problem, this research design utilizes a survey, observations, and field notes as methods to collect both quantitative and qualitative data and analyzes the data using statistical analysis and theme analysis, respectively. The study findings serve as inputs to inform subsequent human-centered design applied research methods used to develop an interventional product. Figure 2 outlines all of the methods used in this thesis.

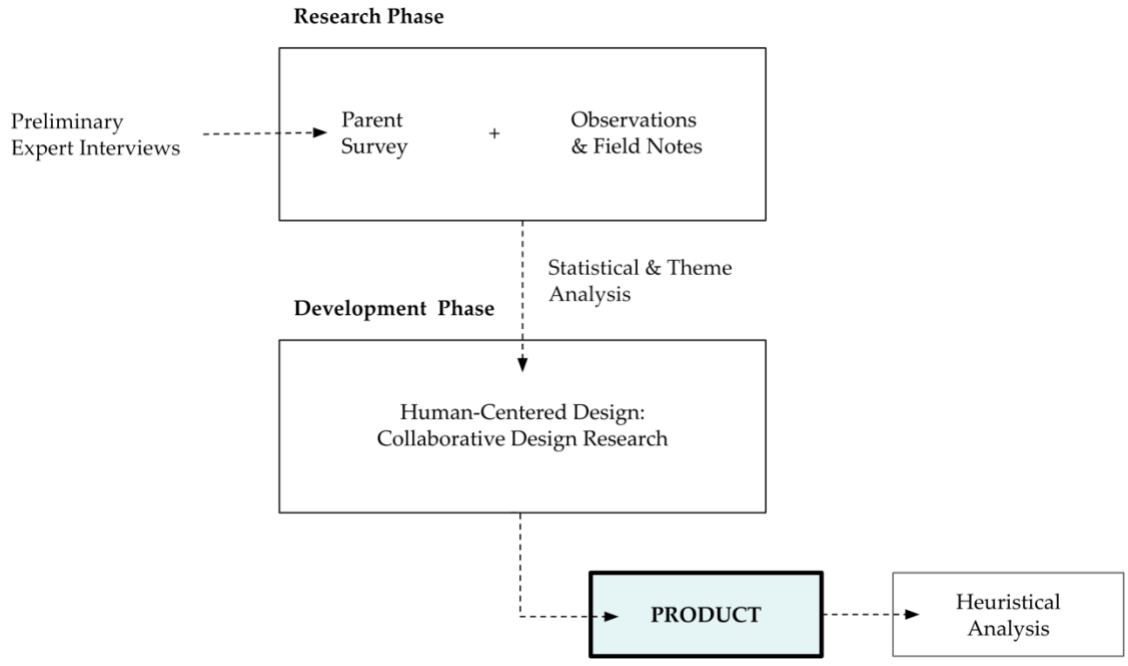


Figure 2. An outline of the methods used in this thesis.

Pre-verbal children and children under 4 years of age are unable to read and unable to describe their anxiety verbally. Therefore, observations and field notes using the mYPAS, whose history and reliability is discussed in the next section, were chosen as the appropriate methods of describing and measuring anxiety. Inspired by previous studies and preliminary expert interviews, which are mentioned in the next section, a parent survey was chosen as the appropriate method of collecting data on factors that influence patient distress prior to arrival at the clinic. Rationale for the choice of each of the factors is provided in the section on methodology.

As displayed in Figure 3, the statistical analysis seeks to identify statistically significant differences between the effects of categorical factors and correlations between several continuous factors and patient anxiety. As displayed in Figure 4, the theme analysis takes descriptive codes developed from the observational data and iteratively compares them to form key themes. These methods are in-line with the descriptive nature of the research design, the philosophical worldviews, and the overall research approach. The resulting findings are intended to prompt critical dialogue and lay the foundation for controlled studies that may seek to prove causation with sample sizes that are larger and more representative of the clinical population.

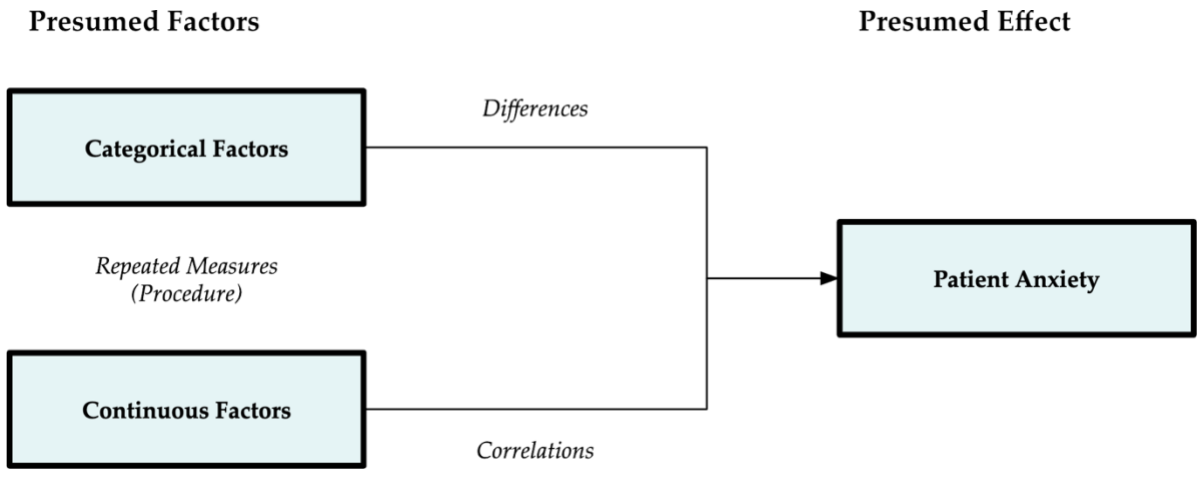


Figure 3. A visual map of the statistical analysis process.

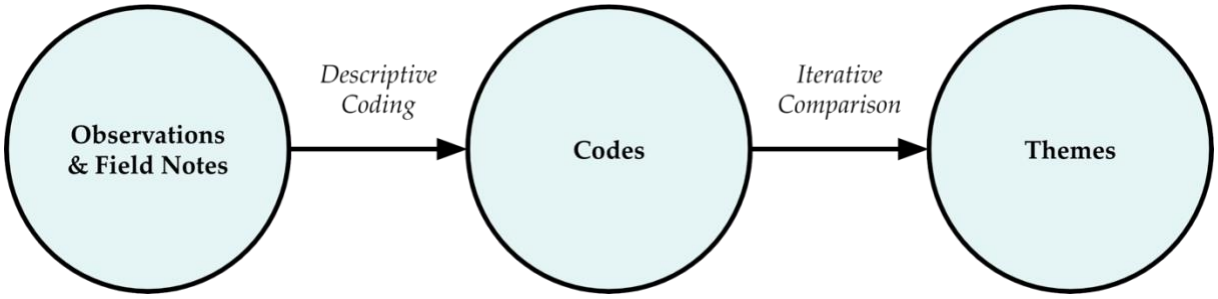


Figure 4. A visual map of the theme analysis process.

2. LITERATURE REVIEW

2.1. Human-Centered Design Gains Attention in Healthcare.

Human-centered design is a mindset and an empathy-rich approach to problem solving that focuses on the user's needs, characteristics, feelings, and perspectives throughout product research and development. It can be thought of as alternating sets of divergent and convergent thinking throughout the inspiration, ideation, and implementation phases of design development.

Design thinking is a closely related applied research and innovation framework that builds upon human-centered design by outlining the process of cyclical innovation, touts diverse and collaborative teams, and encourages rapid prototyping. It frames innovation in terms of human desirability, what is technologically feasible, and what is economically viable.

These approaches can be paired with each other and additional design research methods to ensure that products are truly relevant and meaningful to their users.

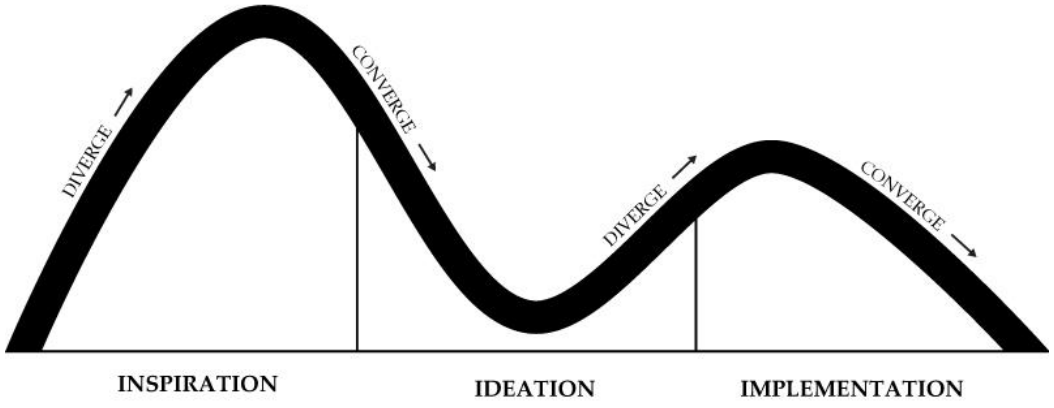


Figure 5. Diagram illustrating human-centered design

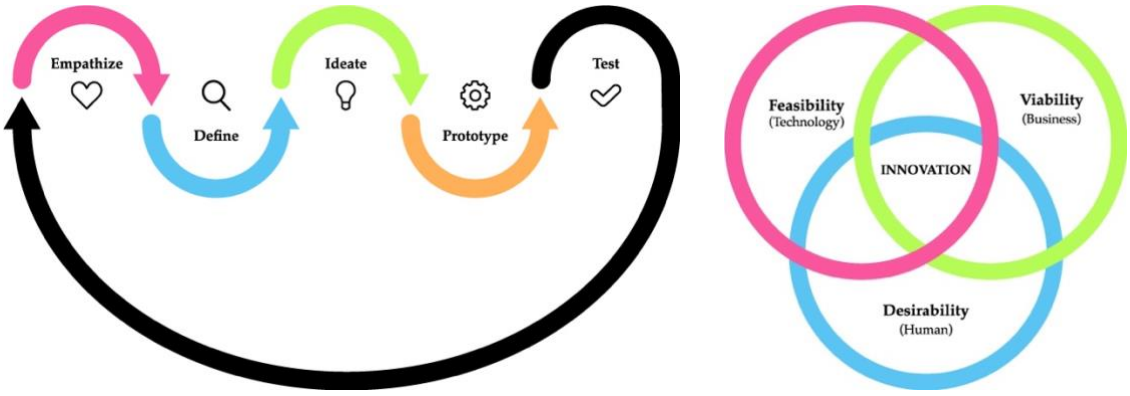


Figure 6. Diagram illustrating the steps of the design thinking process (left) and the three principles of design thinking (right).

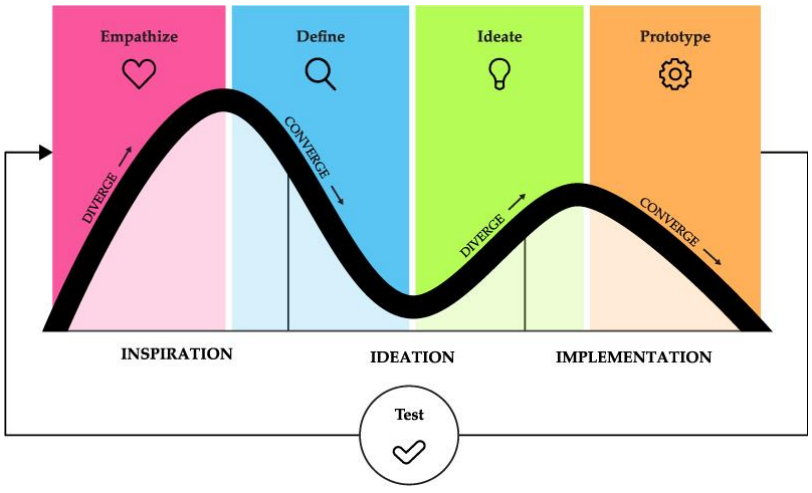


Figure 7. Diagram illustrating human-centered design and design thinking together.

Human-centered design and design thinking are not new approaches. They are a culmination of decades of critical dialogue about the way we design. Szczepanska (2017) and Rammal (2019) tie both approaches to the Scandinavian participatory or co-operative design work of the 1960s. They are, however, relatively new to the healthcare industry. Roberts, Fisher, Trowbridge, & Bent, (2016) discussed that there has recently been a call for change in US healthcare systems as costs and disparities increase. They argue that the healthcare industry should follow the example set forth by the business community and adopt design thinking as a framework to tackle complicated, systemic issues.

Ferreira, Song, Gomes, Garcia, & Ferreira, (2015) agree and position design thinking as a tool to be used by designers and non-designers alike. They encourage healthcare professionals to adopt design thinking and to learn how to empathize with users, rather than prescribe what they believe is best, in order to create meaningful change. Furthermore, they outline the difference between scientific research, which relies on publications and lengthy peer-review and is based on the inside-out Cartesian scientific method that involves developing a hypothesis and then involving users in procedures, and design thinking, which is humanistic in its approach, involves users from the beginning, and seeks to quickly test and validate ideas. They hint that a combination of both could yield new advances in products and services.

Design thinking is making such an impact that medical schools around the country are increasingly incorporating innovation into their programs (Niccum, Sarker, Wolf, & Trowbridge, 2017; van de Grift & Kroeze, 2016; Marcus, Simone, & Block, 2020; Aaronson, White, Black, Sonis, & Mort, 2020; Thomas, Nguyen, Teherani, Lucey, & Harleman, 2020). It is also readily being used in to improve, services, and systems, and tools in hospitals and clinical settings (Sherman et al., 2019; Daniëls, Hochstenbach, van Bokhoven, Beurskens, & Delespaul, 2019). The ongoing trend of merging scientific research and applied design research played a significant role in the development of this thesis.

2.2. *The mYPAS is the Current Standard for Evaluating Anxiety in Children.*

The Yale Preoperative Anxiety Scale (YPAS) was originally developed to fill the need for a statistically valid measurement tool to assess preoperative anxiety in young children (Kain et al., 1997). It's predecessor, the Spielberger's State-Trait Anxiety Inventory, is a questionnaire-based evaluation limited in that it is lengthy (5-10min to complete) and could only be used with children over the age of 5, often with assistance for children under 8 (Kain et al., 1997). In contrast, the YPAS is an observation-based evaluation with 5 domains based on visual and aural cues (activity, emotional expressivity, state of arousal, vocalization, use of parents) that can be completed in less than one minute and has good inter- and intra-observer reliability. The YPAS, later modified and expanded by Kain et al. (1997) into the Modified Yale Preoperative Anxiety Scale (mYPAS), was proven to be as valid as its predecessor and made it possible to assess the anxiety of younger children prior to the administration of anesthesia in preoperative settings. Years later, the "use of parents" domain was eliminated from the mYPAS due to overlap with the other domains, leaving only 4 domains and making the evaluation faster while retaining its accuracy (Jenkins, Fortier, Kaplan, Mayes, & Kain, 2014).

$$mYPAS\ score = \frac{1}{4} * \sum_{i=0}^{4} \frac{100 * x_i}{d_i} \tag{1}$$

Where x_i is the recorded domain score
d_i is the max domain score

A score on the mYPAS is calculated by taking the product of 25 and the sum of each of the 4 domain scores divided by the domain's maximum score. A mYPAS cutoff score of 30 is the appropriate indicator of high anxiety (Kain et al., 1997).

Domain: Activity	
1.	Looking around, curious, playing with toys, reading (or other age-appropriate behavior); moves around holding area/treatment room to get toys or to go to parent; may move toward equipment
2.	Not exploring or playing, may look down, fidget with hands, or suck thumb (blanket); may sit close to parent while waiting, or play has a definite manic quality
3.	Moving from toy to parent in unfocused manner, non-activity-derived movements; frenetic/ frenzied movement or play; squirming, moving on table; may push mask away or cling to parent
4.	Actively trying to get away, pushes with feet and arms, may move whole body; in waiting room, running around unfocused, not looking at toys, will not separate from parent, desperate clinging

Domain: Vocalizations	
1.	Reading (nonvocalizing appropriate to activity), asking questions, making comments, babbling, laughing, readily answers questions but may be generally quiet; child too young to talk in social situations or too engrossed in play to respond
2.	Responding to adults but whispers, "baby talk," only head nodding
3.	Quiet, no sounds or responses to adults
4.	Whimpering, moaning, groaning, silently crying
5.	Crying or may be screaming "no"
6.	Crying, screaming loudly, sustained (audible through mask)

Domain: Emotional Expressivity	
1.	Manifestly happy, smiling, or concentrating on play
2.	Neutral, no visible expression on face
3.	Worried (sad) to frightened, sad, worried, or tearful eyes
4.	Distressed, crying, extreme upset, may have wide eyes

Domain: State of Apparent Arousal	
1.	Alert, looks around occasionally, notices or watches what anesthesiologist does (could be relaxed)
2.	Withdrawn, sitting still and quiet, may be sucking on thumb or have face turned into adult
3.	Vigilant, looking quickly all around, may startle to sounds, eyes wide, body tense
4.	Panicked whimpering, may be crying or pushing others away, turns away

Figure 8. The shortened form of the mYPAS (Jenkins, Fortier, Kaplan, Mayes, & Kain, 2014).

2.3. *Administering Dilation Drops Causes Distress.*

One known cause of distress in eye exams is the administration of drops used to dilate the eyes to facilitate cycloplegic refraction and ocular health assessment.

In their study of distress caused by cyclopentolate drops in children, Hirji, Jones, & Thompson (2012) confirm that drop administration causes significant distress in children. At this point in time, the mYPAS had not been used before in optometry studies. Therefore, guardians of children under 10 were issued questionnaires to assess anxiety using a 1-10 scale upon arrival to the clinic, asked to report factors that they felt contributed to distress, and asked to rate their child's anxiety at home, upon arrival, while receiving drops, and on examination. Wait times and the doctor's perception of whether the child was easy to examine, difficult to examine, or unexaminable were recoded. Only cyclopentolate and phenylephrine drops were used during dilation.

Hirji, Jones, & Thompson (2012) report that distress peaked when receiving drops for all age groups (under 4 years, 4 - 7 years, and 7 - 10 years of age). They conclude that drop administration is a significant source of distress.

They also report that children of all age groups "were significantly more distressed on examination" compared to their anxiety assessments at home and that "distress scores on examination were significantly greater" in children under 4 years of age. Longer wait times were reported to increase distress in all age groups and to the highest degree in children under 4. Discomfort due to the drops, prolonged waiting times, and the use of bright lights during examinations were factors reported by guardians as having contributed to distress. Only children in the two younger age groups, under 4 years and between 4 - 7 years, were reported to have been designated difficult to examine or unexaminable. Children under 4 years were designated difficult to examine or unexaminable to a higher degree.

It would be of interest to examine procedure and age group as factors using an appropriate clinical tool to assess anxiety, such as the mYPAS, that does not rely on the parent's subjective evaluation of their child's anxiety. This study and its findings influenced the selection of age groups in this thesis and supported the notion that examining anxiety levels using the mYPAS over the length of an eye exam could produce meaningful findings. The idea of surveying parents to gain insight on factors otherwise unknown was inspired by the parent's role in this study. The use of the parent observations to provide anxiety ratings and qualitative data during the exam encouraged the use of a mixed methods case study design that included observations in a similar capacity.

Hirji, Jones, & Thompson (2012) discussed that some clinicians are better at administering eye drops than others and that eye drops are best delivered quickly, with confidence, and without much prior discussion. This suggested that the experience of the clinician that administers drops plays a role in causing distress and encouraged the examination of clinician experience as a factor in this thesis.

Lastly, Hirji, Jones, & Thompson (2012) discussed the additional factors reported by parents and suggested the use an anesthetic as a pre-drop solution to the pain of administering drops, that waiting rooms ought to be modified as to not bore and frustrate children, and that clinicians should be educated to be more strategic in their use of bright lights.

A subsequent study by Syrimi, Jones, & Thompson (2013) compares children's tolerance of cyclopentolate spray to that of drops. They find that although "children 7 years or younger were significantly less distressed by administration of cyclopentolate 1% spray," "there was no statistical difference in distress levels in children older than 7 years." Also, "thirteen of the 77 children who received cyclopentolate 1% spray did not have adequate cycloplegia to allow objective refraction" regardless of the amount of delay between administration of the spray and the examination, "as long as at least 30 minutes have elapsed." In contrast to the study by Hirji, Jones, & Thompson (2012), Syrimi, Jones, & Thompson (2013) report that "distress scores were independent of the waiting time between arrival to the department and examination by the physician." They attribute this difference to the successful use of a "play area staffed with a play specialist, who encouraged children to undertake activities such as coloring and making a collage while waiting for their appointment." Due to this study's finding that cyclopentolate spray was ineffective in dilating about 17% of patients, coupled with anecdotes from experts suggesting that cyclopentolate spray is less effective than drops, this thesis did not consider sprays in its study.

In another study, Sujuan, Handa, Perera, & Chia (2015) examined distress in 298 children between the ages of 2 and 12. Drops were administered in 2-3 cycles spaced 5-10 minutes apart followed by refraction 30 minutes later. The first cycle administered 1 drop each of proparacaine, tropicamide, and cyclopentolate; the second cycle administered 1 drop of phenylephrine and cyclopentolate; and the third cycle optionally administered an additional cyclopentolate drop. In total, 5-6 drops were administered to each child to ensure dilation. A cooperative scale (not cooperative, cooperative, and very cooperative) was used to classify patients based on behavioral cues (happy child and no problem, minor sulking <20 seconds, cried but allowed drops, cried and struggled, or failure to instill drops). If the child exhibited the last 3 cues (cried but allowed drops, cried and struggled, or failure to instill drops), the child was deemed not cooperative. Cooperativeness was used as a categorical dependent variable in the analysis of various factors. These factors included age group, sex, race, rank of child in family, general level of anxiety, personality type, experience with eyedrops, predictions and the perception of the child by

doctors, nurses, and optometrists, and anxiety assessed by the child's guardian using mYPAS scores with a high anxiety cutoff score of greater than 30.

Sujuan, Handa, Perera, & Chia (2015) report that 13% of patients were deemed not cooperative. It took longer to administer drops and perform refraction on uncooperative children and they tended to be younger (4.11 times more likely to be between 2.0 and 4.9 years old), male, have had previous negative eyedrop experience, were more anxious, and were described as demanding and aggressive by their parents. Furthermore, only 25.6% of uncooperative children were soothed by rewards. Their use of the mYPAS and choice of factors influenced the selection of research methods used in this thesis and served as a starting point in developing the research goal to provide additional factors and context to better understand the high anxiety group.

Sujuan, Handa, Perera, & Chia (2015) suggest that older children were more likely to tolerate the drops due to more mature cognitive skills, coping skills, and less separation anxiety—a claim supported by other studies and worth discussing if replicated in this thesis.

Another key finding is that 25.8% of patients experienced distress before the drops were administered (Sujuan, Handa, Perera, & Chia, 2015), possibly attributed to other parts of the visit beyond the administration of drops. Despite that only 26.0% of this group were uncooperative, this finding reveals that there may be other procedures that are anxiety-inducing. This is worth following up on and a key goal of this thesis. This thesis seeks to examine if other procedures are correlated with high anxiety or if the pre-drop anxiety is due to the other possibility Sujuan, Handa, Perera, & Chia (2015) provide (supported by other studies)—that different children have different thresholds of distress or have differences in expressions where some children might show overt distress while some are more stoic. They add findings from other studies that postulate "that pain and distress can be influenced by a variety of individual characteristics (e.g., temperament, pain threshold, coping style) and procedure-related factors (e.g., invasiveness, parent and staff behavior, environment)."

Sujuan, Handa, Perera, & Chia (2015) report that within the uncooperative group, later cycles of drop administration showed lower anxiety, improvements in cooperativeness, and less time to

settle down and administer drops. They suggest that the later rounds of drops are more tolerable because fears of the unknown and parental anxieties are removed as children realize their experience was not as frightening as they initially anticipated. However, it may be that these differences were biased because each cycle of drop administration was different, as discussed in their methods section. The first cycle involved 3 drops and subsequent cycles had fewer drops. Also, it is possible that the anesthetic administered in the first cycle (proparacaine 0.5%) had more time to take effect. Inconsistencies in cycles also may have played a role, as 21.8% of children were only subject to 2 cycles, rather than 3. If fears of the unknown and the child's parents truly play a role in creating distress, the children subject to these factors may show elevated anxiety at the start of the exam. A study that examines anxiety throughout the entire length of an eye exam and assesses the parent's emotional state may corroborate this suggestion.

Lastly, Sujuan, Handa, Perera, & Chia (2015) conclude that making initial eyedrop experiences in young children as pleasant as possible is a major challenge for clinicians. Younger children under the age of 5 are at greatest risk for distress and should therefore be the target for strategies seeking to increase cooperation, shorten visits, and improve trust and satisfaction. Drawing suggestions from other studies, Sujuan, Handa, Perera, & Chia (2015) suggest possible solutions may involve improving patient and parent knowledge about procedures through pamphlets or videos, improvements to the environment where drop administration takes place to make it calmer and more pleasant, and use distraction and coping-promoting behaviors.

2.4. Other Potential Factors Leading to Patient Distress.

Blaikie, & Dutton (2015) suggest various other ways to reduce distress in children. They reinforce findings from other studies that suggest that a short wait in a welcoming and uncluttered area is beneficial. Also, they mention that "a feed, a recent sleep, and a short wait enhance comfort, cooperation, and the 'window of opportunity.'" Since meals and sleep are not examined in other studies, they became key factors in this study.

Blaikie, & Dutton (2015) also suggest that clinicians with a calm, friendly, and non-anxious demeanor may reduce distress. Placing the child on a parent's lap, asking the parent to cradle the

child with their arms, and using toys, pacifiers, or bottles may also help reduce distress. Lastly, singing, humming, or whistling a song are useful strategies for clinicians to attract a child's attention throughout an examination. These suggestions influenced the study design of this thesis as it seeks to include methods that could reveal how often these strategies were used and to what degree they impacted a child's anxiety.

It is also recommended that rather than to try to restrain the crying child, which may increase distress further and create long-term negative experiences, clinicians should reschedule such exams (Blaikie & Dutton, 2015; Hirji, Jones, & Thompson, 2012; Syrimi, Jones, & Thompson, 2013).

Strube, Bakal, & Arthur (2010) corroborate that feeding schedule is a factor in patient distress. In their study of retinopathy of prematurity patients, they analyzed whether or not a "relationship exists between the timing of feeding...and gastric side effects or distress associated with [exams]." Their study reveals that feeding neonatal intensive care unit infants 1 hour before an exam, as opposed to 2 or more hours, "may reduce stress during the examination, as measured by percentage crying during the examination, with no increased incidence of vomiting or gastric aspirates." Although retinopathy of prematurity patients are examined by a pediatric ophthalmologist prior to surgical intervention, this study hints that feeding may also be a factor correlated with distress in standard comprehensive eye exams done by an optometrist.

2.5. Preliminary Expert Interviews.

In support of the literature review, preliminary expert interviews with University of Houston College of Optometry fourth-year student doctors and faculty affirmed that crying and tantrums can be disruptive while assessing eye health and that they might be caused by a variety of reasons, including mood, hunger, tiredness, new experiences, new people, and fears to certain procedures or tools used during the exam. These experts postulated that fast and agile exams are the key to taking advantage of a child's window of opportunity and thereby reducing distress. Furthermore, they affirmed that each child was unique in their emotional responses. Moreover, the same child could throw a tantrum one day can be perfectly well-behaved the next depending on numerous factors.

2.6. Literature Review Summary & Expert Interview Takeaways.

As provided, there are sources that describe and suggest best practices in pediatric optometry to reduce patient anxiety, studies that discuss the anxiety effects of the administration of cyclopentolate drops, and studies that analyze the effects of certain factors on distress during drop administration.

Yet, there is more to examine. There is a lack of studies that describe and measure anxiety throughout the entire length of an eye exam despite evidence to suggest that procedures other than dilation may play a role in patient distress. Also, existing studies do not examine the anxiety impact of physical and emotional factors, such as sleep, hunger, and mood, or factors related to the exam, such as length, experience of the clinician, time of day, etc. Lastly, there is a need for studies that provide qualitative themes that describe what occurs between exam procedures, what occurs when children are rewarded, or other ways children are soothed if rewards such as sweets and stickers are not given.

3. DESCRIPTIVE MIXED METHODS CASE STUDY METHODOLOGY

3.1. Setting.

This research was reviewed and approved by the University of Houston Institutional Review Board (IRB). The research took place in the Pediatric and Binocular Vision Service clinic on the first floor of the University of Houston University Eye Institute (UEI) in Health Science Building 1. The address is 4901 Calhoun Rd Houston, Texas 77204. The entrance to the clinic and the exams room facilities are shown in Figure 9 and Figure 10.

3.2. Inclusion Criteria.

Any pediatric optometry patient between the ages of 0 and 12 years of age was eligible to participate in this study. Patients with special needs, learning disabilities, or syndromes did not participate in this study. Patients whose parents were unable to speak or read English were excluded. Otherwise, any parent of the pediatric patient was eligible to participate in this study. Any clinical optometrist practicing at the UEI was eligible to participate in this study, including student doctors, residents, and faculty. The focus of this study is the behaviors of the patients as a result of their interactions with the optometrists.

3.3. Recruitment.

Patients, their parents, and faculty, resident, and student doctor optometrists were recruited at the UEI approximately 30min before a scheduled appointment time. Recruiting an equal number of participants from each age group was determined to be appropriate. A stratified convenience sampling method was used where participants were selected based on patient age, availability, and willingness to take part in the research. Only patient age data was used to determine eligibility. Patient age data was obtained from a list of appointments scheduled for each day posted inside the reception office. No advertisement materials were used to recruit patients. Upon selection, subjects were brought to a private room, a recruitment script was read to them, and informed consent was obtained, as detailed in the next section. Subject enrollment did not exceed 30 minutes.

Figure 9. The layout of the entrance to the clinic.

3.4. Risks, Informed Consent, and Privacy & Confidentiality.

All informed consent documents are provided in Appendix A: Data Collection Instruments. Upon selection, subjects were read a script (Recruitment Script). Informed consent was obtained from all optometrists (HRP-502c) and parents (HRP-502a), parental permission was obtained from the parents (HRP-502d), and assent was obtained from pediatric patients above the cognitive age of 7 (Child Assent). Patients below the cognitive age of 7 were given a verbal explanation of the research and only parental permission was obtained. Authorization to disclose information regarding the patient's age and the eye exam observations was obtained from the parents (HIPAA Authorization). All subjects were assured that the quality of care they would receive would not be contingent upon their participation in the study and that they could rescind their consent at any time. Signed copies of the informed consent documents were provided to all study participants.

This research falls under federal regulation Category 1 (Research involving children under 21 CFR §50.51/45 CFR §46.404), where no greater than Minimal Risk to children is presented.

The UEI pediatric clinic has one-way window and speaker systems which were used as tools to minimize risk. Thus, the investigator was not in the exam room and did not interact with the patient, the parents, or the optometrists during the exam. If necessary, questions relating to specific optometry procedures, objects, or tools were asked after the exam was complete. Only study-relevant data was collected, e.g. patient age, duration and time of exam, mYPAS scores, field notes detailing what procedures, objects, or tools were used, and information about the factors listed in the parent survey. No identifiable personal information data was collected beyond age. Neither video nor photography of the exam was collected. Subjects were assured that individual session data would not be shown and that study findings would only be in aggregate form if this study were to be published.

Provisions were made to protect the privacy interests of subjects. Throughout the study, only one investigator collected data and had access to it. For each session, a code was generated that consisted of six numbers for the date and a letter for whether the session took place in the morning (M) or the afternoon (A) (000000-X). The code was generated on location at the beginning of each session and no key was made for the code, as it was determined that there would be no need to de-identify the data. Collected data was digitized after each session and all physical data collection instruments will be shredded. The data will be stored and used on the PI's personal computer, which is user and password protected. Following completion of the research, a digital copy of the data will be stored in a USB drive and provided to the Committee Chair of this thesis, Dr. EunSook Kwon, who is also the Director of the Industrial Design Program. She will store the data in her office, room 317 at the Gerald D. Hines College of Architecture & Design on the University of Houston campus, and manage it for 3 years.

3.5. Timeline.

The duration of an individual subject's participation depended on the amount of time required to complete an eye exam, which was determined by the optometrist. Generally, student doctors saw patients at 4 time slots per day—8:30am, 10:00am, 1:30pm, and 3:00pm. Residents had 8 time

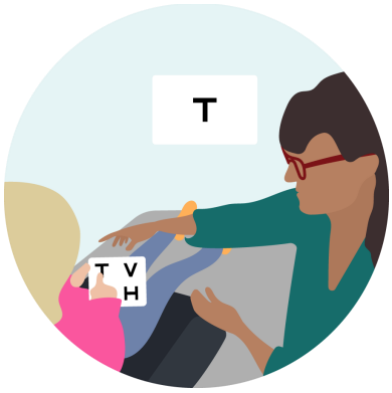
slots—8:30am, 9:15am, 10:00am, 10:45am, 1:30pm, 2:15pm, 3:00pm, and 4:15pm—yet generally only had 4 patients scheduled per day. Appointments generally lasted between 1 hour to 3 hours.

This study focused on comprehensive exams and therefore excluded patients scheduled for a progress exam. There were no repeat patients. No long-term follow ups took place.

3.6. A Sequential Map of Eye Exam Procedures.

This sequential map represents common procedures done at the University of Houston College of Optometry's Pediatric and Binocular Vision Service clinic. These procedures are specific to pediatric patients and are listed in semi-arbitrary order. Depending on the patient's age, medical history and suspected ocular conditions, additional procedures may be completed and some procedures may be skipped. Procedures, and the order with which they were done, were at the discretion of the optometrists. This sequential map was developed from the study's observations and is meant to offer context for those unfamiliar with eye exams.

1. Patient history

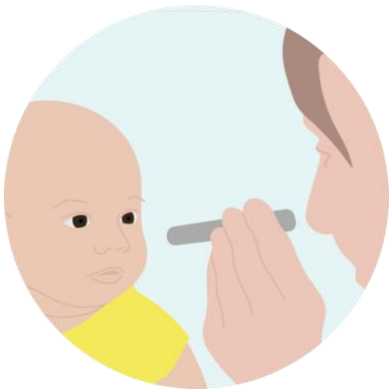


2. Vision test:
   Measures how well patients see up close and far away.

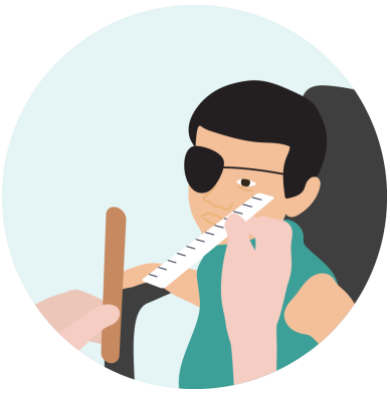
3. Visual fields and extraocular movement test:
   Evaluates peripheral vision and eye muscle functionality, respectively.

4. Cover test:
   Measures eye alignment.

5. Stereopsis and color vision test:
   Evaluates depth perception and color blindness, respectively.



6. Near point convergence test:
   Evaluates ability to maintain fixation on a target without seeing two images of it as it is moved closer to the patient.



7. Amplitude of accommodation test:
   Evaluates ability to focus up close.

8. Denver or SASP/PASP:
   Screens for the development of spatial and auditory skills.

9. Tonometry:
   Measures fluid pressure in the eyes.

10. Retinoscopy:
    Measures refractive error (farsighted, nearsighted, astigmatism) and evaluates need for glasses.

11. Slit lamp test:
    Evaluates the health of the surface of the eyes.

12. Dilation with cycloplegia:
    Increases pupil size to facilitate ocular health assessment and temporarily reduces the ability of the eye to focus to improve the accuracy of the determination of refractive error.

13. Retinoscopy repeated after dilation with cycloplegia.

14. Ophthalmoscope test:
    Measures and evaluates ocular health (the macula, optic nerve, and retina).

3.7. Procedures.

As introduced in the first section, the research design is a descriptive mixed methods case study involving observations, a brief survey, and field notes. After obtaining informed consent, the parent was given an 8-question survey to be completed before or during the exam.

The 8-question survey asked the following questions:

1. At what time did the patient last eat a meal or a snack?
2. How many hours did the patient sleep last night?
3. Does the patient sleep this amount on an average night?
4. At what time did the patient last wake up from their most recent rest (this morning or a nap)?
5. Is this the patient's first eye exam?
   If no, please estimate their total number of eye exams.
6. In general, how has the patient's mood been today?
7. In general, how has your mood been today?
8. Please use the remaining space to share if there is a reason for your answers to questions 6 and 7.

Upon calling the patient, the optometrist would take the patient and the parent (if appropriate) into the exam room, shut the door, and begin the exam. The primary investigator observed and took notes of the exam proceedings from outside of the exam room on the non-visible side of a 1-way window. A speaker system was used to listen in on the exam proceedings from outside of the room.

Figure 10. An exam room's one-way window and speaker system.

The duration and time of the exam was recorded using a stopwatch, as well as the type of exam. Qualitative observations and field notes detailing procedures, objects, and tools used by the optometrist to conduct the eye exam were also recorded. The patient's anxiety was assessed using the mYPAS at the beginning of each exam and throughout the exam whenever a change in anxiety was observed. The range of the mYPAS is 22.9 to 100. A mYPAS score above 30 indicates the presence of anxiety. The time was recorded whenever the mYPAS score was observed to have changed or whenever a new procedure took place. The data collection instruments are provided in Appendix A.

Drops were administered to patients by 1-2 optometrists and the patient's parent often assisted by restraining their child. A controlled drop regimen was not used in order to not interfere with a typical exam and to measure the effect of optometrist experience on patient distress. The amount and type of drops used were determined by each optometrist and were sometimes delivered in cycles. Drops used were limited to cyclopentolate (1%), tropicamide (1%), phenylephrine (2.5%), and proparacaine (0.5%).

Detailed notes about each research subject's role and the interactions they had with the patient were recorded, including how the patient was restrained and what was done to soothe a distressed patient. Questions the primary investigator had relating to procedures, objects, and tools used during the exam were written down and asked after the exam concluded. Pictures of tools used during the exam were taken after the exam had concluded and the patient was no longer in the room.

3.8. Number of Subjects, Factor Rationale, & Statistical Analysis Methods.

Due to a lengthy IRB approval process and the COVID-19 pandemic, the study was only able to recruit a total of 62 participants: 12 patients, 12 parents, and 38 optometrists. Due to the small sample size, the analysis of the data and the discussion that follows applies only to the study sample and conclusions about the clinical population cannot be made. Furthermore, not all patients underwent all 14 procedures (the repeated measure) during their comprehensive eye exam. Procedures varied between exam due to the patient's age, medical history and suspected ocular conditions. The resulting fragmented dataset of anxiety scores of the 12 patients over 14 procedures used as repeated measures was missing 41 values for a total of 127 values. Because of these shortcomings, this study is intended to serve as a pilot for future studies.

Factors were chosen in support of the research questions presented in section 1 of this thesis. A total of 14 common procedures (presented in section 2.2) were observed and used as categorical repeated measures to examine anxiety over the length of an exam. Age group categories were chosen based on the aforementioned studies on anxiety in pediatric optometry exams. Age data for each subject was obtained from the clinic's appointment schedule. The remaining factors were chosen because they have not yet been examined. Optometrist type, exam type, and exam time were determined from the clinic's schedule. Number of eye exams, hours slept the previous night, normal sleep amount, child's mood, and parent's mood were determined directly from the survey responses. For the child's mood and parent's mood factors, a 1 to 5 rating scale was used where a score of 1 indicated a bad mood, a score of 3 indicated a fair mood, and a score of 5 indicated a good mood. Exam length was calculated by taking the difference between an exam's end time

from its start time. Time since last meal and time since last nap were calculated by taking the difference in time between an exam's start time and the corresponding response from the survey. Lastly, a value for max number of people in the exam room was determined during the observations by tallying the highest count of people that were in the exam room together at any given time throughout an exam. A total of 15 factors were examined in this study. Equation 1 in section 2.3 was used to calculate mYPAS scores from the observations.

Statistical tests were chosen based on the distribution of the quantitative data and to support the research questions presented in section 1 of this thesis. As discussed in detail in the next section, the dependent variable of the study, the mYPAS scores, did not show a normal distribution. Non-parametric alternative tests were chosen to analyze both the differences between the mYPAS scores of categorical factors and the correlations of continuous factors with mYPAS scores.

Exam totals, percentages, and descriptive means with standard deviations of mYPAS scores were calculated for 8 categorical factors. Due to fragmented repeated measures data and small sample size, it was not possible to run a repeated measures General Linear Model on the unmodified dataset or a repeated measures Linear Mixed Model using all 8 categorical factors, respectively. As a compromise, differences in the marginal means of mYPAS scores between categorical factors were analyzed separately using univariate tests from multiple repeated measure Linear Mixed Models, using a maximum likelihood method, a heterogeneous first-order autoregressive covariance structure, and post hoc least significant difference pairwise comparisons. The rational is discussed in detail in the next section.

Correlations between mYPAS scores and 7 continuous factors were analyzed using two-tailed Spearman Correlations. A P value of <0.05 was considered statistically significant. Statistical analysis was done using IBM SPSS® Statistics software build 1.0.0.1347 (IBM Armonk, NY).

4. FINDINGS

4.1. Quantitative Data – Normality

Anxiety in patients generally fluctuated throughout an exam. However, 42.5% of mYPAS scores did not indicate anxiety (equal to or less than a score of 30), which skewed the data set to the left. This is likely due to the fact that not many procedures cause very high anxiety (distress) and that not having anxiety is the resting state of most children. Researchers should take note of this finding when choosing a repeated measures research design that utilizes the mYPAS because this scale will often result in data that is not normally distributed. Even if the data set was not fragmented and all repeated measures were present, the mYPAS would still be skewed. The distribution of the fragmented dataset of mYPAS scores is shown by the histogram in Figure 11 and the failed normality test shown in Table 1.

This has important implications when analyzing the data because parametric statistical tests for differences, such as repeated measures ANOVA, and parametric statistical tests for associations, such as the Pearson's Correlation test, become inappropriate because their assumption of normality is violated. Adjustments to the data set were attempted to transform the data set logarithmically but the resulting adjusted data set still failed normality tests. Therefore, no adjustments were done, the violation of the normality assumption was accepted, and non-parametric statistical tests were used.

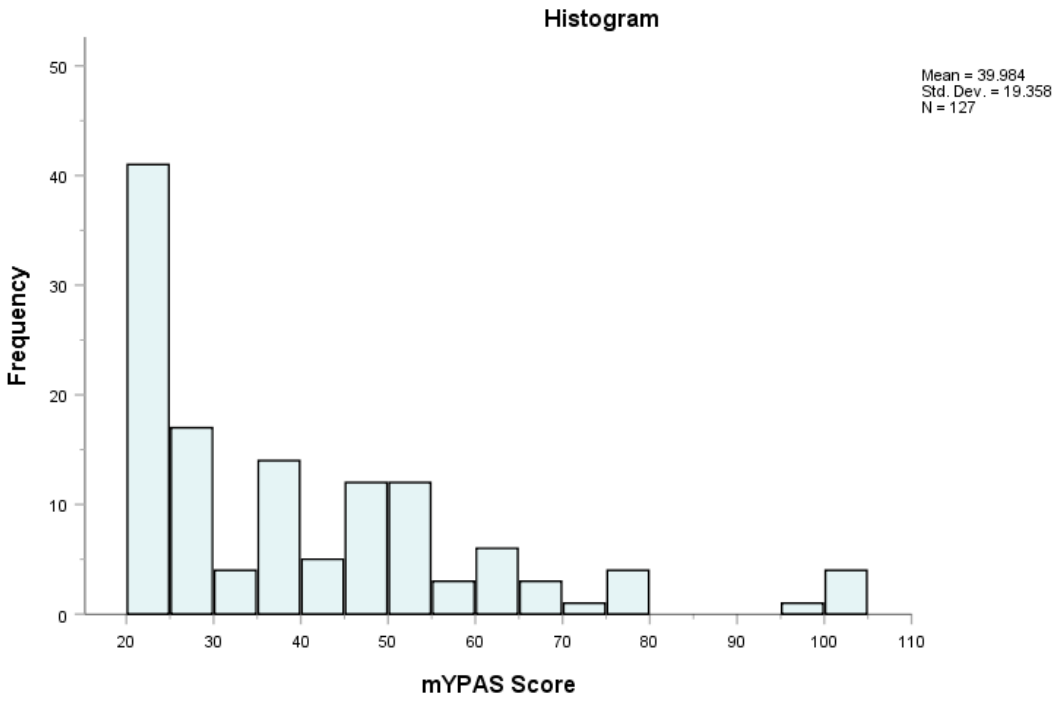


Figure 11. Histogram of the fragmented dataset of mYPAS scores (N = 127).

Table 1. Normality test of the fragmented dataset of mYPAS scores (N = 127).

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
mYPAS Score	0.189	127	0.000	0.828	127	0.000

a. Lilliefors Significance Correction

4.2. Quantitative Data – Differences Between Categorical Factors

Non-parametric alternatives to a repeated measures ANOVA include Friedman's ANOVA or a repeated measures General Linear Model (GLM). A GLM is preferred over Friedman's ANOVA in this case as it allows for the analysis of the effects of multiple factors within a single model as predictors. However, there is an issue: not all patients underwent all 14 procedures (the repeated measure) during their comprehensive eye exam. Procedures varied between exam due to the patient's age, medical history and suspected ocular conditions. Only 3 procedures were always done: patient history, vision test, and retinoscopy. A GLM (and the less-useful Friedman's ANOVA) requires that repeated measures for all subjects be complete, which was not the case for this study.

Another non-parametric alternative is a repeated measures Linear Mixed Model (LMM). LLMs do not require that repeated measures for all subjects be complete. Therefore, this method of analysis is most appropriate for this study. If all 8 categorical factors were included in the model, then it would have been possible to analyze the effect of each factor on the marginal means of the LMM. However, due to the small sample size, it is not possible to run a single LMM using all 8 categorical factors. Nevertheless, it is possible to run univariate tests by running multiple LMMs for each factor separately, but this approach is not ideal either.

In order to decide which test to use, the advantages and disadvantages of each were weighed. In order to run a GLM, the data set must be modified using listwise deletion such that 2 exams and 8 procedures are removed, resulting in a total of 10 exams and 6 procedures. This smaller, fully populated dataset would be used to run a repeated measures GLM using less than half of the data, which is a major disadvantage due to bias and reduced power. Conversely, a LMM is more robust and is able to handle missing data without modifying the dataset.

However, an advantage of a GLM is that a single model could be produced to compare the effects between the categorical variables, even with a small sample size. A LMM must be run multiple times due to the small sample size, thereby preventing the factors from being analyzed in relation

to each other. If the sample size was larger, a LMM would also be able to process the effects between the categorical variables.

As a compromise, it was decided that a LMM would be the better test, as it would not have to drastically modify the data set and would still be able to detect a difference between the levels of each individual factor. Thus, differences in the means of mYPAS scores between fixed categorical factors were analyzed separately using univariate tests from multiple repeated measure Linear Mixed Models, using a maximum likelihood method, a heterogeneous first-order autoregressive covariance structure to account for unequal variances between time points, and post hoc least significant difference pairwise comparisons.

A total of 12 patients were recruited equally from 3 age groups. The mean subject age was 5.25 ± 2.90 years. As shown in Table 2, the majority of exams (58.3%) had patients that were new to the clinic, received an exam with a student doctor in the afternoon, and slept a normal amount the previous night. In 75.0% of exams the patient was in a good mood and in 66.7% of exams the parent was in a good mood. Anxious patients were identified by a mYPAS score greater than 30. The only procedure where all patients were observed to be anxious was dilation (procedure 12). Figure 12 compares the descriptive mean anxiety scores between all 14 procedures.

P values from univariate tests on the marginal means from each of the LMMs of the fixed categorical factors are shown in Table 2. Univariate tests showed significant differences in procedure ($F = 7.43$, $p < 0.001$), age group ($F = 117$, $p < 0.001$), exam type ($F = 8.69$, $p = 0.005$), exam time ($F = 8.25$, $p = 0.006$), and child's mood rating ($F = 9.12$, $p = 0.003$).

Table 2. Summary of descriptive mean mYPAS scores and P values from univariate tests on marginal means for 8 categorical factors.

Factors	Total (%)	mYPAS Score ($\mu \pm \sigma$)	P value
Procedure			**< 0.001**
1. Patient history	N = 12	30.6 ± 9.54	
2. Vision test	N = 12	38.9 ± 21.4	
3. Visual fields and extraocular movement test	N = 11	30.5 ± 12.3	
4. Cover test	N = 9	44.7 ± 18.1	
5. Stereopsis and color vision test	N = 7	30.1 ± 9.15	
6. Near point convergence test	N = 9	39.4 ± 15.0	
7. Amplitude of accommodation test	N = 3	27.8 ± 8.42	
8. Denver or SASP/PASP	N = 8	29.8 ± 9.48	
9. Tonometry	N = 6	51.7 ± 17.5	
10. Retinoscopy	N = 12	35.4 ± 9.89	
11. Slit lamp test	N = 10	36.6 ± 13.3	
12. Dilation	N = 11	78.0 ± 19.8	
13. Retinoscopy repeated after dilation	N = 6	31.3 ± 9.22	
14. Ophthalmoscope test	N = 11	43.0 ± 18.7	
Age Group	**N = 12**		**< 0.001**
< 4	4 (33.3)	44.1 ± 21.0	
4 - 7	4 (33.3)	38.5 ± 21.0	
> 7	4 (33.3)	36.8 ± 15.1	
Optometrist Type	N = 12		0.467
Student	7 (58.3)	43.0 ± 20.6	
Resident	5 (41.7)	33.8 ± 15.1	
Exam Type	**N = 12**		**0.005**
New	7 (58.3)	44.0 ± 20.6	
Yearly	5 (41.7)	36.0 ± 17.3	
Exam Time	**N = 12**		**0.006**
Morning	5 (41.7)	44.0 ± 20.8	
Afternoon	7 (58.3)	38.1 ± 18.4	
Normal Sleep Amount	N = 12		0.751
Yes	7 (58.3)	40.6 ± 19.2	
No	4 (33.3)	37.5 ± 18.8	
Undisclosed	1 (8.3)	43.6 ± 22.3	
Child's Mood	**N = 12**		**0.003**
3	1 (8.3)	50.4 ± 23.9	
4	2 (16.7)	35.7 ± 17.6	
5	9 (75.0)	39.7 ± 19.1	
Parent's Mood	N = 12		0.189
3	3 (25.0)	41.0 ± 20.9	
4	1 (8.3)	33.3 ± 21.3	
5	8 (66.7)	40.6 ± 18.7	

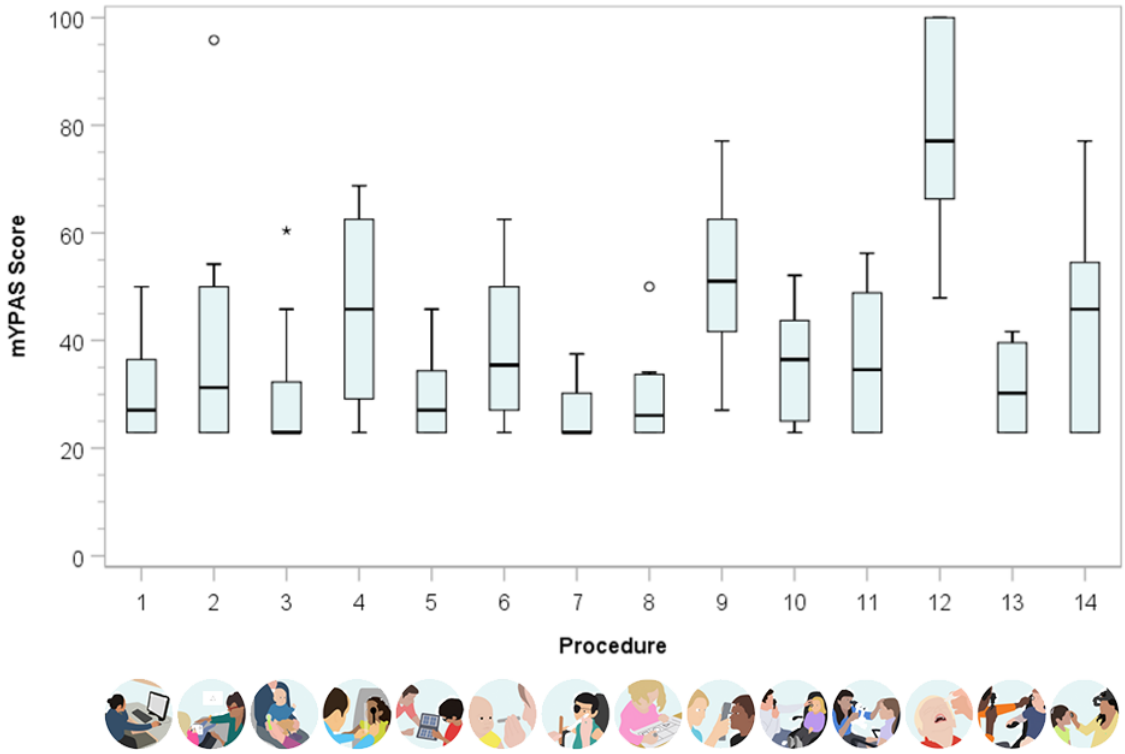


Figure 12. Comparison of the descriptive mean mYPAS scores and procedures.

Note: For all boxplots, the thick line in the middle is the median. The top and bottom box lines show the first and third quartiles. The whiskers show the maximum and minimum values, with the exceptions of outliers (circles) and extremes (asterisks). Outliers are at least 1.5 box lengths from the median and extremes are at least three box lengths from the median.

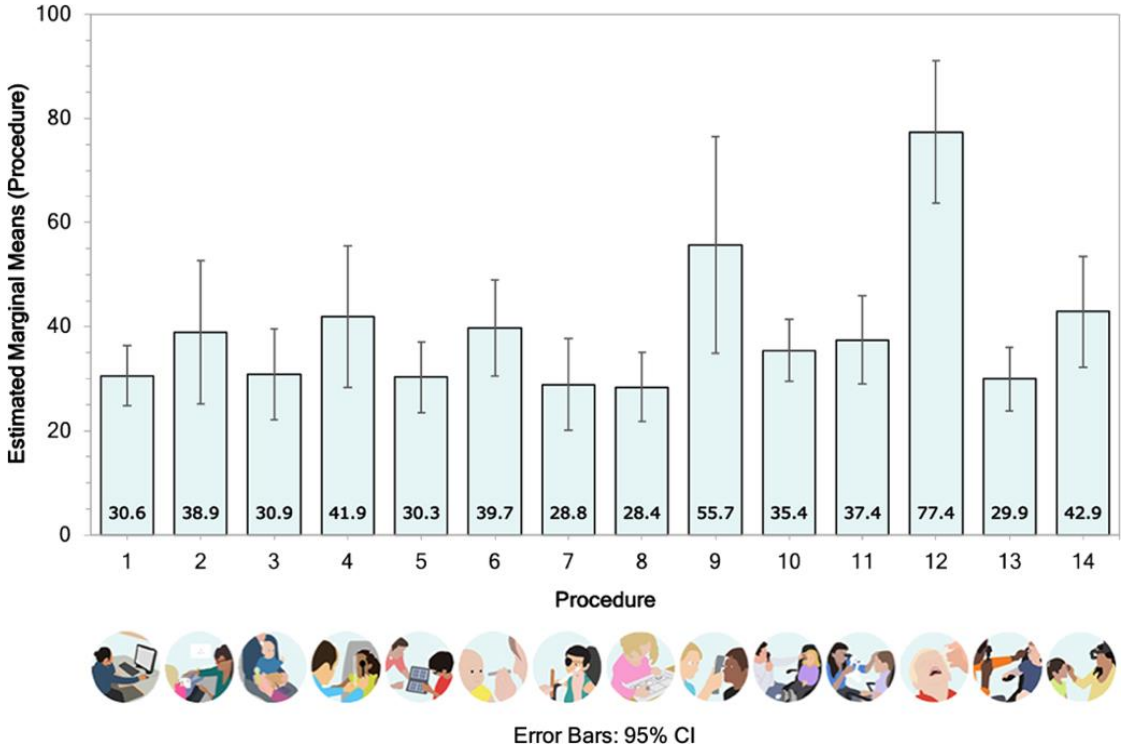


Figure 13. Comparison of the procedure factor's LMM estimated marginal mean mYPAS scores and procedures.

Figure 13 compares the estimated marginal mean anxiety scores of the LMM for procedure. A pairwise comparison based on the estimated marginal means of the LMM for procedure (provided in Appendix C) showed that of the 91 unique pairs of procedures, 27 pairs (29.7%) were significantly different.

A simplified pairwise comparison showing a subset of the relevant comparisons is shown in Table 3. Using patient history (procedure 1) (M_m = 30.6, SE = 2.65) as a baseline, tonometry (procedure 9) (M_m = 55.7, SE = 8.12) ($p = 0.025$), dilation (procedure 12) (M_m = 77.4, SE = 6.21) ($p < 0.001$), and ophthalmoscope test (procedure 14) (M_m = 42.9, SE = 4.92) ($p = 0.040$) had significantly higher anxiety than the baseline. Additionally, dilation showed significantly higher anxiety ($p \leq 0.001$) than ophthalmoscope test and all other procedures with the exception of tonometry, which did not have a significant difference when compared to dilation ($p = 0.052$).

Table 3. Subset of the pairwise comparison of the procedure factor's LMM estimated marginal means at the 0.05 level.

(I) Procedure	(J) Procedure	Mean Difference (I-J)	Sig.
1	2	-8.333	0.165
	3	-0.316	0.943
	4	-11.343	0.100
	5	0.278	0.944
	6	-9.171	0.079
	7	1.717	0.687
	8	2.175	0.587
	9	**-25.158***	**0.025**
	10	-4.858	0.215
	11	-6.891	0.159
	12	**-46.803***	**0.000**
	13	0.629	0.869
	14	**-12.314***	**0.040**
12	**1**	**46.803***	**0.000**
	2	**38.470***	**0.000**
	3	**46.487***	**0.000**
	4	**35.460***	**0.001**
	5	**47.081***	**0.000**
	6	**37.632***	**0.000**
	7	**48.520***	**0.000**
	8	**48.978***	**0.000**
	9	21.645	0.052
	10	**41.945***	**0.000**
	11	**39.912***	**0.000**
	13	**47.431***	**0.000**
	14	**34.489***	**0.000**

Based on estimated marginal means of the LMM.

*. The mean difference is significant at the .05 level.

Figure 14 compares descriptive mean anxiety level with age groups. Figure 15 compares the estimated marginal mean anxiety scores of the LMM for age group. The pairwise comparison based on the estimated marginal means of the LMM for age group (provided in Appendix C) showed that there was a significant difference between the < 4 group and the 4 – 7 group ($p < 0.001$) and between the < 4 group and the > 7 group ($p < 0.001$), but not between the 4 – 7 group and the > 7 group ($p = 0.787$). Thus, the < 4 group ($M_m = 37.1$, SE = 0.685) had significantly higher anxiety than the 4 – 7 group ($M_m = 22.1$, SE = 1.15) and the > 7 group ($M_m = 22.5$, SE = 0.831).

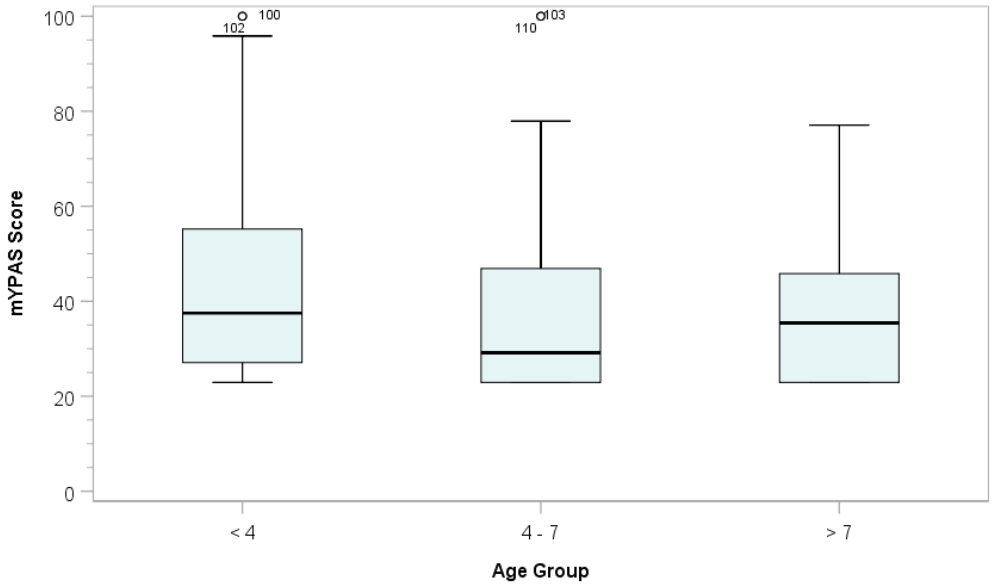


Figure 14. Comparison of the descriptive mean mYPAS scores and age groups.

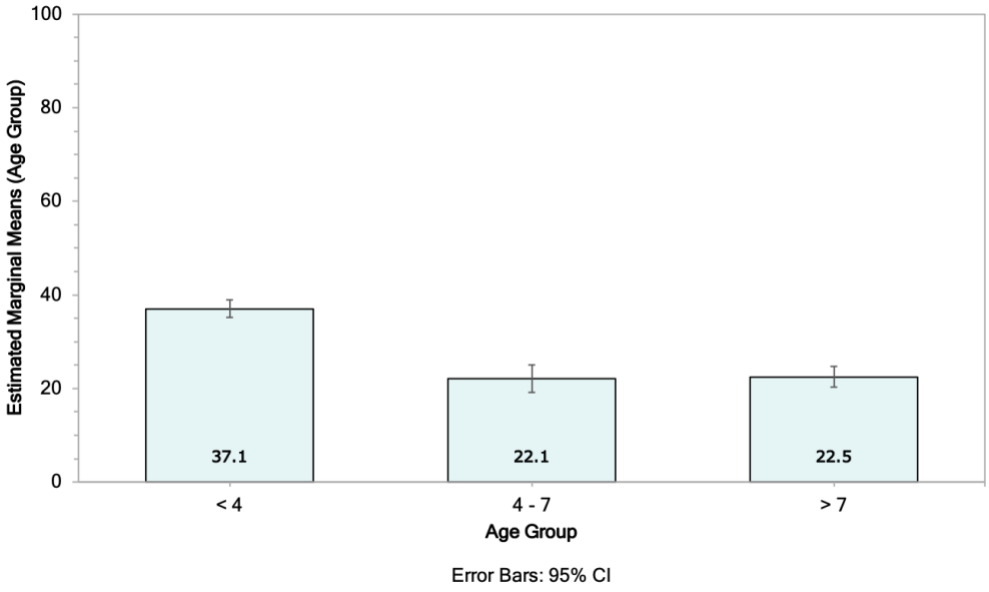


Figure 15. Comparison of the age group factor's LMM estimated marginal mean mYPAS scores and age groups.

Table 4 and Figure 16 break down each procedure by age group to further compare descriptive mean mYPAS scores between procedures.

Table 4. Summary of descriptive mean mYPAS scores and procedures separated by age group.

Factors	Total Values (%)	mYPAS Score ($\mu \pm \sigma$)
1. Patient history	N = 12	30.6 ± 9.5
< 4	4 (33.3)	31.3 ± 12.8
4 - 7	4 (33.3)	28.6 ± 6.2
> 7	4 (33.3)	31.8 ± 11.1
2. Vision test	N = 12	38.9 ± 21.4
< 4	4 (33.3)	50.0 ± 33.5
4 - 7	4 (33.3)	34.9 ± 13.5
> 7	4 (33.3)	31.8 ± 11.1
3. Visual fields and extraocular movement test	N = 11	30.5 ± 12.3
< 4	4 (36.4)	33.3 ± 18.2
4 - 7	3 (27.3)	25.0 ± 3.6
> 7	4 (36.4)	31.8 ± 11.1
4. Cover test	N = 9	44.7 ± 18.1
< 4	3 (33.3)	46.0 ± 21.3
4 - 7	4 (44.4)	45.8 ± 23.1
> 7	2 (22.2)	40.6 ± 7.4
5. Stereopsis and color vision test	N = 7	30.1 ± 9.1
< 4	2 (28.6)	25.0 ± 2.9
4 - 7	2 (28.6)	34.4 ± 7.4
> 7	3 (42.9)	30.6 ± 13.2
6. Near point convergence test	N = 9	39.4 ± 15.0
< 4	3 (33.3)	42.4 ± 13.2
4 - 7	4 (44.4)	42.2 ± 19.1
> 7	2 (22.2)	29.2 ± 8.8
7. Amplitude of accommodation test	N = 3	27.8 ± 8.4
< 4	2 (66.7)	30.2 ± 10.3
4 - 7	1 (33.3)	22.9 ± 0.0
8. Denver or SASP/PASP	N = 8	29.8 ± 9.5
< 4	4 (50.0)	29.9 ± 5.1
4 - 7	2 (25.0)	36.5 ± 19.2
> 7	2 (25.0)	22.9 ± 0.0
9. Tonometry	N = 6	51.7 ± 17.5
< 4	2 (33.3)	41.7 ± 20.6
> 7	4 (66.7)	56.8 ± 16.3
10. Retinoscopy	N = 12	35.4 ± 9.9
< 4	4 (33.3)	38.5 ± 10.3
4 - 7	4 (33.3)	33.7 ± 8.3
> 7	4 (33.3)	34.0 ± 12.8
11. Slit lamp test	N = 10	36.6 ± 13.3
< 4	4 (40.0)	45.7 ± 12.8
4 - 7	2 (20.0)	25.0 ± 2.9
> 7	4 (40.0)	33.4 ± 12.2
12. Dilation	N = 11	78.0 ± 19.8
< 4	4 (36.4)	85.4 ± 16.9
4 - 7	3 (27.3)	92.6 ± 12.7
> 7	4 (36.4)	59.7 ± 13.6
13. Retinoscopy repeated after dilation	N = 6	31.3 ± 9.2
< 4	3 (50.0)	39.6 ± 2.1
4 - 7	1 (16.7)	22.9 ± 0.0
> 7	2 (33.3)	22.9 ± 0.0
14. Ophthalmoscope test	N = 11	43.0 ± 18.7
< 4	4 (36.4)	59.6 ± 15.3
4 - 7	3 (27.3)	30.9 ± 13.8
> 7	4 (36.4)	35.4 ± 14.5

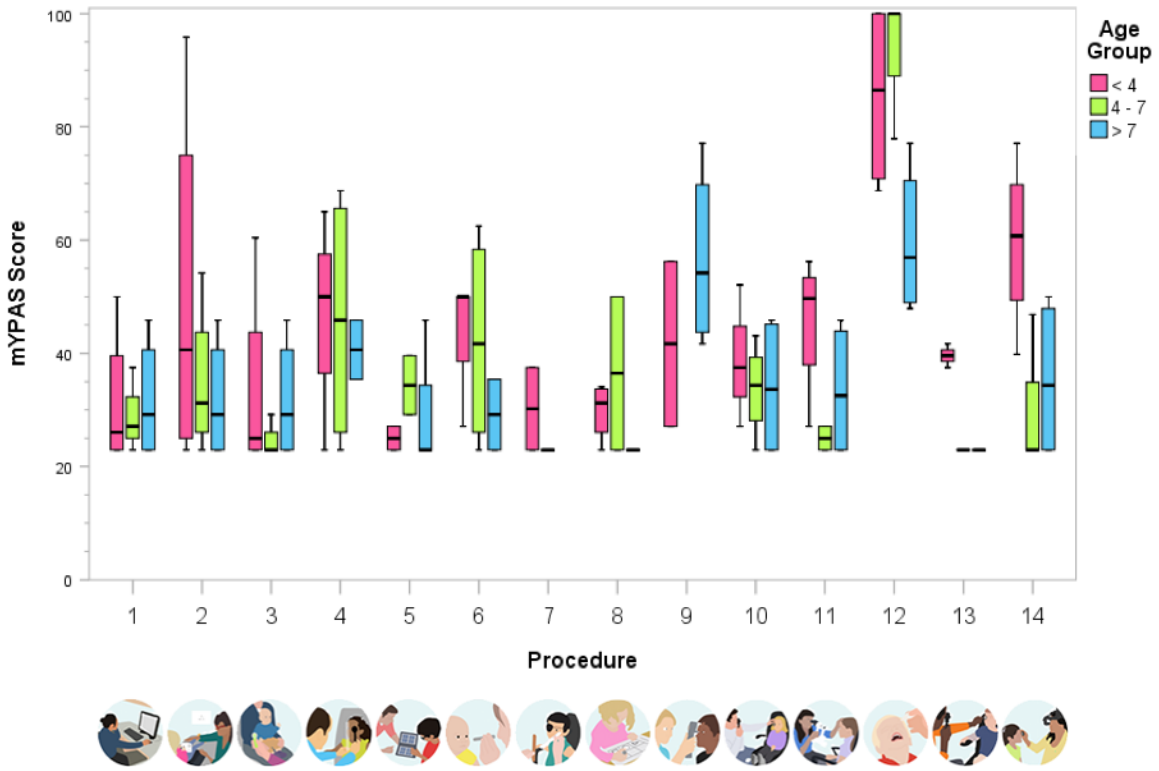


Figure 16. Comparison of the descriptive mean mYPAS scores and procedures by age group.

Figure 17 compares descriptive mean mYPAS scores with exam types. Figure 18 compares the estimated marginal mean anxiety scores of the LMM for exam type. The univariate test on the estimated marginal means from the LMM for exam type showed that patients who were new to the clinic (M_m = 32.6, SE = 1.71) had significantly higher anxiety than patients receiving a yearly exam (M_m = 25.8, SE = 1.59), F = 8.69, p = 0.005.

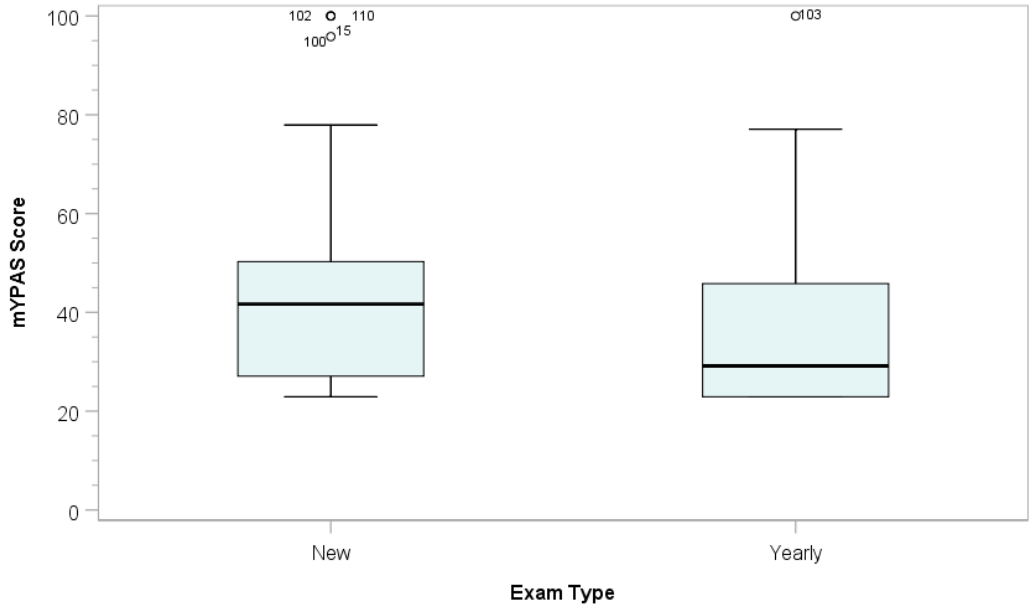


Figure 17. Comparison of the descriptive mean mYPAS scores and exam types.

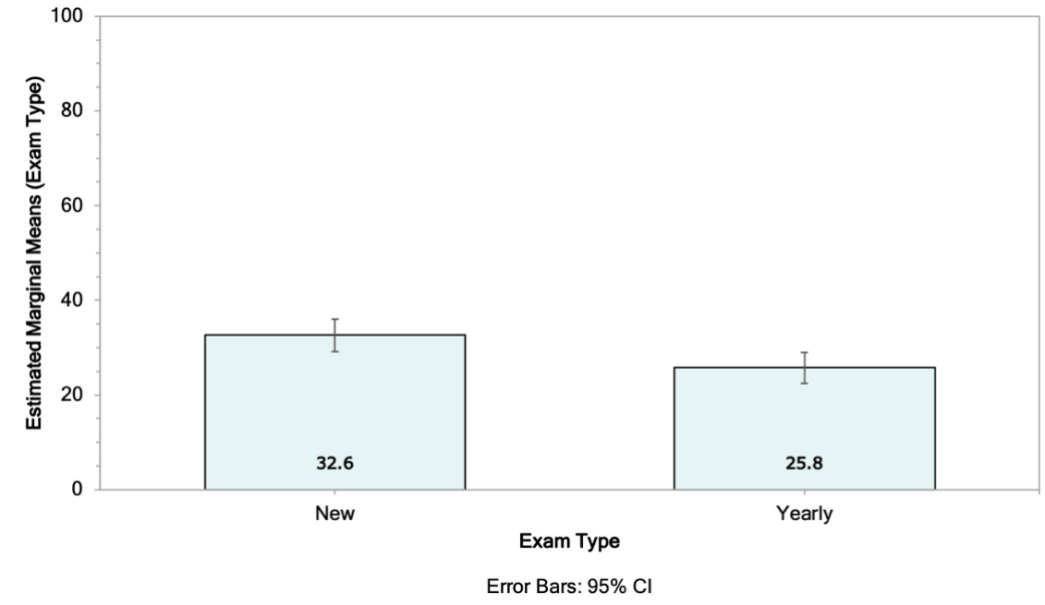


Figure 18. Comparison of the exam type factor's LMM estimated marginal mean mYPAS scores and exam types.

Figure 19 compares descriptive mean mYPAS scores with exam time. Figure 20 compares the estimated marginal mean anxiety scores of the LMM for exam time. The univariate test on the marginal means from the LMM for exam time showed that patients who received a morning exam (M_m = 32.9, SE = 2.24) had significantly higher anxiety than patients receiving an exam in the afternoon (M_m = 25.3, SE = 1.43), F = 8.25, p = 0.006.

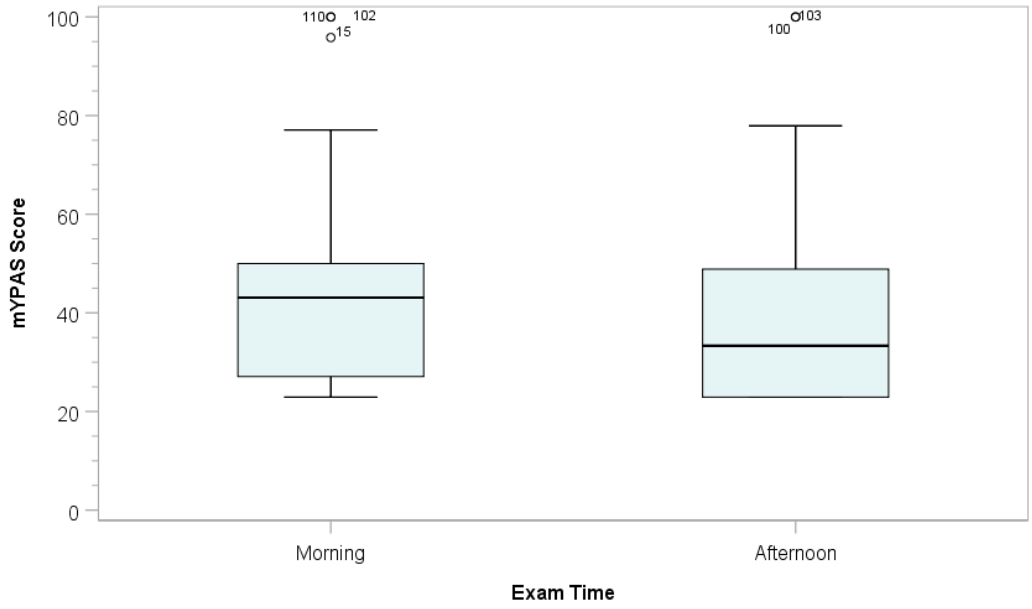


Figure 19. Comparison of the descriptive mean mYPAS scores and exam times.

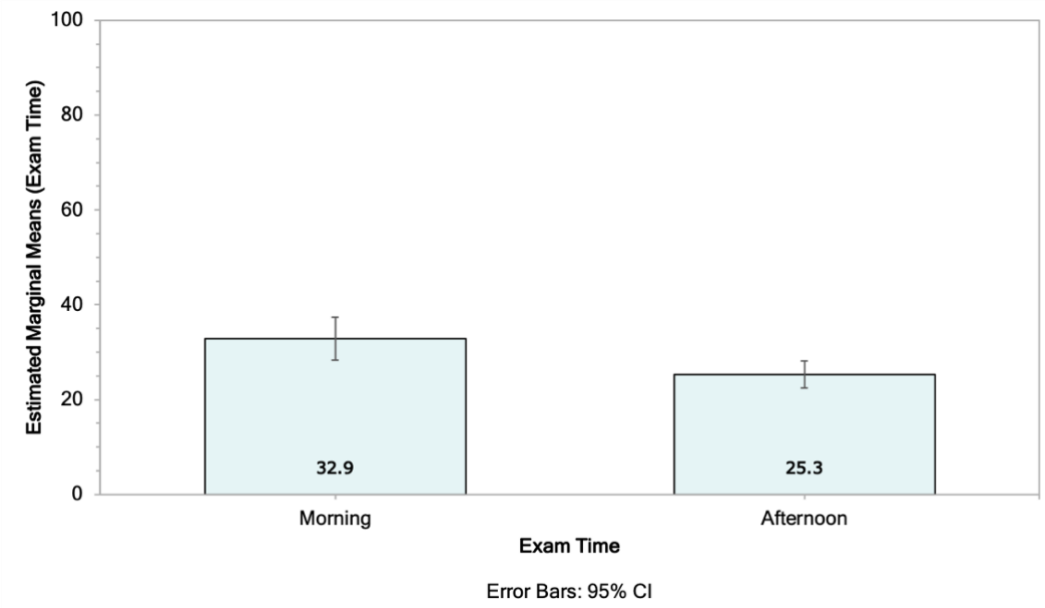


Figure 20. Comparison of the exam time factor's LMM estimated marginal mean mYPAS scores and exam times.

For the child's mood factor, a 1 to 5 rating scale was used where a score of 1 indicated a bad mood, a score of 3 indicated a fair mood, and a score of 5 indicated a good mood. Figure 21 compares descriptive mean mYPAS scores with child's mood ratings. Figure 22 compares the estimated marginal mean anxiety scores of the LMM for child's mood. The pairwise comparison based on the estimated marginal means of the LMM for child's mood (provided in Appendix C) showed that there was a significant difference between the 3 rating group and the 4 rating group ($p = 0.002$) and between the 3 rating group and the 5 rating group ($p = 0.002$), but not between the 4 rating group and the 5 rating group ($p = 0.413$). Thus, the 3-rating group ($M_m = 44.3$, $SE = 4.26$) had significantly higher anxiety than the 4-rating group ($M_m = 23.1$, $SE = 3.48$) and the 5-rating group ($M_m = 26.1$, $SE = 1.19$).

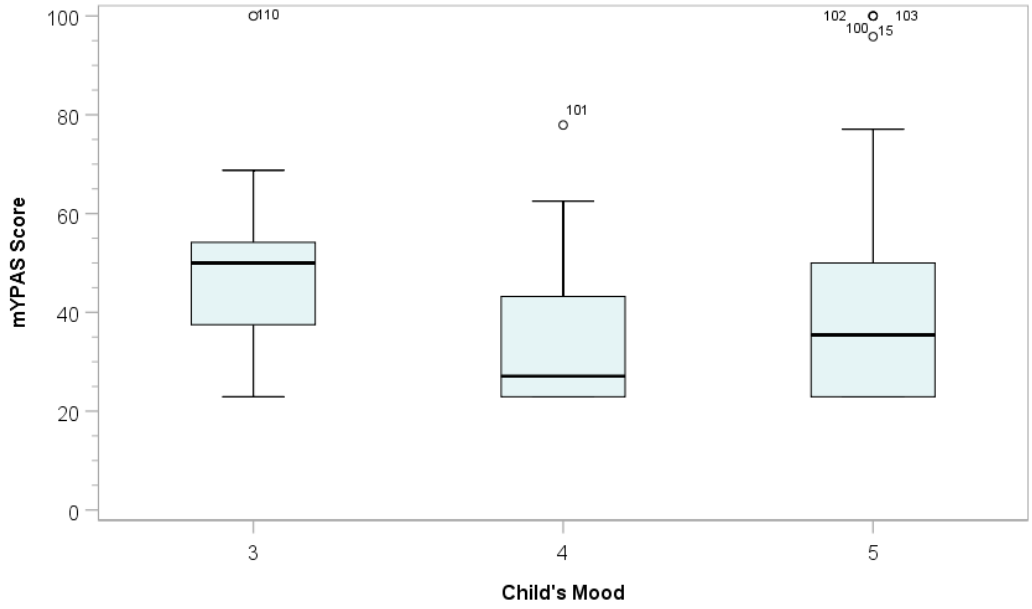


Figure 21. Comparison of the descriptive mean mYPAS scores and child's mood ratings.

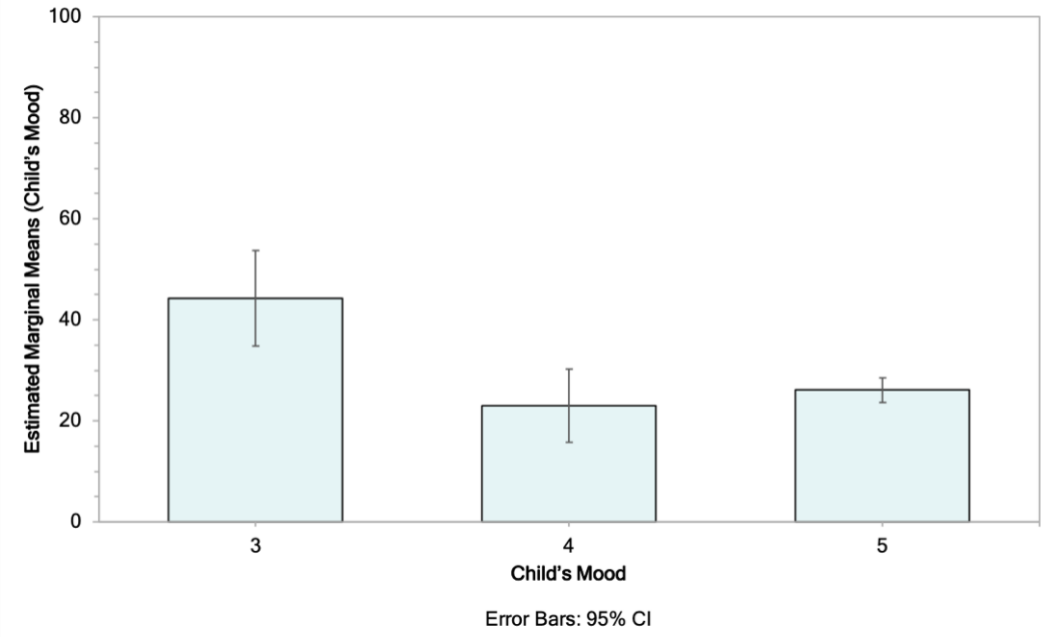


Figure 22. Comparison of the child's mood factor's LMM estimated marginal mean mYPAS scores and child's mood ratings.

4.3. Quantitative Data – Correlations Between Continuous Factors

Table 5 shows that patient age and mYPAS scores were strongly negatively correlated, $r_s(127) = 0.306$, $p < 0.001$. Time since last nap and mYPAS scores were also strongly negatively correlated, $r_s(127) = 0.395$, $p < 0.001$. Lastly, number of eye exams and mYPAS scores were also strongly negatively correlated, $r_s(127) = 0.448$, $p < 0.001$. These results suggest that older patients, those who have had more eye exams before, and those who were not groggy from a recent nap were more likely to have experienced less anxiety throughout their exams.

Table 5. Summary of the Spearman correlation of mYPAS scores and continuous factors.

		Age	Exam Length	Time Since Last Meal	**Time Since Last Nap**	Hours Slept Previous Night	**Number of Eye Exams**	Max Number of People in Exam Room
mYPAS Score	Spearman Correlation	**-.306****	0.021	0.068	**-.395****	0.114	**-.448****	0.126
	Sig. (2-tailed)	**0.000**	0.817	0.448	**0.000**	0.203	**0.000**	0.157
	N	**127**	127	127	**127**	127	**127**	127

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

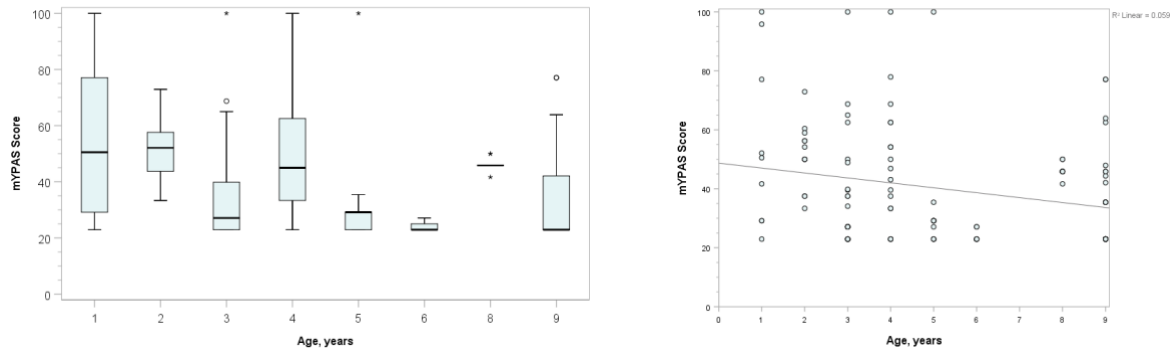


Figure 23. Comparison of the descriptive means (left) and linear regression (right) of mYPAS scores and patient age.

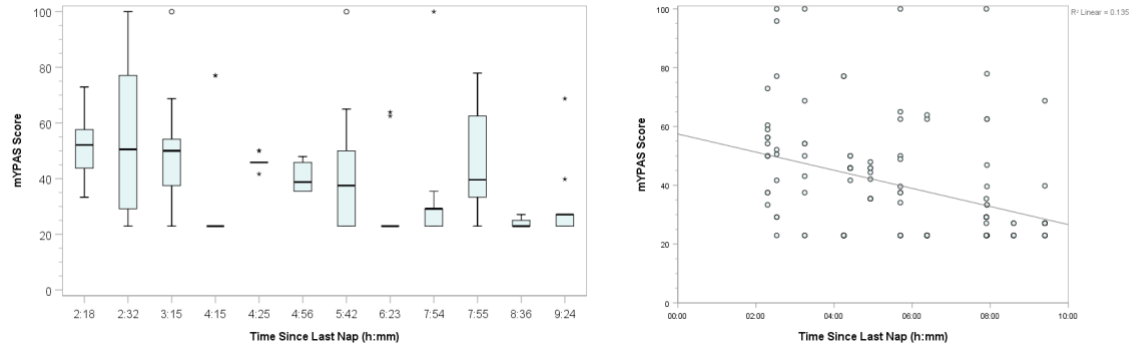


Figure 24. Comparison of the descriptive means (left) and linear regression (right) of mYPAS scores and time since last nap.

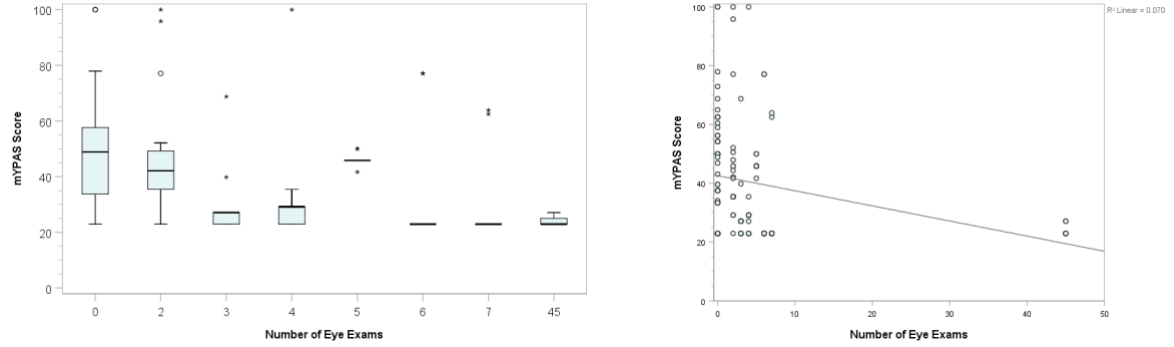


Figure 25. Comparison of the descriptive means (left) and linear regression (right) of mYPAS scores and number of eye exams.

4.4. Qualitative Data – Theme Analysis

Physical data collection instruments were digitized by typing all handwritten observations, notes, and anxiety measurements on a word processor in preparation for the theme analysis. The research questions outlined in section 1 were reviewed to provide objectives and the digitized data was carefully read and analyzed. Descriptive codes were developed by identifying tools used, behaviors that occurred during the observations, and the apparent effect of both on the mYPAS scores. Using the word processor's comment feature, parts of the observations were highlighted and assigned a code. Each code was given a number and a description. Special findings were identified by particularly relevant but uncommon events, notable things that were said, or extraordinary occurrences. A key was developed to keep track of existing codes during the analysis, provided in Appendix E. A total of 65 descriptive codes were developed and used a total of 333 times. Of the 65 descriptive codes, 9 of them were special findings.

Table 6 shows the use of codes throughout the study in order of most to least. The use of codes was not correlated with the sequence by which the exams were recorded, $r(12) = 0.159$, $p = 0.621$, nor was it correlated with the mean mYPAS scores of the exams, $r(12) = 0.337$, $p = 0.337$. Therefore, the data suggests that the use of codes was consistent throughout the length of the study and independent of patient anxiety.

Table 6. Comparison of sessions with the most codes and mYPAS scores.

Exam	Codes Used (% Total Codes)	mYPAS Score ($\mu \pm \sigma$)
1	54 (16%)	43.6 ± 22.3
7	49 (15%)	44.7 ± 19.3
2	45 (14%)	55.4 ± 29.1
3	37 (11%)	33.3 ± 21.3
4	32 (10%)	30.0 ±12.4
12	33 (10%)	40.3 ± 5.21
11	30 (9%)	51.4 ± 11.2
10	20 (6%)	46.3 ± 2.37
5	15 (5%)	24.1 ± 2.03
9	8 (2%)	32.8 ± 21.9
6	7 (2%)	29.6 ± 15.7
8	3 (1%)	50.4 ± 23.9

Table 7 shows the top 5 most frequently used codes and Table 8 shows the codes used in at least half of all exams. All of the codes in Table 7 are also found in Table 8, meaning that not only were they the most often used codes, they were also the most consistently used codes throughout the study.

Table 7. Top 5 most frequently used codes.

Codes and Descriptions	Frequency (% Total Codes)
C50. Child squirms	26 (8%)
C6. Use of parents to control	19 (6%)
C14. Lowest anxiety score when doctors are not present	17 (5%)
C41. Use of parents to soothe	17 (5%)
C3. Signs of child being tired	15 (5%)

Table 8. Codes used in at least half of all exams.

Codes and Descriptions	Number of Exams (% Total Exams)	Frequency (% Total Codes)
C50. Child squirms	9 (75%)	26 (8%)
C41. Use of parents to soothe	9 (75%)	17 (5%)
C19. High anxiety score while administering eye drops	9 (75)	13 (4%)
C14. Lowest anxiety score when doctors are not present	8 (67%)	17 (5%)
C3. Signs of child being tired	8 (67%)	15 (5%)
C6. Use of parents to control	7 (58%)	19 (6%)
C8. Doctor shows tools/prepares the child for what is about to happen	7 (58%)	12 (4%)
C63. High anxiety score while being restrained	6 (50%)	9 (3%)

These codes were iteratively compared, rephrased, and presented as 8 key themes. As discussed in the following section, these themes were referenced when developing directions and were carried through the personas, briefs, and ultimately, the specifications.

The following 8 key themes emerged:

1. The administration of cyclopentolate, tropicamide, and phenylephrine drops was the most anxiety-inducing procedure within a single eye exam.
2. Being restrained was anxiety inducing, even before drops were administered.
3. Having a parent restrain their child or sit the child on their lap occurred in most exams.
4. Tools and tricks used to capture a child's attention incorporated color, movement, lights, and sounds.
5. Children sought their parents during times of stress in most exams.
6. Children were more anxious when doctors were present.
7. Children experienced anxiety even when doctors showed them their tools and explained the procedures.
8. Children squirmed when in anxious situations in most exams.

5. DESIGN RESEARCH & DEVELOPMENT

The second goal of this thesis is to use the study's findings as an input to the research and development of a product to help reduce distress and to continue the conversation about merging scientific research and applied design research. Table 9 shows a summary of the study findings and Figure 26 outlines the design research methods used in this section. This thesis uses participatory design methods and a human-centered design mindset to translate research findings into design principles. The design principles led to specifications for the device that guided ideation.

Table 9. Summary of the study's findings.

Statistical Analysis	Theme Analysis
1. Using patient history (procedure 1) as a baseline, tonometry (procedure 9) ($p = 0.025$), dilation (procedure 12) ($p < 0.001$), and ophthalmoscope test (procedure 14) ($p = 0.040$) had significantly higher anxiety than the baseline, $F = 7.43$, $p < 0.001$.	1. The administration of cyclopentolate, tropicamide, and phenylephrine drops was the most anxiety-inducing procedure within a single eye exam.
2. Dilation showed significantly higher anxiety ($p \leq 0.001$) than ophthalmoscope test and all other procedures with the exception of tonometry, which did not have a significant difference when compared to dilation ($p = 0.052$), $F = 7.43$, $p < 0.001$.	2. Being restrained was anxiety inducing, even before drops were administered.
3. For age group, the < 4 group had significantly higher anxiety than the 4 – 7 group and the > 7 group, $F = 117$, $p < 0.001$.	3. Having a parent restrain their child or sit the child on their lap occurred in most exams.
4. Patients who were new to the clinic had significantly higher anxiety than patients receiving a yearly exam, $F = 8.69$, $p = 0.005$.	4. Tools and tricks used to capture a child's attention incorporated color, movement, lights, and sounds.
5. Patients who received a morning exam had significantly higher anxiety than patients receiving an exam in the afternoon, $F = 8.25$, $p = 0.006$.	5. Children sought their parents during times of stress in most exams.
6. For child's mood, the 3-rating group had significantly higher anxiety than the 4-rating group and the 5-rating group, $F = 9.12$, $p = 0.003$.	6. Children were more anxious when doctors were present.
7. Patient age and mYPAS scores were strongly negatively correlated, $r_s(127) = 0.306$, $p < 0.001$.	7. Children experienced anxiety even when doctors showed them their tools and explained the procedures.
8. Time since last nap and mYPAS scores were strongly negatively correlated, $r_s(127) = 0.395$, $p < 0.001$.	8. Children squirmed when in anxious situations in most exams.
9. Number of eye exams and mYPAS scores were strongly negatively correlated, $r_s(127) = 0.448$, $p < 0.001$.	

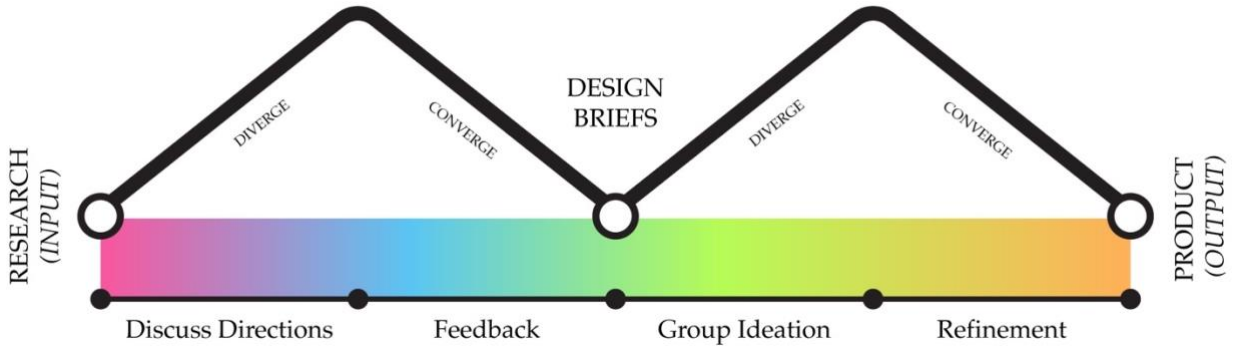


Figure 26. Outline of design research methods.

5.1. User Persona Development.

The age groups from the study were translated into user groups called personas. As shown in Figure 27, the youngest age group was split into two separate user personas because children under the age of one were observed to behave differently. Compared to older groups, infants had fickler emotions and were less likely to tolerate discomfort, such as having light shined in their eyes. Moreover, they were less likely to need to be restrained by their parent due to their small size and lack of motor control. These different needs made it necessary to create a separate user group for infants.

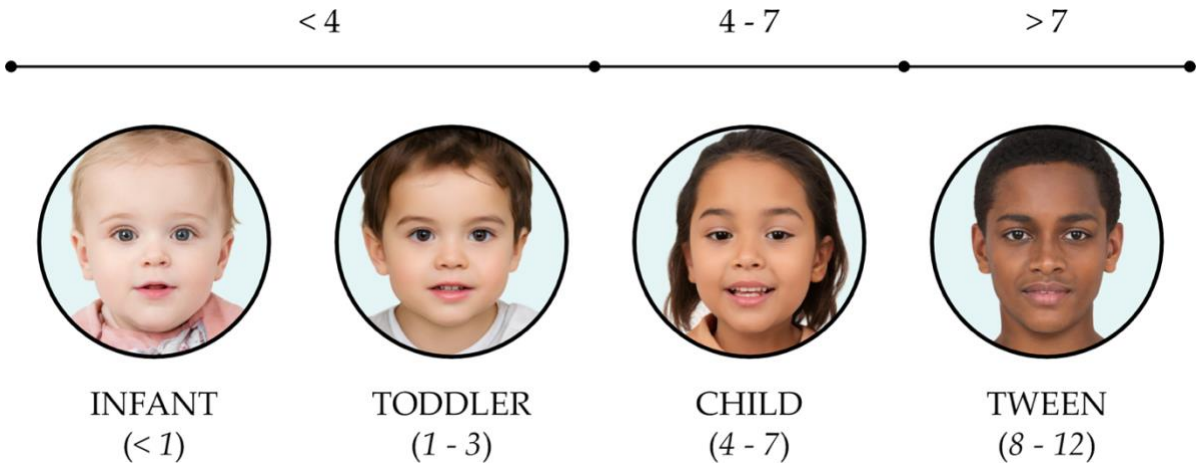


Figure 27. User personas developed from age groups.

5.2. Discussing Directions.

Basically, the administration of drops is crucial in assessing eye health. From literature review, the study findings, and discussions with optometrists, it was clear that unless drops were developed that were not acidic and did not sting, dilation would continue to be a major source of distress for children. Until then, efforts to make this procedure as quick as possible and less prone to mistakes would help reduce anxiety. Redefining the experience of receiving drops (at least until the drops make contact with the eyes) would also be helpful.

There are multiple ways to approach any challenge. A brainstorming session was used as a way to collaboratively discuss and list out potential directions so that they could be evaluated. Normally, brainstorming sessions are done at the earliest stages of a design cycle and without much input. These sessions are meant to employ human-centered design and design thinking in order to reveal assumptions or shortages of knowledge about a particular issue or subject and pose questions that ought to be researched by a designer. In this case, however, the brainstorming session follows a study with massive amounts of insight. This data-driven brainstorming approach led to a wealth of empathy.

A total of 6 graduate design students participated in this brainstorming session. During the session, the user personas were presented and key insights from the study were discussed. This discussion resulted in a list of "How Might We" (HMW) questions that described potential directions using a uniform format. HMW questions are structured to include a user, a problem, and context for the problem. They aim to postulate solutions that focus on emotions, aim to create value, and question assumptions.

For example, the study findings showed that children were more anxious when doctors were present, that children sought their parents when anxious, and that children were more anxious when they were new to the clinic and had fewer exams. HMW questions that followed included:

- "HMW help children trust their optometrist while receiving their first eye exam?"
- "HMW help optometrist become more approachable and relatable while working with a new patient?"
- "HMW give optometrists the ability to soothe kids as effectively as a parent?"
- "HMW keep children from losing trust when their optometrist causes them discomfort?"

As another example, the findings showed that children squirmed when anxious and that dilation was the most anxiety inducing procedure. The following HMW questions emerged as a result:

- "HMW help optometrists restrict a child's arms and legs while making it a fun and positive experience?"
- "HMW help children in pain open their eyes after receiving an eye drop that stings?"
- "HMW help optometrists administer eye drops without the need to restrain a child?"
- "HMW help optometrists open a child's eyes naturally and without intervention?"
- "HMW help optometrists confirm that eye drops were successfully administered while a child is crying and squirming?"
- "HMW allow children to accurate administer drops themselves while gamifying the experience?"
- "HMW help optometrists administer drops to both eyes at the same time while the child is oblivious to the procedure?"

This process was repeated for all of the findings and the list of HMW questions was reviewed at the end of the brainstorming session. Ideas regarding potential directions and methods to receive feedback were discussed.

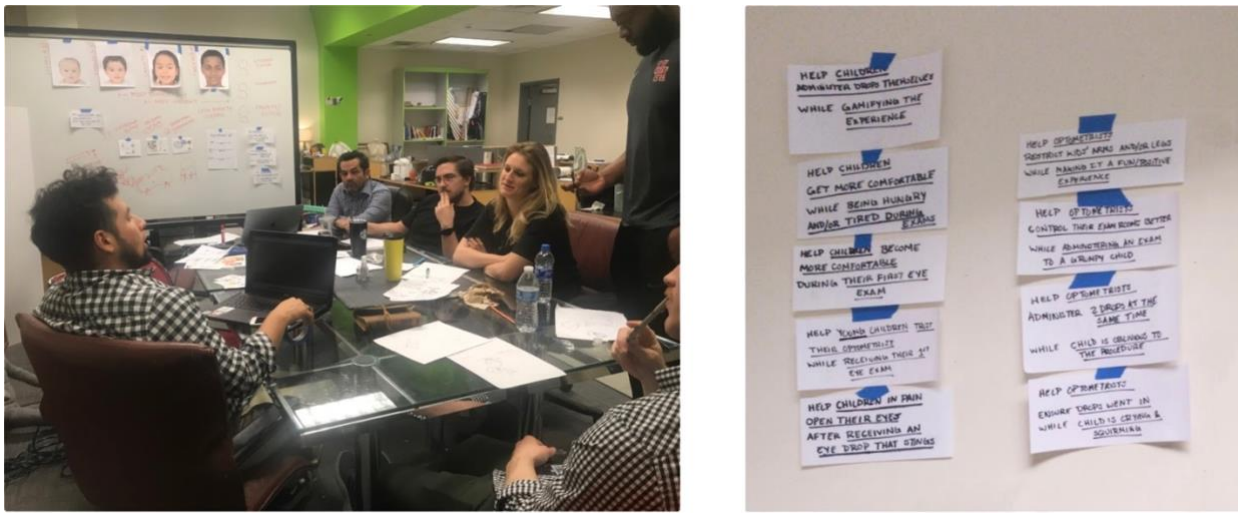


Figure 28. Graduate student collaborative brainstorming session and HMW question development.

5.3. Receiving Feedback.

As discussed in section 1 of this thesis, the three principles of design thinking are desirability (appealing to humans), viability (commercial potential), and feasibility (technologically possible).

A solution must be desirable if it is meant to be successful. Desirability can be understood as a compelling quality or an ability to provide advantages. Desirability can also be interpreted as impact. Impact is just as affecting, gripping, and impressive. These qualities can be summarized by two questions: "do I want it?" and "will it create change?" These are key questions in assessing user needs.

Therefore, a desirability/impact matrix was constructed to allow doctors to evaluate the desirability of potential directions. The directions that emerged through the creation of HMWs were summarized and placed on sticky notes. Poster board and tape was used to create a large matrix with four quadrants. One axis represented the potential positive impact that a direction could have on patients and the field of optometry. The other axis represented the doctor's desire to apply the direction to their practice. Figure 29 shows how this method was implemented.

Directions that were placed in the top right quadrant were seen as both desirable and impactful. These directions were assigned points. Due to their advanced knowledge and experience, faculty members assigned two points while student doctors assigned one point. A total of 4 student doctors and 2 faculty were tasked with placing directions on the matrix. Thus, the minimum score that a direction could receive was 0 and the max score was 8. Photos were taken to document the evaluations.

Figure 29. Desirability x Impact matrix.

5.4. Scored Affinity Diagram and Design Briefs.

Scores for each of the directions were calculated. Figure 30 shows each of the directions sorted by score. Directions that scored a 4 or higher were given priority. These directions were organized into groups based on their relationships to each other. Figure 31 shows the Affinity Diagram produced as a result of grouping the more desirable solutions. Each of the affinity groups implied a unique design brief and a total of 3 design briefs were created as a result: Redefining Experiences, Agile Eye Drops, and Comfortable Exams. Handouts were produced that describe each of the design briefs, provide background, and pose key questions. They are provided in Appendix F.

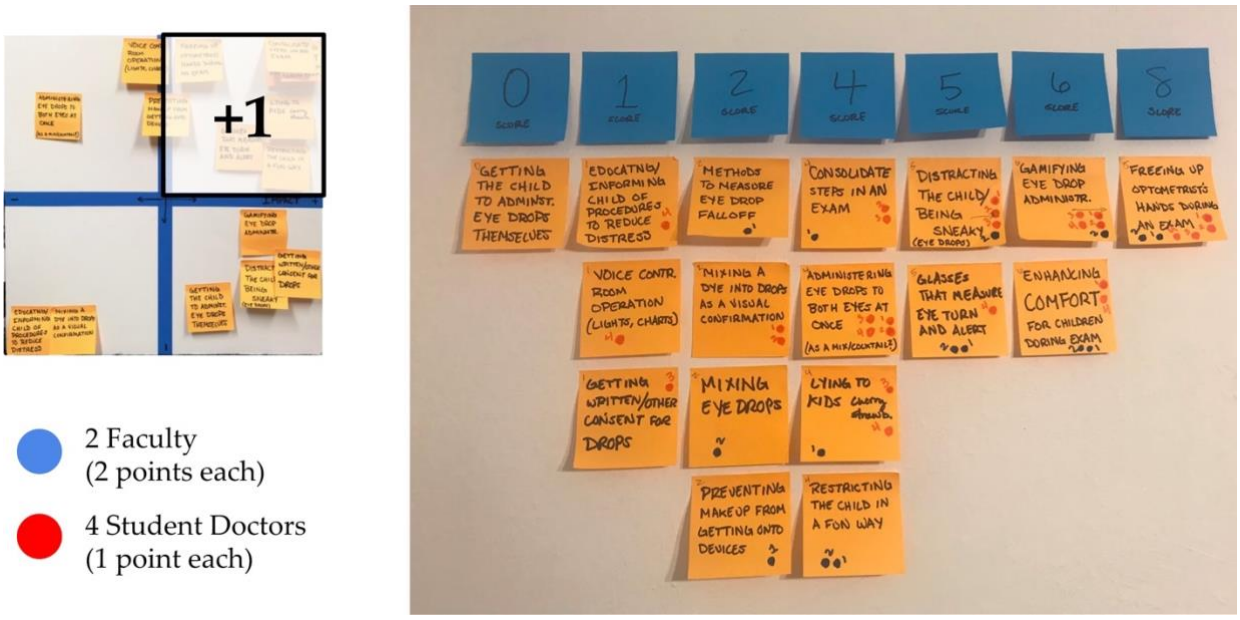


Figure 30. Directions ordered by the scores they received.

Figure 31. Affinity diagram of the most desirable directions.

5.5. Workshops and Group Ideation.

Two workshops were held to present my research, to share my process of developing design briefs from research insights, and to capture divergent thinking. A presentation outlining my process and reenactments of key observations were provided to participants, as well as print outs of the user personas, the sequential map of procedures presented in section 2.2, and the three design brief handouts provided in Appendix F. A tool key, also provided in Appendix F, was developed to supplement the third design brief so that participants could understand what each of the tools looks like. Print outs of the tool key were also given to the participants during the workshop.

After the presentation and reenactments, participants were split into three groups and tasked with sketching solutions that meet each of the design briefs. The groups of participants were given 10 minutes for each brief and asked to switch.

A total of 15 undergraduate design students participated in the two workshop sessions. They produced a total of 47 sketches. A selection of 17 of the best ideas that were sketched during the workshop is shown in Figure 33.

Figure 32. Pictures of workshop events.

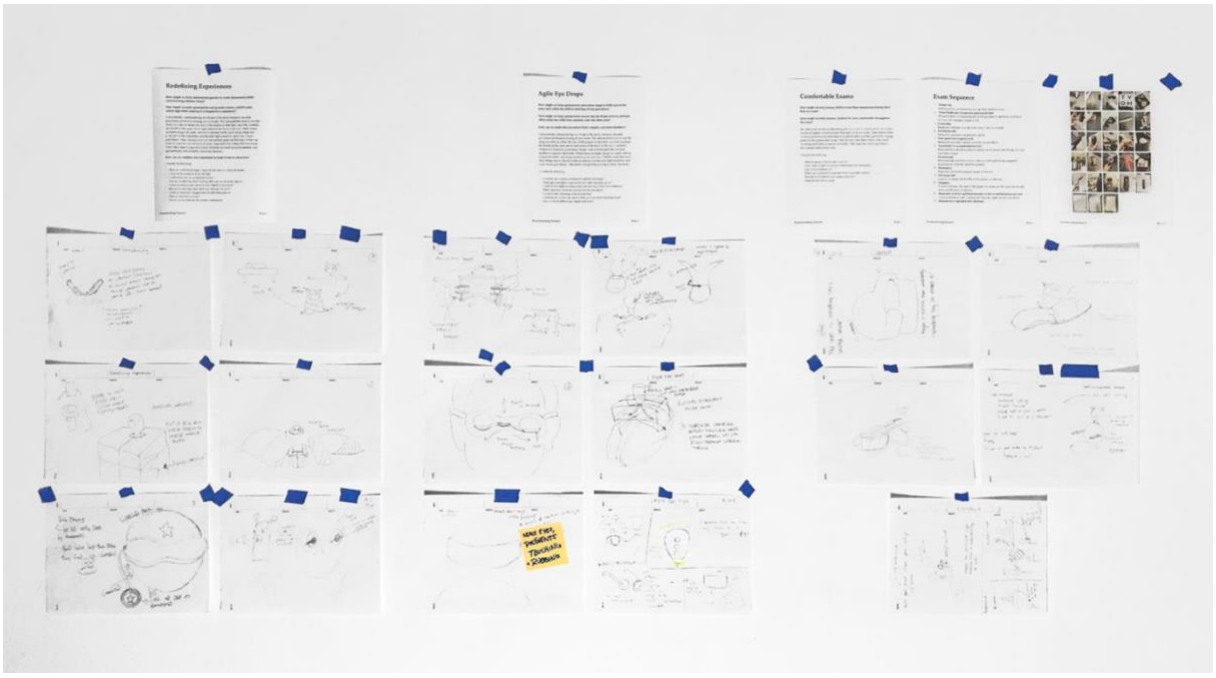


Figure 33. A selection of the sketches produced during the workshop.

5.6. Refinement.

All of the sketches from the workshop were evaluated using the three principles of design thinking in order to select the brief with the most potential for success. The second brief, Agile Eye Drops, was determined to be most successful based on the quantity and quality of the ideas produced from the sketches. These ideas, along with ideas of my own, fueled the development of heuristic principles.

In addition to selecting a design brief, a target user persona was also selected. It was determined that the toddler persona would receive the most benefit from the brief. Toddlers are young enough that they are unlikely to have had many eye exams and are unlikely to remember the exams they had as infants. They are old enough to have conditioned fears, yet they are generally not emotionally mature enough to control fickle emotions. Moreover, they have developed enough motor skills and are large enough to need restraint when distressed.

The target user persona has the following characteristics:

- New to the clinic
- Has had few or no eye exams in the past
- Receiving an exam in the morning
- Not in a good mood
- Tired and want to go home
- Dislikes drops because they sting
- Tries to squirm away in stressful situations
- Does not like being restrained
- Not comfortable around doctors
- Turns to parents in times of stress

5.7. Heuristic Principles and Specification.

The Agile Eye Drops brief presents a challenge to create a solution that delivers eye drops to both eyes at the same time while the child remains unaware of the procedure. The solution must allow the optometrist to ensure that the drops were successfully administered and must speed up and simplify the procedure.

Thus, it was determined that a successful solution that meets this brief must therefore abide by the 7 key heuristic principles provided in Table 10. To meet these principles, specifications were developed that guided ideation and further refinement. Potential features that were ideated are also provided.

Table 10. Heuristic principles and the specifications and features that followed.

Heuristic Principles	Specifications	Features
Deploys drops quickly	In seconds	Spring-loaded plungers vs. syringes
Adjusts to head size	5.1″ - 5.7″	Sliding mechanism
Hides drops, deploys covertly	Opaque body material	Polycarbonate or ABS
Keeps eyelids open without touching lashes	No lash contact	Visual target above line of sight
Captures attention	Color, movement, light, sound	Suspended glitter or oil solution
Allows doctors to see	Transparent visual target material	Polycarbonate
Simplifies the procedure	No restraining the child	Visual target and face attachment

A compelling idea was to use a visual target positioned above a child's line of sight to naturally open a child's eyes when they look up. Inspired by sensory bottles, which are containers filled with various materials that encourage sensory play for children, these visual targets could capture a child's attention by leveraging the use of color, movement, and light. The idea to use color, movement, and light came directly from the study's observations of tools used as visual targets during exam procedures. In ideation sketches, the visual target took the form of a hollow containers shaped like large lenses. The container would be filled with common sensory bottle materials, such as glitter or colorful oil suspensions, and sealed after being filled. The container's material would be transparent to allow patients and optometrists to see through the visual target.

Shown in Figure 34, ideation focused on two main device designs. The first design was a handheld device with ergonomics similar to that of a retinoscope. This device would feature a bifurcated inner channel that allows eye drop delivery to both eyes at the same time at the push of a button. The bifurcation angle is designed to match the curvature of a child's bridge of the nose and the device is meant to be angled appropriately by the optometrist. A solution of eye drops could be loaded into the device where an inner plunger or syringe mechanism would depress and deliver the drops out of the device and into a child's eyes. A visual target would snap onto the body of the device at the point of bifurcation to draw a child's attention away from the device's nozzle. This design takes advantage of optical physics to hide the device's nozzles from children. The point of bifurcation would be far away enough from the nozzles such that if a child focused on the visual target, then there would be a blurring effect on the nozzles due to differences in focal distance and the depth of field of the eye's lens.

Figure 34. Ideation sketches of the features developed from heuristic principles.

The second design, explained in further detail in the next section, was a device in the form of glasses. This device would feature an adjustable body with two channels positioned directly in front of the eyes to deliver drops and notched legs that wrap around a child's ears. To ensure sterility of the drops, the channels are sized to fit custom syringes that are pre-loaded with a drop solution. Optometrists would insert these syringes into the channels prior to an exam. The length of the syringes is designed to allow the optometrist to grip each syringe and comfortably plunge the solution out of the syringe and into the child's eyes. Removable visual targets snap onto the body of the device and sit above the line of sight, forcing a child to look up. Looking up naturally opens the eyelids and distracts from the nozzles of the device, using the same optical physics concept as the first design. The body adjusts to the child's head size using a nosepiece that fits and locks into grooves inside both halves of the body. The grooves allow for the two halves of the body to slide away from each other in order to fit a child's head size, using the nosepiece for support. The nosepiece is designed to match the curvature of a child's bridge of the nose.

The two designs were compared using the aforementioned principles in order to decide which design to propose. The first design is less able to meet the principle of deploying drops covertly. Although it hides the nozzles using optical physics, the overall form of the device is comparable to a spray bottle or squirt gun and therefore visually implies that a liquid will shoot out of it. It is possible that this may make children anxious. Furthermore, the intended use of the device, wherein it is held by the optometrist and brought up close to a child, may frighten or cause a child to squirm away. Lastly, a benefit of the second design that the first design does not have is the ability to prevent a child from rubbing their eyes immediately after the drops are delivered. When a child rubs their eyes immediately after receiving drops, some of the drops are forced out of the eyes and the effect of dilation is reduced. To mitigate this effect, another round of drops must be administered, resulting in additional distress. This is one of the special findings from the observations provided in Appendix E.

With this comparison in mind, it was determined that the form of the second design was more appropriate in meeting the brief. Multiple iterations of this design were produced. This design is ultimately proposed.

5.8. Testing & Refinement.

The design was modeled in SOLIDWORKS, rendered in KeyShot, and 3D printed to-scale a total of 3 times, each time with increasing fidelity and additional features. Shown in Figure 35, the first iteration featured spring-loaded plungers, inspired by the plungers of most soap dispensers, a fixed device body, notched legs, and a single visual target. Measurements for the spring-loaded mechanism were determined by reverse engineering the inside of multiple common soap dispenser plungers. Measurements for the body of the device were based on head circumference measurements for a toddler (Craft Yarn Council, n.d.).

This iteration aimed to test the delivery of drops and the fit of the device. Using springs sourced from soap bottle dispensers, the spring-loaded mechanism worked well when tested. However, the size of the plungers was too large in proportion to the overall body size. Improvements to the measurements and additional features drove modeling decisions for the next iteration.

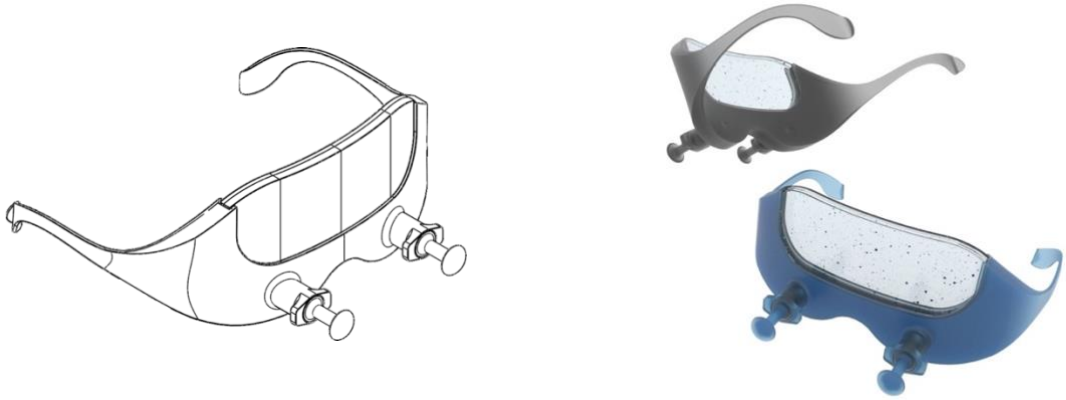


Figure 35. First iteration model of the design with a render of the material.

Shown in Figure 36, the second iteration featured smaller spring-loaded plungers that were incorporated into the device's body, mirrored body halves with less-severely notched legs, two visual targets, and a twist-lock mechanism for extending the two halves of the device's body. The twist-lock mechanism included a bar that slid within grooves on both halves of the body. The bar's front facing surface when in the locked position was flat and had a ruler for precise adjustments to the space between the two halves of the body. The ruler allowed for the device to be adjusted based on the child's measured inter-pupillary distance.

This iteration aimed to shorten the length of the spring-loaded plungers and incorporate a new feature that allowed for head size adjustments. The previous springs were cut in half and the measurements for the spring-loaded mechanism were adjusted accordingly.

The model was presented to the thesis committee and it was advised that spring-loaded plungers were not appropriate due to sterility concerns. In this iteration, drops were meant to be loaded into the plunger chamber by optometrists. This was convenient in that it allowed drops to be mixed in concentrations deemed appropriate by the optometrist before each exam without shelf-life concerns, but it required that the plunger chamber be sterilized at regular intervals.

Also, the visual targets called for improvements. The tolerances given to the grooves that allowed the visual targets to snap into the body were too large. Therefore, the visual targets would fall out if the device was inverted. The visual targets for both the first and second iterations had a parting line with a lip and groove. This feature did not function well when filled with liquids.

Furthermore, although the twist-lock mechanism worked well, it did not sit comfortably on the nose. A mechanism that incorporated a nosepiece was the next logical step.

Therefore, a disposable, insertable, pre-loaded syringe-like alternative to the plungers, visual targets that could be filled from the top and then sealed, and a sliding nosepiece mechanism drove modeling decisions for the next iteration.

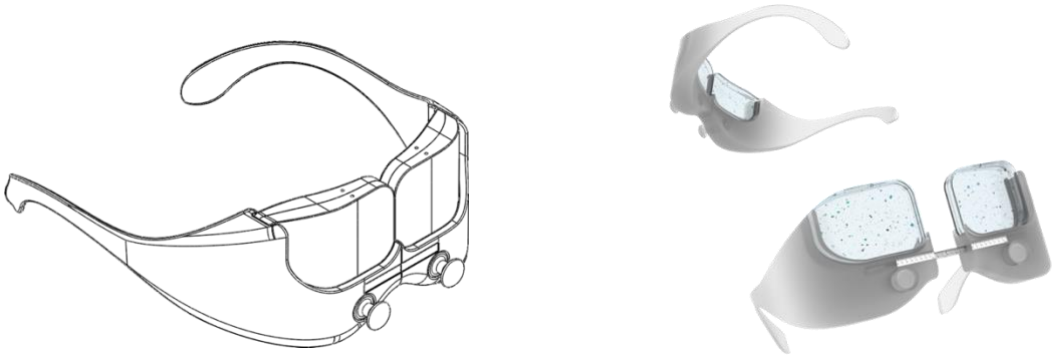


Figure 36. Second iteration model of the design with a render of the material.

Shown in Figure 37, the final iteration featured mirrored body halves with channels for custom syringes, two custom syringes, notched legs, two visual targets with adjusted groove tolerances, and a nosepiece that locks and slides within grooves inside both halves of the body.

Anatomical measurements of the nose were determined by using an image of a toddler's face generated by an artificial intelligence system (Generated Photos, n.d.), which was scaled to life-size using head circumference measurements (Craft Yarn Council, n.d.), as an underlay for the nosepiece. The image was generated from generative adversarial networks that were trained

using a proprietary dataset of images to produce composite images of many people. The image used is shown in Figure 27 for the toddler persona.

Detailed information about each feature is provided in the next section.

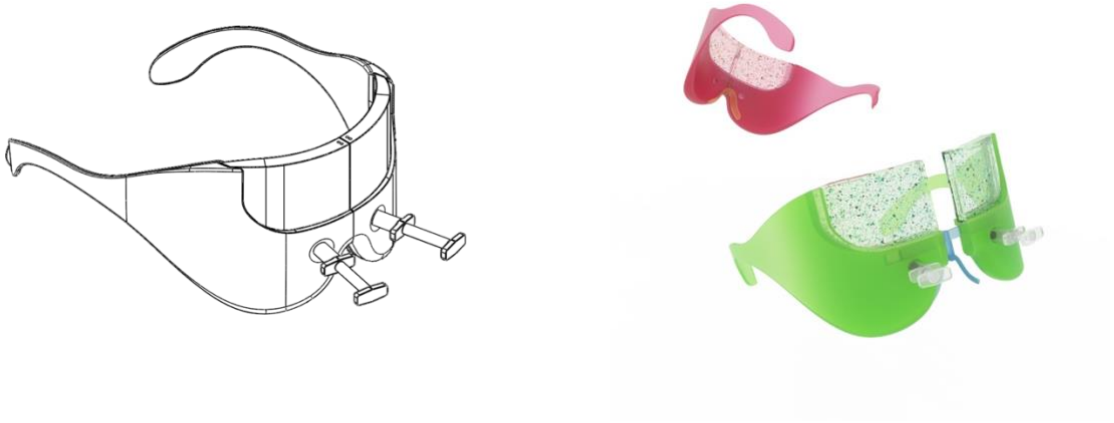


Figure 37. Final iteration model of the design with a render of the material.

Figure 38. Render of the proposed solution.

6. PROPOSED SOLUTION

This thesis proposes the aforementioned final iteration of the second design as a solution to reduce distress when administrating eye drops during dilation.

As previously discussed, the administration of drops is crucial in assessing eye health. From literature review, the study findings, and discussions with optometrists, it was clear that unless drops were developed that were not acidic and did not sting, dilation would continue to be a major source of distress for children. Until then, efforts to make this procedure as quick as possible and less prone to mistakes would help reduce anxiety. Redefining the experience of receiving drops (at least until the drops make contact with the eyes) would also be helpful.

Shown in Figure 38, the design takes the form of glasses and features an adjustable body with two channels positioned directly in front of the eyes to deliver drops, legs that wrap around a child's ears, and visual targets that snap in and serve to distract a child and naturally open their eyes. This design is intended to be used while the child is sitting upright in a chair, completely eliminates the need for restraint, makes administering drops faster and less prone to mistakes, and redefines the experience of receiving eye drops up until the moment they are deployed.

6.1. The Adjustable Body & Nosepiece.

In order to provide the ability to adjust to different head sizes, the body of the device is separated into two mirrored halves with notched legs that wrap around a child's ears. An exploded view showing each of the components of the proposed design and their approximate relationships is provided in Figure 39.

The body of the device adjusts to the child's head size using a nosepiece that locks and slides within grooves inside both halves of the body. The grooves allow for the two halves of the body to slide away from each other in order to fit a child's head size, using the nosepiece for support. The nosepiece is designed to match the curvature of a child's bridge of the nose. Figure 40 shows the mechanism of the grooves and the nosepiece.

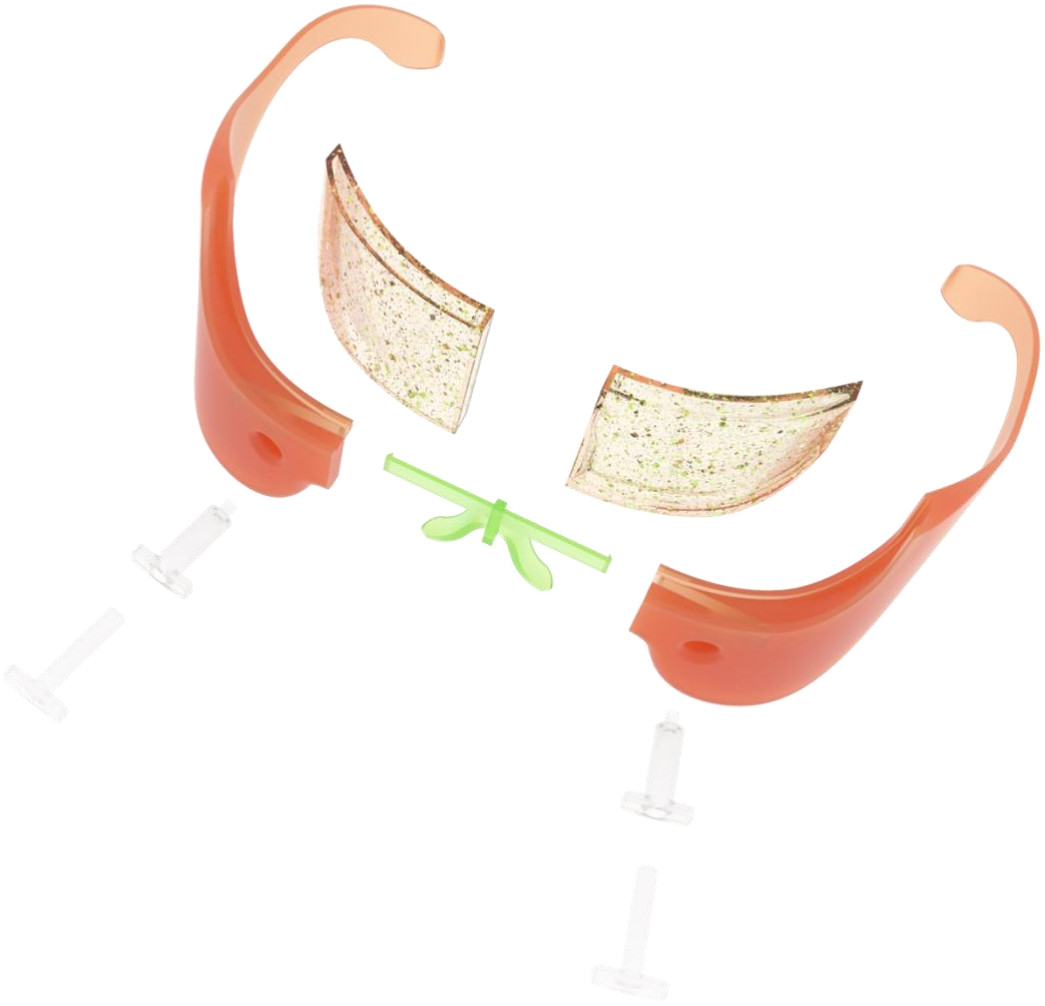


Figure 39. Exploded view of the components of the proposed design.

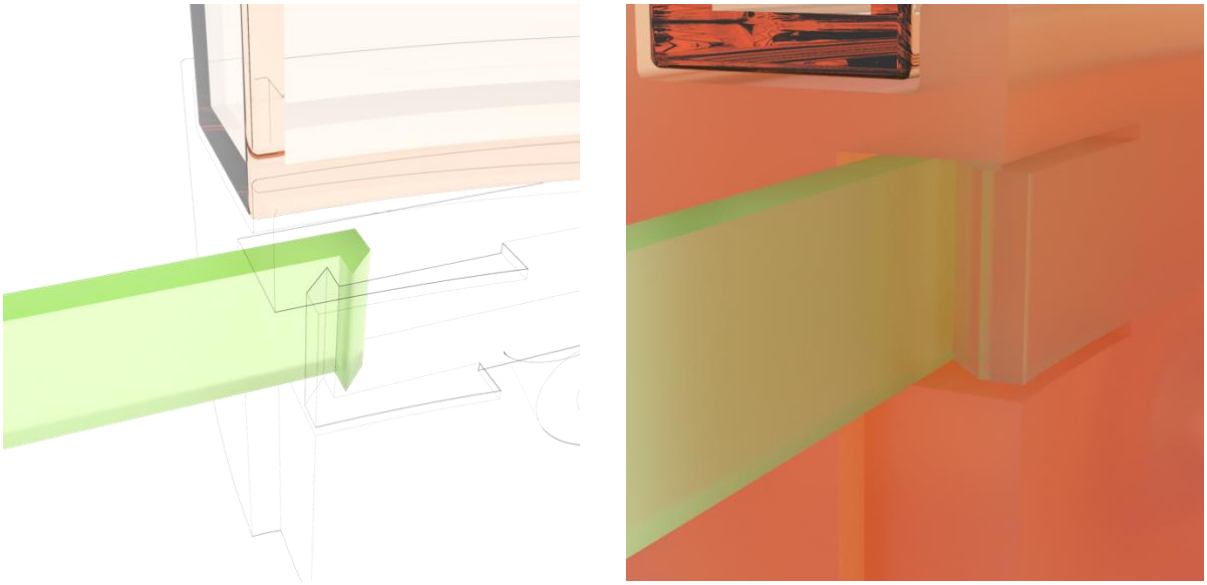


Figure 40. The slide and lock mechanism of the groove and nosepiece (green).

6.2. The Visual Targets.

As previously discussed, the idea of using visual targets positioned above a child's line of sight to naturally open a child's eyes when they look up is a key feature of the proposed solution.

Inspired by sensory bottles, which are containers filled with various materials that encourage sensory play for children, these visual targets capture a child's attention by leveraging the use of color, movement, and light. The idea to use color, movement, and light came directly from the study's observations of tools used as visual targets during exam procedures. The visual targets take the form of a hollow container shaped like a large lens. The container is filled with common sensory bottle materials, such as glitter or colorful oil suspensions, and is sealed after being filled. The container's material is transparent to allow patients and optometrists to see through the visual target.

The visual targets are removable. They snap onto the body of the device above the line of sight, forcing a child to look up. Looking up naturally opens the eyelids and distracts from the nozzles of the device by applying the concepts of focal distance and depth of field. Figure 41 shows an

example of this effect. In this figure, the child sits in the intended upright seated position on a chair in front of the optometrist. Figure 42 shows the child-facing side of the device and provides an example of how the visual targets snap into the body of the device.

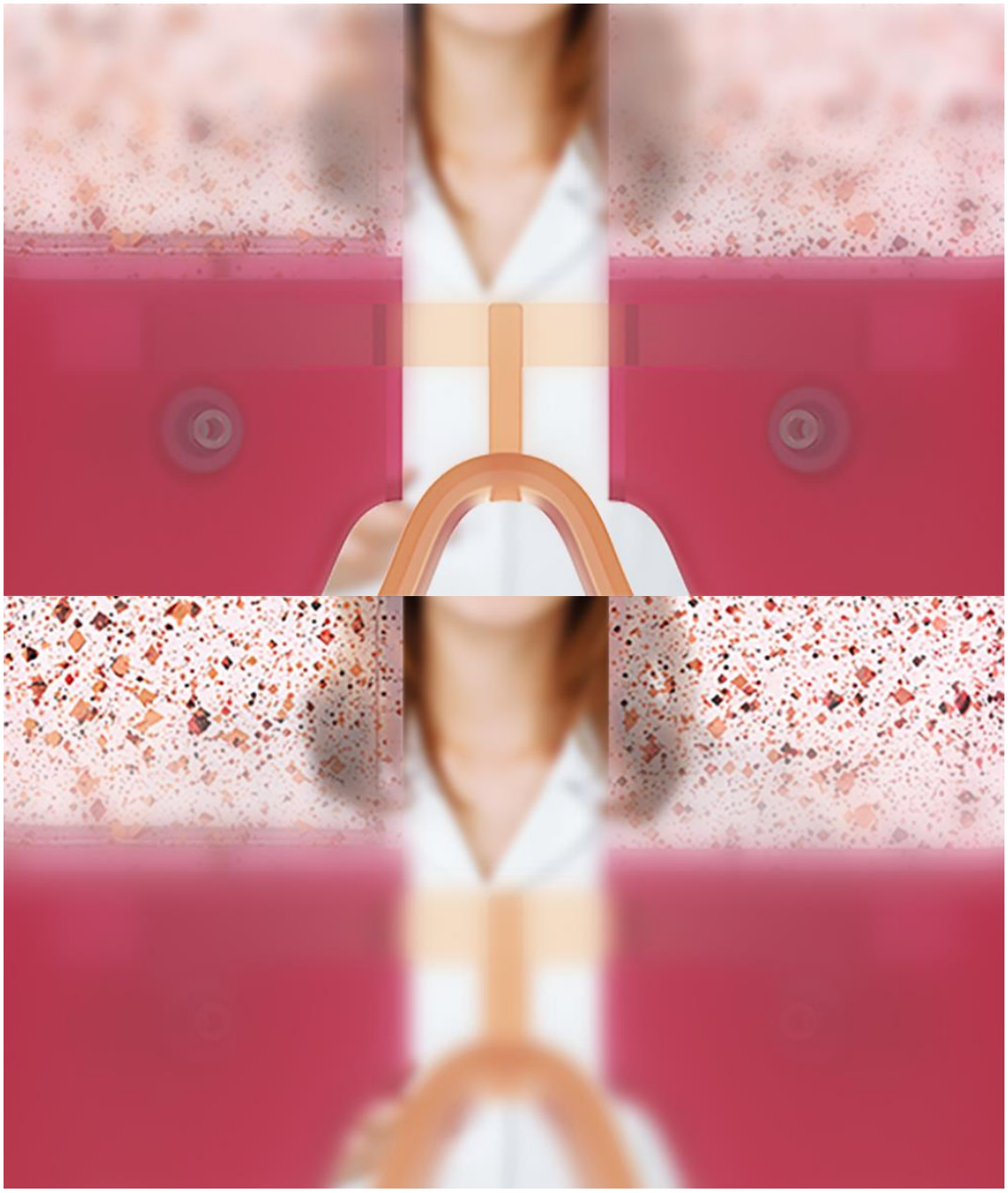


Figure 41. Example of the effect of depth of field when looking down (top) vs. up (bottom).

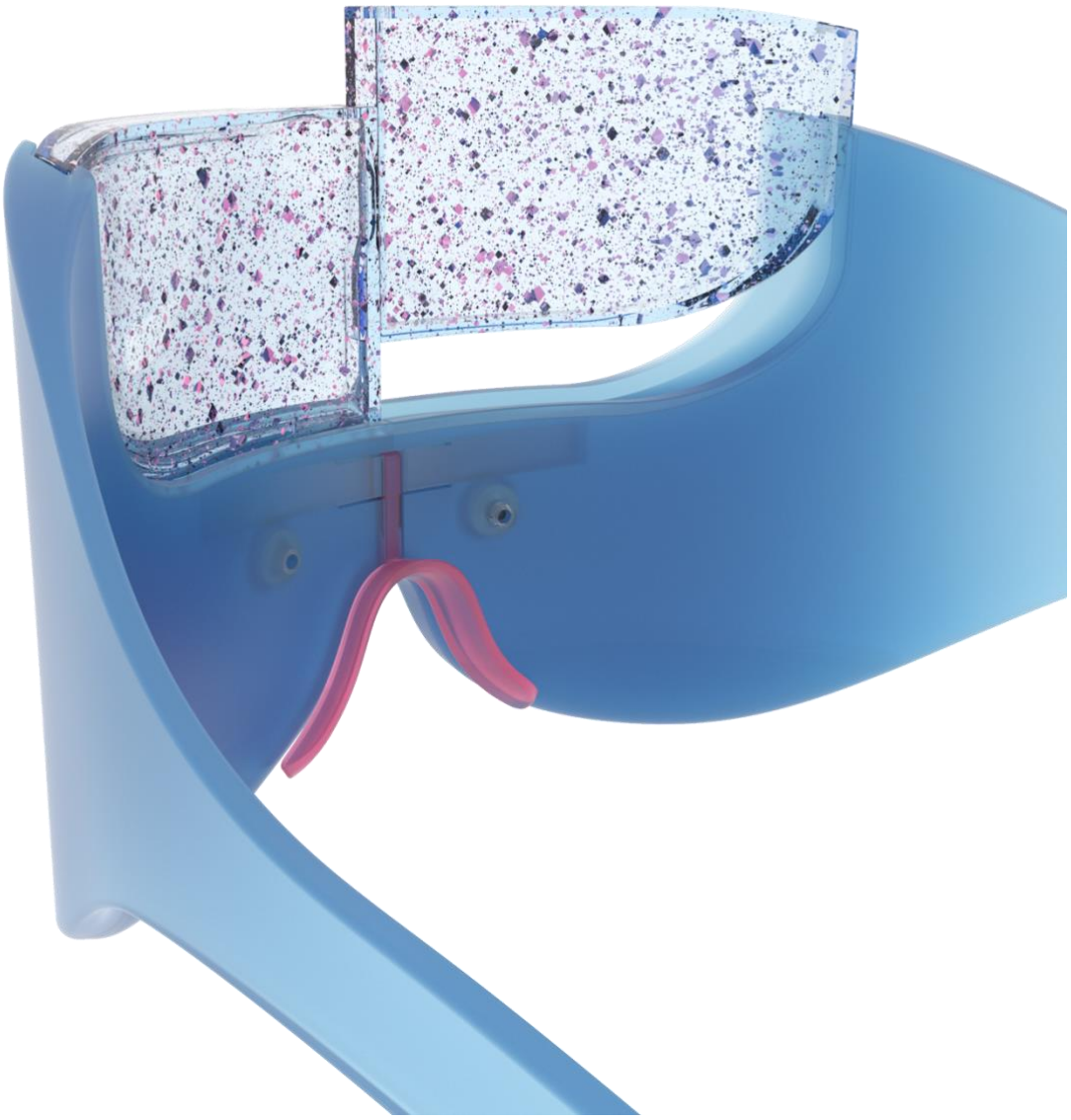


Figure 42. Example of the visual target snapping into the body of the device.

6.3. The Custom Syringes.

At the front of both halves of the body are channels sized to fit custom syringes. Optometrists would insert these syringes into the channels prior to an exam. The syringes are small but when inserted into the channels, the length of the protruding end of each syringe is long enough to allow an optometrist to grip each syringe and comfortably plunge the solution out of the syringe and into the child's eyes. Figure 38 shows the syringes inserted into the channels of the body. Figure 39 shows the size of the syringe chambers, the syringe plungers, and the syringe channels in the body halves.

The syringes are pre-loaded with drop solutions and sealed to ensure the sterility of the drops. Once used, they may be disposed or sterilized and reused. A business model and go-to-market plan are beyond the scope of this thesis, but a recurring service to sterilize and repackage syringes may serve as a more sustainable alternative to disposing the syringes.

The syringe chamber has an approximate volume of $0.017in^3$, or approximately 0.279mL. One milliliter is roughly equal to 20 drops. Therefore, the syringe chamber is able to hold about 5.579 drops. This is an appropriate volume to hold one drop each of cyclopentolate (1%), tropicamide (1%), phenylephrine (2.5%), and proparacaine (0.5%) and provide additional volume to fit a portion of the syringe plunger. Different combinations of drops may, of course, be offered as alternatives.

6.4. Color, Material, & Finish.

Bright, well-saturated colors were chosen to attract the attention of children and to convey a cheerful, energetic, and playful visual brand language. For each version of the device, the color of the nosepiece and glitter is different from the color of the body. Table 11 lists the 4 colors in the form of a 2x2 matrix. Color combinations are paired clockwise as to not pair two complementary colors together.

Table 11. The 4 colors arranged in a matrix with their complement on the diagonal.

Bright Pink #FA569E RGB 250, 86, 158 PANTONE 812 C	**Bright Orange** #FFB058 RGB 255, 176, 88 PANTONE 150 C
Bright Blue #5AC5F3 RGB 90, 197, 243 PANTONE 2985 C	**Bright Green** #B6FC57 RGB 182, 252, 87 PANTONE 374 C

The syringes are meant to be injection molded in clear polypropylene, the material of choice for all medical syringes. All other components are meant to be injection molded in dyed semi-transparent polycarbonate, which is a common material for glasses frames due to its strength, stiffness, and impact resistance, and hardcoated using a film with a matte or satin finish. Figure 43 shows a render of the intended color, material, and finish.

Figure 43. The color, material, and finish of the proposed solution.

7. DISCUSSION

7.1. Combining Traditional & Applied Research Results in a Wealth of Empathy.

As was suggested by Ferreira, Song, Gomes, Garcia, & Ferreira, (2015), the combination of traditional research and applied design research methods allowed for a wealth of empathy in the design and development phase. It was possible to take the findings from the study and create a more linear product development process. Rather than starting with unfocused questions, as is the case with design research, the product development process began with advanced understanding of the issues, clear user personas, and focused development of HMW questions and directions. In the end, the study was able to directly translate and materialize into an impactful product, rather than existing on its own.

The proposed solution is a unique product with no direct competitors. This is due to the empathy gained from the study that was fed into heuristic principles to guide ideation and refinement. The combined ideas were creative interpretations of observed behaviors and events that could not have been replicated in a design studio alone. It took both the intuition of a designer and the knowledge of a researcher to successfully combine the individual ideas. Coupled with other strategies to reduce patient anxiety, such as play specialists in waiting rooms (Syrimi, Jones, & Thompson (2013)) and modified wait rooms (Hirji, Jones, & Thompson (2012)), the proposed solution can help reduce distress by completely eliminating the need for restraint, making administering drops faster and less prone to mistakes, and redefining the experience of receiving eye drops up until the moment they are deployed, especially for first time patients.

7.2. Issues with the Study.

That being said, there were issues with the study. First and foremost, the small sample size made it difficult to analyze the quantitative data. Due to limited time and the COVID-19 pandemic, data collection was forced to stop. Univariate tests from multiple repeated measure Linear Mixed Models were used to separately determine differences in each model's marginal means of the mYPAS scores for categorical factors. Although this method was determined to be more

appropriate for this data set than a General Linear Model, it was undoubtedly not ideal. Ideally, the procedures completed throughout every exam ought to have been controlled in order to avoid having missing data. A much larger sample size could have increased the power of the model. Thus, a General Linear Model could have been used to compare the effects of all of the categorical variables within a single model. However, it may be possible that controlling the repeated measures variable may affect anxiety scores such that they would not be reflective of a typical, uncontrolled exam.

Having an observer who is an optometrist would have been helpful in determining when different procedures were occurring. Alternatively, it would have been useful to have the optometrist subject declare what procedure they were doing, when the procedure ended, and if they were repeating the procedure for some reason. This would have made data collection easier and less subjective for an observer with less experience in optometry. However, having the optometrist declare each procedure may affect patient anxiety scores.

Stereopsis and color vision tests were combined as one of the 14 procedures in the study due to their perceived similarity. It was suggested that perhaps this was not an appropriate decision due to differences between the two tests. However, the findings do not show that this procedure (procedure 5) has a large range in anxiety scores. Thus, it can be concluded that these two tests have a similar correlation with anxiety.

The use of audio and video would have improved the study in multiple ways. The use of audio and video would have allowed the observer to review exam events and behaviors in detail, instead of merely what was written down. Multiple observers could have reviewed the audio and video and corroborated their observations and anxiety scores in order to reduce observer bias. The audio and video could have been shown to an optometrist if there were any doubts about what occurred during an exam. However, the addition of audio and video collection may affect the patient's anxiety scores and the performance of the optometrist. It may also make it less likely for a subject to consent to take part in the research. The collection of audio and video increases the risk of the research and it may be required to take additional steps to mitigate that risk in order to receive approval for the study.

If audio and video are not used, it would be helpful to observe and take notes from inside the exam room. Being inside the exam room may be distracting and anxiety inducing to patients, but it makes listening to conversations easier. Also, it is easier to see what is going on when the lights are turned off from inside the room than from behind a window due to glare. This was a common occurrence as many procedures required the lights to be off.

7.3. Issues with the mYPAS.

Although the mYPAS is generally an appropriate tool for assessing anxiety, is able to be used to determine a difference in anxiety levels, and has been shown to have great inter- and intra-observer stability, the mYPAS in its current form is not ideal for assessing anxiety in optometry. As previously discussed, it was originally developed for pre-operative settings and was applied to optometry by previous studies despite some cues in the mYPAS domains not being relevant to an optometry exam. For example, there are references to anesthesia equipment and anesthesiologists in most of the domains that are not present during an eye exam, the emotional expressivity domain relies on facial expressions that may be occluded to the observer while the optometrist evaluates the patient or not visible with the lights off, and it doesn't take into account that young patients are often placed on their parent's lap and will therefore be more likely to turn to their parent. Refining the cues to make a more appropriate clinical tool for optometry would be beneficial for future work.

Additionally, a cutoff score indicator for distress would also be beneficial. As previously discussed, a score of 30 is the cutoff score that indicates the presence of anxiety. However, the same does not exist for distress. The absence of such a score limits discussion to comparisons between factors and correlations with the higher end of the range of mYPAS scores.

Furthermore, the mYPAS does not produce normally distributed data when used throughout the length of an eye exam. As previously discussed, the resting state throughout the exam for most children is not having anxiety and children generally were able to recover from periods of high anxiety, resulting in peaks and valleys in the anxiety scores throughout the exam and frequently low scores. Most of the scores were on the lower range of the mYPAS and the data skewed

towards the left. Although it is not inherently bad, having data that is not normally distributed limits you to only using non-parametric tests.

Previous studies limit the use of the mYPAS or other anxiety scales to 4 points, which ignores the many other procedures. Having fewer procedures produces a normal distribution because the second and third points are always higher than the baseline first point. However, only one suspected high-anxiety procedure could be examined in comparison to a baseline using this strategy. Until now, the focus has been on proving that the administration of cycloplegic drops produces anxiety. This thesis chose to stray from this established strategy in order to describe differences in anxiety scores between all of the procedures but suffered from the non-parametric test limitation as a result. A more thought-out, refined strategy for comparing differences in anxiety scores between procedures using the mYPAS could benefit future work.

7.4. Comparing the Findings to Those of Previous Studies.

Despite its unique use of the mYPAS, the findings of this thesis generally corroborated the findings of previous studies. Dilation was by far the most anxiety inducing procedure, followed by tonometry. This agrees with previous studies that show that dilation causes distress. Previous studies do not examine differences in anxiety between all procedures in an eye exam. The establishment of tonometry as another procedure correlated with high-anxiety is a novel finding. The youngest age group experienced the most anxiety, which is often the case in previous studies, and lower anxiety scores were correlated with older patients. Sujuan, Handa, Perera, & Chia (2015) attribute this to more mature coping skills, better understanding of the rationale behind procedures, and less separation anxiety.

In addition to procedures and age, this thesis examined other factors not included in previous studies. Being new to a clinic, receiving an exam in the morning, having a sub-optimal mood, being groggy from a recent nap, and having done few eye exams in the past were correlated with higher anxiety scores. Gender was not included as a factor in order to collect as little identifiable patient data as possible to minimize risk. It was suggested that including gender as a factor could

have made these findings stronger and allowed for a better characterization of the sampled group.

Furthermore, this thesis provides 8 insightful themes from the qualitative data. Among other themes, it was observed that being restrained during dilation was anxiety inducing, even before drops were administered. This led to a solution that eliminated the need for restraint.

7.5. Next Steps in Product Development.

A few next steps remain in the development of the proposed solution. First, it would be useful to include a twist and lock mechanism for the nozzle of the syringes and the inner part of the syringe channels on both of the two halves of the body. A twist and lock mechanism, perhaps something similar to a Luer lock, could secure the syringes in place better than the friction fit that the current design relies on. The syringes currently stay in place so this addition is not that important, but it would be a valuable addition to the design.

The bar of the nosepiece could be thickened or the nosepiece groove inside each of the halves of the body could be tightened. This would secure the nosepiece better to the body.

Lastly, the entire design must be tested on actual children to fully validate the various decisions made. The COVID-19 pandemic prevented testing due to quarantine. It was suggested that it is possible that colors chosen could have unwanted effects on the behaviors of children. Testing whether or not this occurs and making the appropriate color, material, and finish changes to the design would be valuable. It would also be useful to collect information about the performance of the device and feedback from children to incorporate into the design.

8. CONCLUSION

Certainly, children have unique needs that ought to be designed for in healthcare. In optometry, children can be difficult to examine if they are distressed. This thesis tackled the need for a more holistic understanding of anxiety throughout the entire length of an eye exam, the need for qualitative themes about the exam, and the need to examine factors that had not yet been covered by other studies.

Furthermore, this thesis serves as an example of how to maximize empathy and include diverse perspectives by merging both traditional scientific research and applied design research methods when designing for healthcare. The underlying call to action is that there needs to be more work like this in order to include diverse perspectives when designing for healthcare. The experiences of children, as well as those of other groups, deserve to be taken into account in healthcare designs to improve clinical outcomes. As disparities and costs in healthcare rise, it is now more important than ever to be critical of the way we design tools, equipment, and services to best meet the needs of their users. By sharing new knowledge and a hybrid methodology, this thesis aims to create positive impact and make the world happier and healthier.

REFERENCES

Blaikie, A. J., & Dutton, G. N. (2015). *How to assess eyes and vision in infants and preschool children*. Bmj, 350, h1716.

Seppa, N. (2013). *Urban eyes: Too much time spent indoors may be behind a surge in nearsightedness*. Science News, 183(3), 22-25.

Vitale, S., Sperduto, R. D., & Ferris, F. L. (2009). *Increased prevalence of myopia in the United States between 1971-1972 and 1999-2004*. Archives of ophthalmology, 127(12), 1632-1639.

Prousali, E., Mataftsi, A., Ziakas, N., Fontalis, A., Brazitikos, P., & Haidich, A. B. (2017). *Interventions to control myopia progression in children: protocol for an overview of systematic reviews and meta-analyses*. Systematic reviews, 6(1), 188.

Rose, K., Smith, W., Morgan, I., & Mitchell, P. (2001). *The increasing prevalence of myopia: implications for Australia*. Clinical & experimental ophthalmology, 29(3), 116-120.

Zadnik, K., Sinnott, L. T., Cotter, S. A., Jones-Jordan, L. A., Kleinstein, R. N., Manny, R. E., ... & Mutti, D. O. (2015). *Prediction of juvenile-onset myopia*. JAMA ophthalmology, 133(6), 683-689.

Irving, E. L., Harris, J. D., Machan, C. M., Robinson, B. E., Hrynchak, P. K., Leat, S. J., & Lillakas, L. (2016). *Value of routine eye examinations in asymptomatic patients*. Optometry and Vision Science, 93(7), 660-666.

Scheiman, M. M., Amos, C. S., Ciner, E. B., Marsh-Tootle, W., Moore, B. D., & Rouse, M. W. (2002). *Optometric clinical practice guideline: pediatric eye and vision examination*.

Garzia, R. P., Borsting, E. J., Nicholson, S. B., Press, L. J., Scheiman, M. M., & Solan, H. A. (2008). *Optometric Clinical Practice Guideline: Care of the patient with learning related vision problems*. St Louis: American Optometric Association, 7-8.

Wood, J. M., Black, A. A., Hopkins, S., & White, S. L. (2018). *Vision and academic performance in primary school children*. Ophthalmic and Physiological Optics, 38(5), 516-524.

Hirji, N., Jones, S., & Thompson, G. (2012). *The causes of distress in paediatric outpatients receiving dilating drops*. Open Journal of Ophthalmology, 2(02), 21.

Sujuan, J. L., Handa, S., Perera, C., & Chia, A. (2015). *The psychological impact of eyedrops administration in children*. Journal of American Association for Pediatric Ophthalmology and Strabismus, 19(4), 338-343.

Syrimi, M., Jones, S. M., & Thompson, G. M. (2013). *A prospective comparison between cyclopentolate spray and drops in pediatric outpatients*. Journal of pediatric ophthalmology and strabismus.

Creswell, J. W., & Creswell, J. D. (2014). *Research design: Qualitative, quantitative, and mixed methods approaches*. Sage publications.

Szczepanska, J. (2017). *Design thinking origin story plus some of the people who made it all happen*. Medium Corporation Inc, 1, 1-7.

Rammal, D. (2019). *From human centered design to human centered marketing: Why is human centered design and marketing a match made in heaven?* Medium Corporation Inc, 1, 1-7.

Roberts, J. P., Fisher, T. R., Trowbridge, M. J., & Bent, C. (2016, March). *A design thinking framework for healthcare management and innovation*. In Healthcare (Vol. 4, No. 1, pp. 11-14). Elsevier.

Ferreira, F. K., Song, E. H., Gomes, H., Garcia, E. B., & Ferreira, L. M. (2015). *New mindset in scientific method in the health field: Design Thinking*. Clinics, 70(12), 770-772.

Niccum, B. A., Sarker, A., Wolf, S. J., & Trowbridge, M. J. (2017). *Innovation and entrepreneurship programs in US medical education: a landscape review and thematic analysis*. Medical education online, 22(1), 1360722.

van de Grift, T. C., & Kroeze, R. (2016). *Design thinking as a tool for interdisciplinary education in health care*. Academic Medicine, 91(9), 1234-1238.

Marcus, D., Simone, A., & Block, L. (2020). *Design thinking in medical ethics education*. Journal of Medical Ethics, 46(4), 282-284.

Aaronson, E. L., White, B. A., Black, L., Sonis, J. D., & Mort, E. A. (2020). *Using Design Thinking to Improve Patient-Provider Communication in the Emergency Department*. Quality Management in Healthcare, 29(1), 30-34.

Thomas, L. R., Nguyen, R., Teherani, A., Lucey, C. R., & Harleman, E. (2020). *Designing Well-Being: Using Design Thinking to Engage Residents in Developing Well-Being Interventions*. Academic Medicine: Journal of the Association of American Medical Colleges.

Sherman, J. P., Hedli, L. C., Kristensen-Cabrera, A. I., Lipman, S. S., Schwandt, D., Lee, H. C., ... & Austin, N. S. (2019). *Understanding the Heterogeneity of Labor and Delivery Units: Using Design Thinking Methodology to Assess Environmental Factors that Contribute to Safety in Childbirth*. American journal of perinatology.

Daniëls, N. E., Hochstenbach, L. M., van Bokhoven, M. A., Beurskens, A. J., & Delespaul, P. A. (2019). *Implementing Experience Sampling technology for functional analysis in family medicine–a design thinking approach*. Frontiers in Psychology, 10, 2782.

Kain, Z. N., Mayes, L. C., Cicchetti, D. V., Bagnall, A. L., Finley, J. D., & Hofstadter, M. B. (1997). *The Yale Preoperative Anxiety Scale: how does it compare with a "gold standard"?.* Anesthesia & Analgesia, 85(4), 783-788.

Jenkins, B. N., Fortier, M. A., Kaplan, S. H., Mayes, L. C., & Kain, Z. N. (2014). *Development of a short version of the modified Yale Preoperative Anxiety Scale*. Anesthesia & Analgesia, 119(3), 643-650.

Strube, Y. N. J., Bakal, J. A., & Arthur, B. W. (2010). *Relationship between feeding schedules and gastric distress during retinopathy of prematurity screening eye examinations*. Journal of American Association for Pediatric Ophthalmology and Strabismus, 14(4), 334-339.

Head Circumference Chart. (n.d.). Craft Yarn Council. Retrieved March 2020, from https://www.craftyarncouncil.com/standards/head-circumference-chart.

Unique, Worry-Free Model Photos. (n.d.). Generated Photos. Retrieved March 2020, from https://generated.photos/.

APPENDICES

Appendix A: Data Collection Instruments

Parent Survey

1. At what time did the patient last eat a meal or a snack?

   _____
   (EXAMPLE: 12:00 PM)

2. How many hours did the patient sleep last night?

   _____
   (EXAMPLE: 9)

3. Does the patient sleep this amount on an average night?

   ☐ YES ☐ NO
   (PLEASE CHECK ONE)

4. At what time did the patient last wake up from their most recent rest?
   (THIS MORNING OR A NAP)

   _____
   (EXAMPLE: 12:00 PM)

5. Is this the patient's first eye exam?

   ☐ YES ☐ NO
   (PLEASE CHECK ONE)

   If no, please estimate their total number of eye exams.

   _____
   (EXAMPLE: 5)

6. In general, how has the patient's mood been today?

   ☐ ☐ ☐ ☐ ☐
   BAD *FAIR* *GOOD*
   (PLEASE CHECK ONE)

7. In general, how has your mood been today?

   ☐ ☐ ☐ ☐ ☐
   BAD *FAIR* *GOOD*
   (PLEASE CHECK ONE)

8. Please use the remaining space to share if there is a reason for your answers to questions 6 and 7.

Data Collection Instrument | Parent Survey

DISTRESS & TANTRUMS IN OPTOMETRY EXAMINATIONS SESSION:

Observations & Field Notes

TIME	mYPAS	NOTES

Data Collection Instrument | Observations

DISTRESS & TANTRUMS IN OPTOMETRY EXAMINATIONS SESSION:

Domain: Activity	
1.	Looking around, curious, playing with toys, reading (or other age-appropriate behavior); moves around holding area/treatment room to get toys or to go to parent; may move toward equipment
2.	Not exploring or playing, may look down, fidget with hands, or suck thumb (blanket); may sit close to parent while waiting, or play has a definite manic quality
3.	Moving from toy to parent in unfocused manner, non-activity-derived movements; frenetic/ frenzied movement or play; squirming, moving on table; may push mask away or cling to parent
4.	Actively trying to get away, pushes with feet and arms, may move whole body; in waiting room, running around unfocused, not looking at toys, will not separate from parent, desperate clinging

Domain: Vocalizations	
1.	Reading (nonvocalizing appropriate to activity), asking questions, making comments, babbling, laughing, readily answers questions but may be generally quiet; child too young to talk in social situations or too engrossed in play to respond
2.	Responding to adults but whispers, "baby talk," only head nodding
3.	Quiet, no sounds or responses to adults
4.	Whimpering, moaning, groaning, silently crying
5.	Crying or may be screaming "no"
6.	Crying, screaming loudly, sustained (audible through mask)

Domain: Emotional Expressivity	
1.	Manifestly happy, smiling, or concentrating on play
2.	Neutral, no visible expression on face
3.	Worried (sad) to frightened, sad, worried, or tearful eyes
4.	Distressed, crying, extreme upset, may have wide eyes

Domain: State of Apparent Arousal	
1.	Alert, looks around occasionally, notices or watches what anesthesiologist does (could be relaxed)
2.	Withdrawn, sitting still and quiet, may be sucking on thumb or have face turned into adult
3.	Vigilant, looking quickly all around, may startle to sounds, eyes wide, body tense
4.	Panicked whimpering, may be crying or pushing others away, turns away

Data Collection Instrument | mYPAS Scoring Sheet

DISTRESS & TANTRUMS IN OPTOMETRY EXAMINATIONS

Appendix B: Informed Consent Documents

Optometrist Consent

UNIVERSITY of HOUSTON
A CARNEGIE-DESIGNATED TIER ONE PUBLIC RESEARCH UNIVERSITY

Consent to Take Part in a Human Research Study

Title of research study: Distress & Tantrums in Optometry Examinations

Investigator: Ronal Infante
Project is part of Master's thesis being conducted under the supervision of Dr. Eunsook Kwon.

Key Information:

The following focused information is being presented to assist you in understanding the key elements of this study, as well as the basic reasons why you may or may not wish to consider taking part. This section is only a summary; more detailed information, including how to contact the research team for additional information or questions, follows within the remainder of this document under the "Detailed Information" heading.

What should I know about a research study?

- Someone will explain this research study to you.
- Taking part in the research is voluntary; whether or not you take part is up to you.
- You can choose not to take part.
- You can agree to take part and later change your mind.
- Your decision will not be held against you.
- You can ask all the questions you want before you decide, and can ask questions at any time during the study.

We invite you to take part in a research study about identifying factors that play a role in contributing to pediatric patient distress because you meet the following criteria: any clinical optometrist working with pediatric patients at the University of Houston University Eye Institute.

In general, your participation in the research involves performing a regular, uninterrupted eye exam under the observation of the investigator listed above who will stand behind a 1-way window and take notes on the exam's proceedings.

There are no known risks to this study and there is no personal benefit. However, possible benefit to society may include a better understanding of factors contributing to pediatric patient distress during eye exams. You will not receive compensation for participation.

Consent to Take Part in a Human Research Study

Detailed Information:

The following is more detailed information about this study, in addition to the information listed above.

Why is this research being done?

There is a lack of research that takes into account children's perspectives in eye exams. The study aims to identify and quantify factors that lead to distress by determining how often distress and crying occur in pediatric optometry examinations and to what degree they affect examinations. This knowledge may lead to further research or the development of products, tools, or services that prevent these factors from causing distress in patients.

How long will the research last?

We expect that you will be in this research study for as long as it takes to administer a normal, uninterrupted eye exam.

How many people will be studied?

We expect to enroll about 20 pediatric patients, 20 parents, and 1 - 10 optometrists in this study.

What happens if I say yes, I want to be in this research?

You will administer an eye exam normally, without interruption. The investigator listed above will stand behind a 1-way window and take notes on the exam's proceedings. The duration and time of the exam will be recorded using a stopwatch as well as qualitative field notes detailing procedures, objects, and tools used by the optometrist to conduct the eye exam in order to develop a sequential map of the procedures. Whether you are a student or resident will be noted to gauge whether experience plays a role. Distress, if any, will be assessed using the Modified Yale Preoperative Anxiety Scale (mYPAS) and recorded. Whether or not any distress result in an uncooperative patient that requires the exam to be rescheduled will be recorded. If distress subsides, notes on what was done will be recorded. Any questions the investigator may have relating to procedures, objects, and tools used will be written down and asked after the exam concludes as to not interfere with the exam. The study will last as long as it takes to administer a normal, uninterrupted eye exam. You will not interact with the investigator, only the patients, during the eye exam. The study will take place in the pediatric optometry clinic on the first floor of the UH University Eye Institute in Health Science Building 1. The address is 4901 Calhoun Rd Houston, Texas 77204.

You will not be asked to complete any study-related procedure. The study is purely observational. You will determine the eye exams procedures. You will not be audio or video recorded.

What happens if I do not want to be in this research?

You can choose not to take part in the research and it will not be held against you. Choosing not to take part will involve no penalty or loss of benefit to which you are otherwise entitled.

Consent to Take Part in a Human Research Study

What happens if I say yes, but I change my mind later?

You can leave the research at any time and it will not be held against you.

Any data collected will not be used during the rest of the research or any subsequent work. Data and notes will be permanently deleted.

Is there any way being in this study could be bad for me?

We do not expect any risks related to the research activities. If you choose to take part and undergo a negative event you feel is related to the study, please contact the researcher.

Will I receive anything for being in this study?

No.

Will being in this study help me in any way?

There are no known benefits to you from your taking part in this research. However, possible benefit to society may include a better understanding of factors contributing to pediatric patient distress during eye exams.

What happens to the information collected for the research?

Efforts will be made to keep your personal information private, including research study records, to people who have a need to review this information. Each subject's name will only appear in the consent documents, not the written study materials. A code will appear on study material showing the date and time of the session. There will be no list or key pairing the subject's name to the code number. We cannot promise complete secrecy. Organizations that may inspect and copy your information include the Institutional Review Board (IRB) and other representatives of this organization, as well as collaborating institutions and federal agencies that oversee our research.

We may publish the results of this research. However, unless otherwise detailed in this document, we will keep your name and other identifying information confidential. Published results will only be in the form of aggregate data.

What else do I need to know?

Your information and samples (both identifiable and de-identified) may be used to create products or to deliver services, including some that may be sold and/or make money for others. If this happens, there are no plans to tell you, or to pay you, or to give any compensation to you or your family.

Consent to Take Part in a Human Research Study

Who can I talk to?

If you have questions, concerns, or complaints, or think the research has hurt you, you should talk to the investigator, Ronal Infante, at rinfante@uh.edu or his advisor, Dr. Eunsook Kwon, at ekwon@uh.edu or (713) 743-2396.

This research has been reviewed and approved by the University of Houston Institutional Review Board (IRB). You may also talk to them at (713) 743-9204 or cphs@central.uh.edu if:

- Your questions, concerns, or complaints are not being answered by the research team.
- You cannot reach the research team.
- You want to talk to someone besides the research team.
- You have questions about your rights as a research subject.
- You want to get information or provide input about this research.

Your signature documents your consent to take part in this research.

Signature of subject	Date
Printed name of subject	
Signature of person obtaining consent	Date
Printed name of person obtaining consent	

UNIVERSITY of HOUSTON
A CARNEGIE-DESIGNATED TIER ONE PUBLIC RESEARCH UNIVERSITY

Consent to Take Part in a Human Research Study

Title of research study: Distress & Tantrums in Optometry Examinations

Investigator: Ronal Infante
Project is part of Master's thesis being conducted under the supervision of Dr. Eunsook Kwon.

Key Information:

The following focused information is being presented to assist you in understanding the key elements of this study, as well as the basic reasons why you may or may not wish to consider taking part. This section is only a summary; more detailed information, including how to contact the research team for additional information or questions, follows within the remainder of this document under the "Detailed Information" heading.

What should I know about a research study?

- Someone will explain this research study to you.
- Taking part in the research is voluntary; whether or not you take part is up to you.
- You can choose not to take part.
- You can agree to take part and later change your mind.
- Your decision will not be held against you.
- You can ask all the questions you want before you decide, and can ask questions at any time during the study.

We invite you to take part in a research study about identifying factors that play a role in contributing to pediatric patient distress because you meet the following criteria: a parent of the pediatric patient at the University of Houston University Eye Institute. Only English-speaking subjects will be included.

In general, your participation in the research involves completing a brief, 8 question survey.

There are no known risks to this study and there is no personal benefit. However, possible benefit to society may include a better understanding of factors contributing to pediatric patient distress during eye exams. You will not receive compensation for participation.

Detailed Information:

The following is more detailed information about this study, in addition to the information listed above.

Consent to Take Part in a Human Research Study

Why is this research being done?

There is a lack of research that takes into account children's perspectives in eye exams. The study aims to identify and quantify factors that lead to distress by determining how often distress and crying occur in pediatric optometry examinations and to what degree they affect examinations. This knowledge may lead to further research or the development of products, tools, or services that prevent these factors from causing distress in patients.

How long will the research last?

We expect that you will be in this research study for as long as it takes to administer a normal, uninterrupted eye exam.

How many people will be studied?

We expect to enroll about 20 pediatric patients, 20 parents, and 1 - 10 optometrists in this study.

What happens if I say yes, I want to be in this research?

You will complete a brief, 8 question survey. The study will take place in the pediatric optometry clinic on the first floor of the UH University Eye Institute in Health Science Building 1. The address is 4901 Calhoun Rd Houston, Texas 77204. You will not be asked to complete any study-related procedures beyond taking the survey.

What happens if I do not want to be in this research?

You can choose not to take part in the research and it will not be held against you. Choosing not to take part will involve no penalty or loss of benefit to which you are otherwise entitled. **The quality of care your child will receive will not be influenced by whether or not you choose to participate.**

What happens if I say yes, but I change my mind later?

You can leave the research at any time and it will not be held against you.

Any data collected will not be used during the rest of the research or any subsequent work. Data and notes will be permanently deleted.

Is there any way being in this study could be bad for me?

We do not expect any risks related to the research activities. If you choose to take part and undergo a negative event you feel is related to the study, please contact the researcher.

Will I receive anything for being in this study?

No.

Consent to Take Part in a Human Research Study

Will being in this study help me in any way?

There are no known benefits to you from your taking part in this research. However, possible benefit to society may include a better understanding of factors contributing to pediatric patient distress during eye exams.

What happens to the information collected for the research?

Efforts will be made to keep your personal information private, including research study records, to people who have a need to review this information. We cannot promise complete secrecy. Organizations that may inspect and copy your information include the Institutional Review Board (IRB) and other representatives of this organization, as well as collaborating institutions and federal agencies that oversee our research. Each subject's name will only appear in the consent documents, not the written study materials. A code will appear on study material showing the date and time of the session. There will be no list pairing the subject's name to the assigned code number.

We may publish the results of this research. However, unless otherwise detailed in this document, we will keep your name and other identifying information confidential. Published results will only be in the form of aggregate data.

What else do I need to know?

Your information and samples (both identifiable and de-identified) may be used to create products or to deliver services, including some that may be sold and/or make money for others. If this happens, there are no plans to tell you, or to pay you, or to give any compensation to you or your family.

Who can I talk to?

If you have questions, concerns, or complaints, or think the research has hurt you, you should talk to the investigator, Ronal Infante, at rinfante@uh.edu or his advisor, Dr. Eunsook Kwon, at ekwon@uh.edu or (713) 743-2396.

This research has been reviewed and approved by the University of Houston Institutional Review Board (IRB). You may also talk to them at (713) 743-9204 or cphs@central.uh.edu if:

- Your questions, concerns, or complaints are not being answered by the research team.
- You cannot reach the research team.
- You want to talk to someone besides the research team.
- You have questions about your rights as a research subject.
- You want to get information or provide input about this research.

Consent to Take Part in a Human Research Study

Your signature documents your consent to take part in this research.

Signature of subject	Date
Printed name of subject	
Signature of person obtaining consent	Date
Printed name of person obtaining consent	

UNIVERSITY of HOUSTON
A CARNEGIE-DESIGNATED TIER ONE PUBLIC RESEARCH UNIVERSITY

Parental Permission to Take Part in a Human Research Study

Title of research study: Distress & Tantrums in Optometry Examinations

Investigator: Ronal Infante
Project is part of Master's thesis being conducted under the supervision of Dr. Eunsook Kwon.

Key Information:

The following focused information is being presented to assist you in understanding the key elements of this study, as well as the basic reasons why you may or may not wish to consider taking part. This section is only a summary; more detailed information, including how to contact the research team for additional information or questions, follows within the remainder of this document under the "Detailed Information" heading.

What should I know about a research study?

- Someone will explain this research study to you and your child.
- Taking part in the research is voluntary; whether or not you decide to provide permission for your child to take part is up to you.
- In most cases, your child will also be asked for his/her assent to take part.
- You can choose not to provide permission for your child to take part.
- You can agree to provide permission and later change your mind.
- Your decision will not be held against you or your child.
- You and your child can ask all the questions you want before you decide, and can ask questions at any time during the study.

We invite you to take part in a research study about identifying factors that play a role in contributing to pediatric patient distress because your child meets the following criteria: any pediatric optometry patient between the ages of 0 and 12 years, including those with special needs, learning disabilities, eye coordination problems, Down syndrome, autism, cerebral palsy, or anyone with developmental delays as disclosed or determined by the University of Houston University Eye Institute (UEI). Only English-speaking subjects will be included.

In broad terms, your child's involvement in the research will consist of being observed during their eye exam by the investigator listed above who will stand outside the exam room behind a 1-way window and take notes on the exam's proceedings without interruption. Your child will not be asked to complete any study-related procedure. The study is purely observational.

There are no known risks to this study and there is no personal benefit. However, possible benefit to society may include a better understanding of factors contributing to pediatric patient distress during eye exams. You will not receive compensation for participation.

MOD00002577
UH IRB Approved
2/4/2020 - 12/17/2020

Parental Permission to Take Part in a Human Research Study

Detailed Information:

The following is more detailed information about this study, in addition to the information listed above.

Why is this research being done?

There is a lack of research that takes into account children's perspectives in eye exams. The study aims to identify and quantify factors that lead to distress by determining how often distress and crying occur in pediatric optometry examinations and to what degree they affect examinations. This knowledge may lead to further research or the development of products, tools, or services that prevent these factors from causing distress in patients.

How long will the research last?

We expect that your child will be in this research study for as long as it takes to administer a normal, uninterrupted eye exam.

How many people will be studied?

We expect to enroll about 20 pediatric patients, 20 parents, and 1 - 10 optometrists in this study.

What happens if I say yes, I want to provide permission for my child to be in this research?

Your child will participate in their eye exam normally, without interruption. The investigator listed above will stand behind a 1-way window and take notes on the exam's proceedings. The duration and time of the exam will be recorded using a stopwatch as well as qualitative field notes detailing procedures, objects, and tools used by the optometrist to conduct the eye exam in order to develop a sequential map of the procedures. Signs of distress, if any, will be assessed using a numerical scale called the Modified Yale Preoperative Anxiety Scale (mYPAS) and recorded. Whether or not any distress results in an uncooperative patient that requires the exam to be rescheduled will be recorded. If distress subsides, notes on what was done will be recorded. If the investigator has questions relating to procedures, objects, and tools used, as a result of not being an optometrist themselves, they will be written down and asked to the optometrist after the exam concludes, as to not interfere with the exam. The study will last as long as it takes to administer a normal, uninterrupted eye exam. Your child will not interact with the investigator, only the optometrist performing the exam. The study will take place in the pediatric optometry clinic on the first floor of the UH University Eye Institute in Health Science Building 1. The address is 4901 Calhoun Rd Houston, Texas 77204.

Your child will not be asked to complete any study-related procedure. The study is purely observational. Normal eye exams procedures will be administered by the optometrist and the investigator will not be in the room. Your child will not be audio or video recorded and pictures will not be taken.

Parental Permission to Take Part in a Human Research Study

What happens if I do not want my child to be in this research?

You can choose not to provide permission for your child to take part in the research and it will not be held against you or your child. Choosing not to take part will involve no penalty or loss of benefit to which your child is otherwise entitled. **The quality of care your child will receive will not be influenced by whether or not you choose to participate.**

What happens if I say yes, but I change my mind later?

You can withdraw your permission (and/or your child may withdraw his/her assent) and leave the research at any time and it will not be held against you or your child.

Any data collected will not be used during the rest of the research or any subsequent work. Data and notes will be permanently deleted.

Is there any way being in this study could be bad for my child?

We do not expect any risks related to the research activities. If you choose to provide permission for your child to take part and he/she undergoes a negative event you feel is related to the study, please contact the researcher.

Will I or my child get anything for being in this study?

No.

Will being in this study help my child in any way?

There are no known benefits to your child from his/her taking part in this research. However, possible benefit to society may include a better understanding of factors contributing to pediatric patient distress during eye exams.

What happens to the information collected for the research?

Efforts will be made to keep your child's personal information private, including research study and medical records, to people who have a need to review this information. We cannot promise complete secrecy. Organizations that may inspect and copy your information include the Institutional Review Board (IRB) and other representatives of this organization, as well as collaborating institutions and federal agencies that oversee ours. Each child's name will only appear in the consent documents, not the written study materials. A code will appear on study material showing the date and time of the session. There will be no list pairing the child's name to the assigned code number.

We may publish the results of this research. However, unless otherwise detailed in this document, we will keep your name and other identifying information confidential. Published results will only be in the form of aggregate data.

Parental Permission to Take Part in a Human Research Study

What else do I need to know?

Your child's information and samples (both identifiable and de-identified) may be used to create products or to deliver services, including some that may be sold and/or make money for others. If this happens, there are no plans to tell you, or to pay you, or to give any compensation to you or your family.

Who can I talk to?

If you have questions, concerns, or complaints, or think the research has hurt your child, you should talk to the investigator, Ronal Infante, at rinfante@uh.edu or his advisor, Dr. Eunsook Kwon, at ekwon@uh.edu or (713) 743-2396.

This research has been reviewed and approved by the University of Houston Institutional Review Board (IRB). You may also talk to them at (713) 743-9204 or cphs@central.uh.edu if:

- Your questions, concerns, or complaints are not being answered by the research team.
- You cannot reach the research team.
- You want to talk to someone besides the research team.
- You have questions about your child's rights as a research subject.
- You want to get information or provide input about this research.

Parental Permission to Take Part in a Human Research Study

Your signature documents your permission for the named child to take part in this research.

Printed name of child	
Signature of parent or individual legally authorized to consent for the child	Date
Printed name of parent or individual legally authorized to consent for the child	❑ Parent ❑ Individual legally authorized to consent for the child

Note: Investigators are to ensure that individuals who are not parents can demonstrate their legal authority to consent to the child's general medical care. Contact legal counsel if any questions arise.

My signature below documents that the information in the consent document and any other written information was accurately explained to, and apparently understood by, the subject, and that consent was freely given by the subject.

Signature of witness to consent process	Date
Printed name of person witnessing consent process	

Child Assent

UNIVERSITY of HOUSTON
A CARNEGIE-DESIGNATED TIER ONE PUBLIC RESEARCH UNIVERSITY

ASSENT TO TAKE PART IN A RESEARCH STUDY

PROJECT TITLE: Distress & Tantrums in Optometry Examinations

You are invited to take part in a research study conducted by Ronal Infante a graduate student at the University of Houston.

You can say no if you do not want to take part in this study. Adults cannot make you be in this study if you do not want to. If you agree to take part in the study now, but change your mind about it later, you can stop being in the study, and no one will be mad at you.

WHAT IS RESEARCH?

Research is a way to learn information about something. Researchers study different subjects the way you study English or math as a subject in school.

There are many reasons people choose to be in a research study. Sometimes people want to help researchers learn about ways to help people or make programs better.

You should understand why you would say yes to being a research subject. Take the time you need to decide if you want to be in this study. You can ask Ronal and your optometrist any question you have about the study.

WHY ARE WE DOING THIS RESEARCH?

In our research we want to learn about what causes you stress during your eye exam.

WHAT WILL HAPPEN DURING THE STUDY?

The optometrist will be looking at your eyes to see if they are healthy regardless if you are part of the study or not.

If you do participate in the study, the only thing that will change is that your parent will fill out a survey with details about your mood and when you ate and slept. Then, the researcher will watch your exam from outside of the room and take notes about how you react and the tools that are used. You will not be asked to do anything by the researcher.

This study only occurs today and it will not impact your eye exam.

COULD GOOD THINGS HAPPEN TO ME FROM BEING IN THIS STUDY?

What we learn in this research will not help you now. When we finish the research, we hope we know more about what causes you stress. This may help designers and scientists make tools that help other children later on.

COULD BAD THINGS HAPPEN TO ME FROM BEING IN THIS STUDY?

The optometrist will be looking at your eyes to see if they are healthy regardless if you are part of the study or not.

If you do participate in the study, the only thing that will change is that your parent will fill out a survey with details about your mood and when you ate and slept. Then, the researcher will watch your exam from outside of the room and take notes about how you react and the tools that are used. You will not be asked to do anything by the researcher.

Most likely nothing bad should occur but if you feel super shy or embarrassed, we can stop the study and you can have a normal eye exam where no one takes notes.

DO I HAVE OTHER CHOICES?

You can choose not to take part in this study, and you can decide you no longer want to be in the study at any time. You may choose to not answer any question that you are not comfortable with. If you choose to stop taking part at any time, you will not be penalized.

WHAT IF I HAVE QUESTIONS?

If you have any questions or worries about the research, you can ask Ronal at (713) 409-2283 before, during, or after the research. If you wish to talk to someone else or have questions about your rights as a research subject, call the University of Houston Institutional Review Board at (713) 743-9204.

DOCUMENTATION OF SUBJECT ASSENT

I agree to take part in this study called: Distress & Tantrums in Optometry Examinations.

Signature of minor participant: _____

Date: _____

ANY QUESTIONS REGARDING MY RIGHTS AS A RESEARCH SUBJECT MAY BE ADDRESSED TO THE UNIVERSITY OF HOUSTON INSTITUTIONAL REVIEW BOARD (IRB) AT 713-743-9204. ALL RESEARCH PROJECTS THAT ARE CARRIED OUT BY INVESTIGATORS AT THE UNIVERSITY OF HOUSTON ARE GOVERNED BY REQUIREMENTS OF THE UNIVERSITY AND THE FEDERAL GOVERNMENT.

MOD00002577
UH IRB Approved
2/4/2020 - 12/17/2020

UNIVERSITY of HOUSTON
A CARNEGIE-DESIGNATED TIER ONE PUBLIC RESEARCH UNIVERSITY

Authorization for Use and Disclosure of Protected Health Information for Research Purposes

State and federal medical privacy laws protect the use and release of your personally identifiable health information ("Protected Health Information"). By signing this document, you authorize the Principal Investigator and research team to access, use and/or release your Protected Health Information for the following research study:

Title of Research Protocol: Distress & Tantrums in Optometry Examinations

Name of Principal Investigator: Ronal Infante

This research study is described in full in the associated informed consent document.

The health information that we may use or disclose for this research includes your research record and complete health care records. This may include, for example, medical history, results of examinations, treatment and outcomes, results of lab tests, or other information contained within your health, billing and/or other records at the University Eye Institute.

Special permission is required to release drug, alcohol, and substance abuse records, HIV/ AIDS-related information, genetic information and mental health information. These kinds of records will not be used or disclosed in this study unless a separate section is included below and you specifically allow us to do so by initialing the applicable box (es).

In addition to the UH research team, your Protected Health Information may be used by and/or disclosed to:

- Members and staff of the UH Institutional Review Board (IRB)
- The approved data and safety monitoring or coordinating committee for this study
- The approved data coordinating center for this study; and/or
- Others with oversight of the study or who are required by law to review the quality and safety of the research, such as the U.S. Food and Drug Administration and/or the Health and Human Services Office of Human Research Protections.

In addition to the purpose of the research described in the consent form, your Protected Health Information may be used to:

- Improve the design of future studies;
- Share with business partners of the sponsor;
- File applications with U.S. or foreign government agencies to get approval for new drugs or health care products; or

- As authorized by federal/state medical privacy laws or as otherwise required or authorized by federal or state law.

Please note that:

- The research team will use and protect your information as described in this Authorization; however, once your health information is released by the University of Houston, it may not be protected by the privacy laws and might be shared with others. A member of the research team will be happy to respond to any of your questions regarding this.
- Signing this authorization is voluntary. You are not required to agree to the use or disclosure of your Protected Health Information. Signing this authorization is not a condition for treatment (other than treatment related to this research study), payment, or enrollment or eligibility for health plan benefits. However, if you do not sign the document, you cannot participate in this research study and you may not receive research-related treatment.
- The University of Houston will not condition routine clinical treatment, payment, or enrollment of eligibility for benefits based on whether or not you sign this Authorization.
- You may change your mind and revoke (take back) this Authorization at any time. Before doing so, you may want to ask someone on the research team if canceling will affect your research-related medical treatment. If you cancel your permission, you may no longer participate in the research study. Also, if you cancel, your Protected Health Information that has already been collected, used, and/or disclosed in reliance upon this authorization may continue to be used, and to the extent it has already been disclosed may be subject to redisclosure. In addition, the sponsor and government agencies may continue to look at your medical records to review the quality or safety of the study to the extent authorized/required by law.

Specific Authorizations: [Please initial below]

_____I agree to the release of my child's age.

_____ I agree to the release of my child's eye examination observations.

This Authorization does not have an expiration date. If you revoke this Authorization, you may no longer be allowed to participate in the research described in this Authorization.

To revoke this authorization, please contact the research team to tell them of this decision. They will give you an address so that you can inform the investigator in writing.

You must also notify the Director of the UH Research Integrity and Oversight (RIO) Office to revoke the authorization.

Executive Director, Research Integrity and Oversight (RIO)
University of Houston Division of Research
4302 University Drive, Suite 316
Houston, TX 77204-2015

Signing this form indicates that you have read and/or understand the information in this form, that your questions have been answered to your satisfaction, and that you voluntarily agree to participate in this research study. You will receive a copy of this signed authorization.

MOD00002577
UH IRB Approved
2/4/2020 - 12/17/2020

Signature of Participant (or Participant's Personal Representative)	Date
Printed Name of Participant (or Participant's Personal Representative)	If applicable, a description of the Personal Representative's authority to sign for the Participant

Hello, my name is Ronal Infante. I am not an optometrist. I am a graduate student researcher and designer here at the University of Houston. As part of my thesis, I am leading a study to identify factors that play a role in contributing to patient distress by determining how often signs of distress and crying occur in examinations and to what degree they affect examinations.

[Show Data Collection Instrument]

We will be using these two documents. The parent will take a quick 8-question survey and I will be filling out the observation sheet during the exam from outside the exam room. This study does not collect identifiable personal information and will not interfere with the eye exam. Neither video nor photography of the exam will be collected. The study is completely optional, poses minimal risk, and offers no direct benefits. **The quality of care your child will receive will not be influenced by whether or not you choose to participate.** Your participation will help scientists and designers better understand distress in pediatric optometry patients. If we publish this research, the individual exams will not be discussed, only results from the aggregate data.

Are you and your child interested in participating in the study? [If yes, show Consent Documents]

In order to participate, I need to review a few consent documents with you and record your consent and your child's assent. Please let me know if you have any questions throughout the process. Your optometrist has already given consent to be part of the study if you choose to participate. You may back out at any point during or after the study for any reason and any data collected will be destroyed.

Recruitment Script

DISTRESS & TANTRUMS IN OPTOMETRY EXAMINATIONS

Appendix C: Supplemental Data Analysis Tables – Categorical Factors

Procedure

Case Processing Summary

Procedure		Cases					
		Valid		Missing		Total	
		N	Percent	N	Percent	N	Percent
mYPAS Score	1	12	100.0%	0	0.0%	12	100.0%
	2	12	100.0%	0	0.0%	12	100.0%
	3	11	100.0%	0	0.0%	11	100.0%
	4	9	100.0%	0	0.0%	9	100.0%
	5	7	100.0%	0	0.0%	7	100.0%
	6	9	100.0%	0	0.0%	9	100.0%
	7	3	100.0%	0	0.0%	3	100.0%
	8	8	100.0%	0	0.0%	8	100.0%
	9	6	100.0%	0	0.0%	6	100.0%
	10	12	100.0%	0	0.0%	12	100.0%
	11	10	100.0%	0	0.0%	10	100.0%
	12	11	100.0%	0	0.0%	11	100.0%
	13	6	100.0%	0	0.0%	6	100.0%
	14	11	100.0%	0	0.0%	11	100.0%

Descriptives

Procedure				Statistic	Std. Error
mYPAS Score	1	Mean		30.55556	2.754002
		95% Confidence Interval for Mean	Lower Bound	24.49404	
			Upper Bound	36.61707	
		5% Trimmed Mean		29.89969	
		Median		27.08333	
		Variance		91.014	
		Std. Deviation		9.540142	
		Minimum		22.917	
		Maximum		50.000	
		Range		27.083	
		Interquartile Range		14.062	
		Skewness		1.137	0.637
		Kurtosis		0.107	1.232
	2	Mean		38.88889	6.188318
		95% Confidence Interval for Mean	Lower Bound	25.26849	
			Upper Bound	52.50928	
		5% Trimmed Mean		36.61265	

	Median		31.25000	
	Variance		459.543	
	Std. Deviation		21.436962	
	Minimum		22.917	
	Maximum		95.833	
	Range		72.917	
	Interquartile Range		29.167	
	Skewness		1.916	0.637
	Kurtosis		4.112	1.232
3	Mean		30.49242	3.708447
	95% Confidence Interval for Mean	Lower Bound	22.22949	
		Upper Bound	38.75536	
	5% Trimmed Mean		29.25084	
	Median		22.91667	
	Variance		151.278	
	Std. Deviation		12.299529	
	Minimum		22.917	
	Maximum		60.417	
	Range		37.500	
	Interquartile Range		12.500	
	Skewness		1.831	0.661
	Kurtosis		2.865	1.279
4	Mean		44.72222	6.024481
	95% Confidence Interval for Mean	Lower Bound	30.82974	
		Upper Bound	58.61470	
	5% Trimmed Mean		44.59877	
	Median		45.83333	
	Variance		326.649	
	Std. Deviation		18.073442	
	Minimum		22.917	
	Maximum		68.750	
	Range		45.833	
	Interquartile Range		37.708	
	Skewness		0.073	0.717
	Kurtosis		-1.757	1.400
5	Mean		30.05952	3.458021
	95% Confidence Interval for Mean	Lower Bound	21.59805	
		Upper Bound	38.52100	
	5% Trimmed Mean		29.58003	
	Median		27.08333	
	Variance		83.705	
	Std. Deviation		9.149063	

	Minimum		22.917	
	Maximum		45.833	
	Range		22.917	
	Interquartile Range		16.667	
	Skewness		1.118	0.794
	Kurtosis		-0.203	1.587
6	Mean		39.35185	4.988950
	95% Confidence Interval for Mean	Lower Bound	27.84731	
		Upper Bound	50.85639	
	5% Trimmed Mean		38.97891	
	Median		35.41667	
	Variance		224.007	
	Std. Deviation		14.966849	
	Minimum		22.917	
	Maximum		62.500	
	Range		39.583	
	Interquartile Range		27.083	
	Skewness		0.298	0.717
	Kurtosis		-1.686	1.400
7	Mean		27.77778	4.861111
	95% Confidence Interval for Mean	Lower Bound	6.86210	
		Upper Bound	48.69345	
	5% Trimmed Mean			
	Median		22.91667	
	Variance		70.891	
	Std. Deviation		8.419691	
	Minimum		22.917	
	Maximum		37.500	
	Range		14.583	
	Interquartile Range			
	Skewness		1.732	1.225
	Kurtosis			
8	Mean		29.78125	3.350882
	95% Confidence Interval for Mean	Lower Bound	21.85767	
		Upper Bound	37.70483	
	5% Trimmed Mean		29.03935	
	Median		26.04167	
	Variance		89.827	
	Std. Deviation		9.477724	
	Minimum		22.917	
	Maximum		50.000	
	Range		27.083	

	Interquartile Range		10.979	
	Skewness		1.588	0.752
	Kurtosis		2.600	1.481
9	Mean		51.73611	7.124404
	95% Confidence Interval for Mean	Lower Bound	33.42225	
		Upper Bound	70.04998	
	5% Trimmed Mean		51.69753	
	Median		51.04167	
	Variance		304.543	
	Std. Deviation		17.451155	
	Minimum		27.083	
	Maximum		77.083	
	Range		50.000	
	Interquartile Range		28.125	
	Skewness		0.080	0.845
	Kurtosis		-0.156	1.741
10	Mean		35.41348	2.855815
	95% Confidence Interval for Mean	Lower Bound	29.12787	
		Upper Bound	41.69908	
	5% Trimmed Mean		35.18164	
	Median		36.45833	
	Variance		97.868	
	Std. Deviation		9.892834	
	Minimum		22.917	
	Maximum		52.083	
	Range		29.167	
	Interquartile Range		20.088	
	Skewness		0.058	0.637
	Kurtosis		-1.122	1.232
11	Mean		36.64678	4.201115
	95% Confidence Interval for Mean	Lower Bound	27.14320	
		Upper Bound	46.15036	
	5% Trimmed Mean		36.32050	
	Median		34.58333	
	Variance		176.494	
	Std. Deviation		13.285092	
	Minimum		22.917	
	Maximum		56.250	
	Range		33.333	
	Interquartile Range		26.361	
	Skewness		0.204	0.687
	Kurtosis		-1.969	1.334

12	Mean		78.04293	5.982064
	95% Confidence Interval for Mean	Lower Bound	64.71406	
		Upper Bound	91.37180	
	5% Trimmed Mean		78.49677	
	Median		77.08333	
	Variance		393.636	
	Std. Deviation		19.840262	
	Minimum		47.917	
	Maximum		100.000	
	Range		52.083	
	Interquartile Range		36.111	
	Skewness		-0.169	0.661
	Kurtosis		-1.303	1.279
13	Mean		31.25000	3.765400
	95% Confidence Interval for Mean	Lower Bound	21.57073	
		Upper Bound	40.92927	
	5% Trimmed Mean		31.13426	
	Median		30.20833	
	Variance		85.069	
	Std. Deviation		9.223310	
	Minimum		22.917	
	Maximum		41.667	
	Range		18.750	
	Interquartile Range		17.187	
	Skewness		0.083	0.845
	Kurtosis		-3.098	1.741
14	Mean		42.97559	5.634420
	95% Confidence Interval for Mean	Lower Bound	30.42132	
		Upper Bound	55.52986	
	5% Trimmed Mean		42.19510	
	Median		45.83333	
	Variance		349.214	
	Std. Deviation		18.687256	
	Minimum		22.917	
	Maximum		77.083	
	Range		54.167	
	Interquartile Range		36.042	
	Skewness		0.362	0.661
	Kurtosis		-0.838	1.279

Procedure – Repeated Measures Linear Mixed Model

Type III Tests of Fixed Effects[a]

Source	Numerator df	Denominator df	F	Sig.
Procedure	14	13.081	49.566	0.000

a. Dependent Variable: mYPAS Score.

Estimates of Fixed Effects[a]

Parameter	Estimate	Std. Error	df	t	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
[Procedure=1]	30.555556	2.653469	12.878	11.515	0.000	24.817539	36.293572
[Procedure=2]	38.888889	6.317517	12.288	6.156	0.000	25.159900	52.617878
[Procedure=3]	30.871604	3.959920	10.539	7.796	0.000	22.109153	39.634055
[Procedure=4]	41.898090	6.022214	9.262	6.957	0.000	28.333356	55.462824
[Procedure=5]	30.277181	2.975675	8.072	10.175	0.000	23.425923	37.128438
[Procedure=6]	39.726686	4.204325	10.957	9.449	0.000	30.468569	48.984804
[Procedure=7]	28.838469	3.183395	4.047	9.059	0.001	20.040516	37.636423
[Procedure=8]	28.380417	2.924757	8.805	9.704	0.000	21.741761	35.019073
[Procedure=9]	55.713577	8.124145	5.067	6.858	0.001	34.912780	76.514375
[Procedure=10]	35.413475	2.747859	13.173	12.888	0.000	29.485014	41.341936
[Procedure=11]	37.446807	3.891235	11.518	9.623	0.000	28.928996	45.964619
[Procedure=12]	77.358462	6.205044	10.690	12.467	0.000	63.652726	91.064198
[Procedure=13]	29.927015	2.674404	8.632	11.190	0.000	23.837601	36.016429
[Procedure=14]	42.869939	4.916892	12.708	8.719	0.000	32.222788	53.517090

a. Dependent Variable: mYPAS Score.

Information Criteria[a]

-2 Log Likelihood	991.786
Akaike's Information Criterion (AIC)	1049.786
Hurvich and Tsai's Criterion (AICC)	1067.725
Bozdogan's Criterion (CAIC)	1161.268
Schwarz's Bayesian Criterion (BIC)	1132.268

The information criteria are displayed in smaller-is-better form.

a. Dependent Variable: mYPAS Score.

Univariate Tests[a]

Numerator df	Denominator df	F	Sig.
13	22.383	7.425	0.000

The F tests the effect of Procedure. This test is based on the linearly independent pairwise comparisons among the estimated marginal means.

a. Dependent Variable: mYPAS Score.

Pairwise Comparisons[a]

(I) Procedure		Mean Difference (I-J)	Std. Error	df	Sig.[c]	95% Confidence Interval for Difference[c]	
						Lower Bound	Upper Bound
1	2	-8.333	5.665	13.326	0.165	-20.542	3.876
	3	-0.316	4.326	19.407	0.943	-9.358	8.726
	4	-11.343	6.388	12.630	0.100	-25.185	2.500
	5	0.278	3.925	18.728	0.944	-7.944	8.501
	6	-9.171	4.938	18.858	0.079	-19.511	1.169
	7	1.717	4.136	10.196	0.687	-7.474	10.908
	8	2.175	3.944	20.177	0.587	-6.046	10.397
	9	-25.158*	8.544	6.149	0.025	-45.942	-4.375
	10	-4.858	3.819	25.309	0.215	-12.718	3.002
	11	-6.891	4.709	20.265	0.159	-16.706	2.924
	12	-46.803*	6.748	14.351	0.000	-61.243	-32.362
	13	0.629	3.767	20.926	0.869	-7.208	8.465
	14	-12.314*	5.587	19.542	0.040	-23.986	-0.642
2	1	8.333	5.665	13.326	0.165	-3.876	20.542
	3	8.017	5.837	17.815	0.187	-4.255	20.290
	4	-3.009	7.922	22.956	0.708	-19.399	13.381
	5	8.612	6.791	17.592	0.221	-5.679	22.902
	6	-0.838	7.469	21.999	0.912	-16.327	14.651
	7	10.050	7.047	16.773	0.172	-4.833	24.934
	8	10.508	6.945	17.307	0.148	-4.124	25.141
	9	-16.825	10.279	10.834	0.130	-39.490	5.841
	10	3.475	6.886	16.515	0.620	-11.084	18.035
	11	1.442	7.418	19.513	0.848	-14.056	16.940
	12	-38.470*	8.854	21.140	0.000	-56.875	-20.064
	13	8.962	6.860	16.549	0.209	-5.542	23.465
	14	-3.981	8.005	23.354	0.624	-20.527	12.565
3	1	0.316	4.326	19.407	0.943	-8.726	9.358
	2	-8.017	5.837	17.815	0.187	-20.290	4.255
	4	-11.026	5.819	13.969	0.079	-23.510	1.457
	5	0.594	4.571	19.092	0.898	-8.969	10.158
	6	-8.855	5.558	22.429	0.125	-20.369	2.659
	7	2.033	5.029	14.375	0.692	-8.726	12.792
	8	2.491	4.890	19.189	0.616	-7.737	12.719

	9	-24.842*	9.018	7.405	0.027	-45.932	-3.752
	10	-4.542	4.813	18.883	0.357	-14.619	5.535
	11	-6.575	5.548	20.858	0.249	-18.118	4.967
	12	-46.487*	7.359	17.147	0.000	-62.003	-30.971
	13	0.945	4.778	18.266	0.845	-9.083	10.972
	14	-11.998	6.313	22.884	0.070	-25.061	1.064
4	1	11.343	6.388	12.630	0.100	-2.500	25.185
	2	3.009	7.922	22.956	0.708	-13.381	19.399
	3	11.026	5.819	13.969	0.079	-1.457	23.510
	5	11.621	5.802	11.414	0.069	-1.092	24.334
	6	2.171	6.735	16.196	0.751	-12.092	16.435
	7	13.060	6.678	13.064	0.072	-1.360	27.479
	8	13.518	6.620	13.448	0.061	-0.735	27.771
	9	-13.815	10.056	10.264	0.199	-36.144	8.514
	10	6.485	6.602	13.018	0.344	-7.777	20.746
	11	4.451	7.161	16.030	0.543	-10.727	19.629
	12	-35.460*	8.641	19.068	0.001	-53.543	-17.378
	13	11.971	6.588	12.835	0.093	-2.281	26.223
	14	-0.972	7.774	19.424	0.902	-17.218	15.274
5	1	-0.278	3.925	18.728	0.944	-8.501	7.944
	2	-8.612	6.791	17.592	0.221	-22.902	5.679
	3	-0.594	4.571	19.092	0.898	-10.158	8.969
	4	-11.621	5.802	11.414	0.069	-24.334	1.092
	6	-9.450*	4.322	14.373	0.046	-18.697	-0.202
	7	1.439	4.162	9.819	0.737	-7.858	10.735
	8	1.897	4.053	16.367	0.646	-6.680	10.473
	9	-25.436*	8.583	6.444	0.023	-46.092	-4.781
	10	-5.136	4.022	19.287	0.217	-13.547	3.274
	11	-7.170	4.885	19.543	0.158	-17.375	3.036
	12	-47.081*	6.875	15.150	0.000	-61.722	-32.441
	13	0.350	3.999	16.388	0.931	-8.111	8.811
	14	-12.593*	5.746	19.584	0.041	-24.595	-0.591
6	1	9.171	4.938	18.858	0.079	-1.169	19.511
	2	0.838	7.469	21.999	0.912	-14.651	16.327
	3	8.855	5.558	22.429	0.125	-2.659	20.369
	4	-2.171	6.735	16.196	0.751	-16.435	12.092
	5	9.450*	4.322	14.373	0.046	0.202	18.697
	7	10.888*	4.524	12.089	0.033	1.038	20.738
	8	11.346*	4.761	16.390	0.030	1.273	21.420
	9	-15.987	8.941	7.894	0.112	-36.652	4.678
	10	4.313	4.944	19.159	0.394	-6.028	14.655
	11	2.280	5.688	22.568	0.692	-9.499	14.059
	12	-37.632*	7.473	19.245	0.000	-53.259	-22.005
	13	9.800	4.978	17.794	0.065	-0.667	20.266

	14	-3.143	6.465	23.504	0.631	-16.502	10.215
7	1	-1.717	4.136	10.196	0.687	-10.908	7.474
	2	-10.050	7.047	16.773	0.172	-24.934	4.833
	3	-2.033	5.029	14.375	0.692	-12.792	8.726
	4	-13.060	6.678	13.064	0.072	-27.479	1.360
	5	-1.439	4.162	9.819	0.737	-10.735	7.858
	6	-10.888*	4.524	12.089	0.033	-20.738	-1.038
	8	0.458	3.840	8.952	0.908	-8.236	9.152
	9	-26.875*	8.523	6.520	0.018	-47.333	-6.417
	10	-6.575	4.102	10.446	0.139	-15.663	2.513
	11	-8.608	4.977	14.465	0.105	-19.251	2.035
	12	-48.520*	6.948	14.847	0.000	-63.342	-33.698
	13	-1.089	4.151	9.438	0.799	-10.413	8.236
	14	-14.031*	5.853	16.492	0.029	-26.409	-1.654
8	1	-2.175	3.944	20.177	0.587	-10.397	6.046
	2	-10.508	6.945	17.307	0.148	-25.141	4.124
	3	-2.491	4.890	19.189	0.616	-12.719	7.737
	4	-13.518	6.620	13.448	0.061	-27.771	0.735
	5	-1.897	4.053	16.367	0.646	-10.473	6.680
	6	-11.346*	4.761	16.390	0.030	-21.420	-1.273
	7	-0.458	3.840	8.952	0.908	-9.152	8.236
	9	-27.333*	7.802	5.582	0.014	-46.777	-7.890
	10	-7.033	3.667	19.272	0.070	-14.701	0.635
	11	-9.066	4.704	20.236	0.068	-18.872	0.739
	12	-48.978*	6.776	15.367	0.000	-63.392	-34.565
	13	-1.547	3.941	17.092	0.700	-9.859	6.765
	14	-14.490*	5.706	19.680	0.020	-26.404	-2.575
9	1	25.158*	8.544	6.149	0.025	4.375	45.942
	2	16.825	10.279	10.834	0.130	-5.841	39.490
	3	24.842*	9.018	7.405	0.027	3.752	45.932
	4	13.815	10.056	10.264	0.199	-8.514	36.144
	5	25.436*	8.583	6.444	0.023	4.781	46.092
	6	15.987	8.941	7.894	0.112	-4.678	36.652
	7	26.875*	8.523	6.520	0.018	6.417	47.333
	8	27.333*	7.802	5.582	0.014	7.890	46.777
	10	20.300*	7.644	5.275	0.043	0.955	39.645
	11	18.267	8.499	7.159	0.068	-1.740	38.274
	12	-21.645	9.901	10.908	0.052	-43.460	0.170
	13	25.787*	8.495	6.197	0.022	5.159	46.414
	14	12.844	9.443	9.031	0.207	-8.508	34.195
10	1	4.858	3.819	25.309	0.215	-3.002	12.718
	2	-3.475	6.886	16.515	0.620	-18.035	11.084
	3	4.542	4.813	18.883	0.357	-5.535	14.619
	4	-6.485	6.602	13.018	0.344	-20.746	7.777

	5	5.136	4.022	19.287	0.217	-3.274	13.547
	6	-4.313	4.944	19.159	0.394	-14.655	6.028
	7	6.575	4.102	10.446	0.139	-2.513	15.663
	8	7.033	3.667	19.272	0.070	-0.635	14.701
	9	-20.300*	7.644	5.275	0.043	-39.645	-0.955
	11	-2.033	3.714	16.327	0.592	-9.895	5.828
	12	-41.945*	6.292	14.156	0.000	-55.426	-28.464
	13	5.486	3.704	21.261	0.153	-2.211	13.184
	14	-7.456	5.543	19.755	0.194	-19.029	4.116
11	1	6.891	4.709	20.265	0.159	-2.924	16.706
	2	-1.442	7.418	19.513	0.848	-16.940	14.056
	3	6.575	5.548	20.858	0.249	-4.967	18.118
	4	-4.451	7.161	16.030	0.543	-19.629	10.727
	5	7.170	4.885	19.543	0.158	-3.036	17.375
	6	-2.280	5.688	22.568	0.692	-14.059	9.499
	7	8.608	4.977	14.465	0.105	-2.035	19.251
	8	9.066	4.704	20.236	0.068	-0.739	18.872
	9	-18.267	8.499	7.159	0.068	-38.274	1.740
	10	2.033	3.714	16.327	0.592	-5.828	9.895
	12	-39.912*	5.873	15.724	0.000	-52.380	-27.443
	13	7.520	4.403	19.177	0.104	-1.690	16.730
	14	-5.423	6.030	23.381	0.378	-17.886	7.040
12	1	46.803*	6.748	14.351	0.000	32.362	61.243
	2	38.470*	8.854	21.140	0.000	20.064	56.875
	3	46.487*	7.359	17.147	0.000	30.971	62.003
	4	35.460*	8.641	19.068	0.001	17.378	53.543
	5	47.081*	6.875	15.150	0.000	32.441	61.722
	6	37.632*	7.473	19.245	0.000	22.005	53.259
	7	48.520*	6.948	14.847	0.000	33.698	63.342
	8	48.978*	6.776	15.367	0.000	34.565	63.392
	9	21.645	9.901	10.908	0.052	-0.170	43.460
	10	41.945*	6.292	14.156	0.000	28.464	55.426
	11	39.912*	5.873	15.724	0.000	27.443	52.380
	13	47.431*	5.828	12.329	0.000	34.771	60.092
	14	34.489*	7.127	21.673	0.000	19.695	49.282
13	1	-0.629	3.767	20.926	0.869	-8.465	7.208
	2	-8.962	6.860	16.549	0.209	-23.465	5.542
	3	-0.945	4.778	18.266	0.845	-10.972	9.083
	4	-11.971	6.588	12.835	0.093	-26.223	2.281
	5	-0.350	3.999	16.388	0.931	-8.811	8.111
	6	-9.800	4.978	17.794	0.065	-20.266	0.667
	7	1.089	4.151	9.438	0.799	-8.236	10.413
	8	1.547	3.941	17.092	0.700	-6.765	9.859
	9	-25.787*	8.495	6.197	0.022	-46.414	-5.159

	10	-5.486	3.704	21.261	0.153	-13.184	2.211
	11	-7.520	4.403	19.177	0.104	-16.730	1.690
	12	-47.431*	5.828	12.329	0.000	-60.092	-34.771
	14	-12.943*	4.692	13.531	0.016	-23.039	-2.847
14	1	12.314*	5.587	19.542	0.040	0.642	23.986
	2	3.981	8.005	23.354	0.624	-12.565	20.527
	3	11.998	6.313	22.884	0.070	-1.064	25.061
	4	0.972	7.774	19.424	0.902	-15.274	17.218
	5	12.593*	5.746	19.584	0.041	0.591	24.595
	6	3.143	6.465	23.504	0.631	-10.215	16.502
	7	14.031*	5.853	16.492	0.029	1.654	26.409
	8	14.490*	5.706	19.680	0.020	2.575	26.404
	9	-12.844	9.443	9.031	0.207	-34.195	8.508
	10	7.456	5.543	19.755	0.194	-4.116	19.029
	11	5.423	6.030	23.381	0.378	-7.040	17.886
	12	-34.489*	7.127	21.673	0.000	-49.282	-19.695
	13	12.943*	4.692	13.531	0.016	2.847	23.039

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

a. Dependent Variable: mYPAS Score.

c. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Age Group

Case Processing Summary

Age Group		Cases					
		Valid		Missing		Total	
		N	Percent	N	Percent	N	Percent
mYPAS Score	< 4	47	100.0%	0	0.0%	47	100.0%
	4 - 7	37	100.0%	0	0.0%	37	100.0%
	> 7	43	100.0%	0	0.0%	43	100.0%

Descriptives

Age Group				Statistic	Std. Error
mYPAS Score	< 4	Mean		44.09023	3.066069
		95% Confidence Interval for Mean	Lower Bound	37.91856	
			Upper Bound	50.26191	
		5% Trimmed Mean		42.19492	
		Median		37.50000	
		Variance		441.837	
		Std. Deviation		21.019910	

	Minimum		22.917	
	Maximum		100.000	
	Range		77.083	
	Interquartile Range		29.167	
	Skewness		1.130	0.347
	Kurtosis		0.851	0.681
4 - 7	Mean		38.49029	3.460224
	95% Confidence Interval for Mean	Lower Bound	31.47263	
		Upper Bound	45.50795	
	5% Trimmed Mean		35.93828	
	Median		29.16667	
	Variance		443.006	
	Std. Deviation		21.047718	
	Minimum		22.917	
	Maximum		100.000	
	Range		77.083	
	Interquartile Range		25.521	
	Skewness		1.682	0.388
	Kurtosis		2.343	0.759
> 7	Mean		36.78105	2.308778
	95% Confidence Interval for Mean	Lower Bound	32.12174	
		Upper Bound	41.44035	
	5% Trimmed Mean		35.36341	
	Median		35.41667	
	Variance		229.210	
	Std. Deviation		15.139667	
	Minimum		22.917	
	Maximum		77.083	
	Range		54.167	
	Interquartile Range		22.917	
	Skewness		0.940	0.361
	Kurtosis		0.484	0.709

Age Group – Repeated Measures Linear Mixed Model

Type III Tests of Fixed Effects[a]

Source	Numerator df	Denominator df	F	Sig.
Age Group	3	4.842	1343.667	0.000

a. Dependent Variable: mYPAS Score.

Estimates of Fixed Effects[a]

Parameter	Estimate	Std. Error	df	t	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
< 4	37.062706	0.684977	4.591	54.108	0.000	35.253685	38.871728
4 - 7	22.090405	1.147220	5.262	19.256	0.000	19.184975	24.995835
> 7	22.494886	0.831122	4.754	27.066	0.000	20.324672	24.665100

a. Dependent Variable: mYPAS Score.

Information Criteria[a]

-2 Log Likelihood	1026.486
Akaike's Information Criterion (AIC)	1062.486
Hurvich and Tsai's Criterion (AICC)	1068.819
Bozdogan's Criterion (CAIC)	1131.681
Schwarz's Bayesian Criterion (BIC)	1113.681

The information criteria are displayed in smaller-is-better form.

a. Dependent Variable: mYPAS Score.

Univariate Tests[a]

Numerator df	Denominator df	F	Sig.
2	4.910	117.313	0.000

The F tests the effect of Age Group. This test is based on the linearly independent pairwise comparisons among the estimated marginal means.

a. Dependent Variable: mYPAS Score.

Pairwise Comparisons[a]

(I) Age Group		Mean Difference (I-J)	Std. Error	df	Sig.[c]	95% Confidence Interval for Difference[c]	
						Lower Bound	Upper Bound
< 4	4 - 7	14.972*	1.336	5.073	0.000	11.552	18.392
	> 7	14.568*	1.077	4.687	0.000	11.743	17.393
4 - 7	< 4	-14.972*	1.336	5.073	0.000	-18.392	-11.552
	> 7	-0.404	1.417	5.079	0.787	-4.029	3.220
> 7	< 4	-14.568*	1.077	4.687	0.000	-17.393	-11.743
	4 - 7	0.404	1.417	5.079	0.787	-3.220	4.029

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

a. Dependent Variable: mYPAS Score.

c. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Optometrist Type

Case Processing Summary

Optometrist type		Cases					
		Valid		Missing		Total	
		N	Percent	N	Percent	N	Percent
mYPAS Score	Student	85	100.0%	0	0.0%	85	100.0%
	Resident	42	100.0%	0	0.0%	42	100.0%

Descriptives

Optometrist type				Statistic	Std. Error
mYPAS Score	Student	Mean		43.02237	2.229844
		95% Confidence Interval for Mean	Lower Bound	38.58808	
			Upper Bound	47.45666	
		5% Trimmed Mean		41.10057	
		Median		37.50000	
		Variance		422.637	
		Std. Deviation		20.558149	
		Minimum		22.917	
		Maximum		100.000	
		Range		77.083	
		Interquartile Range		31.250	
		Skewness		1.036	0.261
		Kurtosis		0.622	0.517
	Resident	Mean		33.83488	2.329099
		95% Confidence Interval for Mean	Lower Bound	29.13116	
			Upper Bound	38.53859	
		5% Trimmed Mean		31.72460	
		Median		27.08333	
		Variance		227.838	
		Std. Deviation		15.094289	
		Minimum		22.917	
		Maximum		100.000	
		Range		77.083	
		Interquartile Range		22.917	
		Skewness		2.479	0.365
		Kurtosis		8.270	0.717

Optometrist Type – Repeated Measures Linear Mixed Model

Type III Tests of Fixed Effects[a]

Source	Numerator df	Denominator df	F	Sig.
Optometrist Type	2	32.935	195.705	0.000

a. Dependent Variable: mYPAS Score.

Estimates of Fixed Effects[a]

Parameter	Estimate	Std. Error	df	t	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Student	25.442698	1.589278	35.346	16.009	0.000	22.217423	28.667974
Resident	27.542408	2.369388	30.848	11.624	0.000	22.709045	32.375770

a. Dependent Variable: mYPAS Score.

Information Criteria[a]

-2 Log Likelihood	1033.739
Akaike's Information Criterion (AIC)	1067.739
Hurvich and Tsai's Criterion (AICC)	1073.354
Bozdogan's Criterion (CAIC)	1133.090
Schwarz's Bayesian Criterion (BIC)	1116.090

The information criteria are displayed in smaller-is-better form.

a. Dependent Variable: mYPAS Score.

Univariate Tests[a]

Numerator df	Denominator df	F	Sig.
1	34.872	0.542	0.467

The F tests the effect of Optometrist type. This test is based on the linearly independent pairwise comparisons among the estimated marginal means.

a. Dependent Variable: mYPAS Score.

Exam Type

Case Processing Summary

Exam Type		Cases					
		Valid		Missing		Total	
		N	Percent	N	Percent	N	Percent
mYPAS Score	New	63	100.0%	0	0.0%	63	100.0%
	Yearly	64	100.0%	0	0.0%	64	100.0%

Descriptives

Exam Type				Statistic	Std. Error
mYPAS Score	New	Mean		44.01333	2.594313
		95% Confidence Interval for Mean	Lower Bound	38.82737	
			Upper Bound	49.19929	
		5% Trimmed Mean		42.08602	
		Median		41.66667	
		Variance		424.019	
		Std. Deviation		20.591720	
		Minimum		22.917	
		Maximum		100.000	
		Range		77.083	
		Interquartile Range		23.438	
		Skewness		1.214	0.302
		Kurtosis		1.180	0.595
	Yearly	Mean		36.01760	2.164880
		95% Confidence Interval for Mean	Lower Bound	31.69144	
			Upper Bound	40.34377	
		5% Trimmed Mean		34.08061	
		Median		29.16667	
		Variance		299.949	
		Std. Deviation		17.319041	
		Minimum		22.917	
		Maximum		100.000	
		Range		77.083	
		Interquartile Range		22.917	
		Skewness		1.533	0.299
		Kurtosis		2.185	0.590

Exam Type – Repeated Measures Linear Mixed Model

Type III Tests of Fixed Effects[a]

Source	Numerator df	Denominator df	F	Sig.
Exam Type	2	35.507	314.300	0.000

a. Dependent Variable: mYPAS Score.

Estimates of Fixed Effects[a]

Parameter	Estimate	Std. Error	df	t	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
New	32.629026	1.705777	37.807	19.129	0.000	29.175282	36.082771
Yearly	25.757004	1.589154	33.485	16.208	0.000	22.525626	28.988382

a. Dependent Variable: mYPAS Score.

Information Criteria[a]

-2 Log Likelihood	1028.862
Akaike's Information Criterion (AIC)	1062.862
Hurvich and Tsai's Criterion (AICC)	1068.476
Bozdogan's Criterion (CAIC)	1128.213
Schwarz's Bayesian Criterion (BIC)	1111.213

The information criteria are displayed in smaller-is-better form.

a. Dependent Variable: mYPAS Score.

Univariate Tests[a]

Numerator df	Denominator df	F	Sig.
1	37.988	8.689	0.005

The F tests the effect of Exam Type. This test is based on the linearly independent pairwise comparisons among the estimated marginal means.

a. Dependent Variable: mYPAS Score.

Exam Time

Case Processing Summary

Exam Time		Cases					
		Valid		Missing		Total	
		N	Percent	N	Percent	N	Percent
mYPAS Score	Morning	41	100.0%	0	0.0%	41	100.0%
	Afternoon	86	100.0%	0	0.0%	86	100.0%

Descriptives

Exam Time				Statistic	Std. Error
mYPAS Score	Morning	Mean		44.00654	3.252646
		95% Confidence Interval for Mean	Lower Bound	37.43269	
			Upper Bound	50.58038	
		5% Trimmed Mean		42.07309	
		Median		43.09896	
		Variance		433.768	

	Std. Deviation		20.827099	
	Minimum		22.917	
	Maximum		100.000	
	Range		77.083	
	Interquartile Range		23.177	
	Skewness		1.320	0.369
	Kurtosis		1.533	0.724
Afternoon	Mean		38.06626	1.987831
	95% Confidence Interval for Mean	Lower Bound	34.11392	
		Upper Bound	42.01860	
	5% Trimmed Mean		36.13736	
	Median		33.33333	
	Variance		339.827	
	Std. Deviation		18.434386	
	Minimum		22.917	
	Maximum		100.000	
	Range		77.083	
	Interquartile Range		26.231	
	Skewness		1.376	0.260
	Kurtosis		1.611	0.514

Exam Time – Repeated Measures Linear Mixed Model

Type III Tests of Fixed Effects[a]

Source	Numerator df	Denominator df	F	Sig.
ExamTime	2	40.524	264.857	0.000

a. Dependent Variable: mYPAS Score.

Estimates of Fixed Effects[a]

Parameter	Estimate	Std. Error	df	t	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Morning	32.926000	2.242241	41.470	14.684	0.000	28.399262	37.452739
Afternoon	25.291597	1.427100	39.621	17.722	0.000	22.406462	28.176733

a. Dependent Variable: mYPAS Score.

Information Criteria[a]

-2 Log Likelihood	1027.454
Akaike's Information Criterion (AIC)	1061.454
Hurvich and Tsai's Criterion (AICC)	1067.069

Bozdogan's Criterion (CAIC)	1126.805
Schwarz's Bayesian Criterion (BIC)	1109.805

The information criteria are displayed in smaller-is-better form.

a. Dependent Variable: mYPAS Score.

Univariate Tests[a]

Numerator df	Denominator df	F	Sig.
1	42.248	8.251	0.006

The F tests the effect of Exam Time. This test is based on the linearly independent pairwise comparisons among the estimated marginal means.

a. Dependent Variable: mYPAS Score.

Normal Sleep Amount

Case Processing Summary

Normal Amount of Sleep		Cases					
		Valid		Missing		Total	
		N	Percent	N	Percent	N	Percent
mYPAS Score	ERR	13	100.0%	0	0.0%	13	100.0%
	No	37	100.0%	0	0.0%	37	100.0%
	Yes	77	100.0%	0	0.0%	77	100.0%

Descriptives

Normal Amount of Sleep				Statistic	Std. Error
mYPAS Score	ERR	Mean		43.59207	6.179534
		95% Confidence Interval for Mean	Lower Bound	30.12803	
			Upper Bound	57.05612	
		5% Trimmed Mean		41.60693	
		Median		37.50000	
		Variance		496.426	
		Std. Deviation		22.280628	
		Minimum		22.917	
		Maximum		100.000	
		Range		77.083	
		Interquartile Range		33.333	
		Skewness		1.422	0.616
		Kurtosis		2.343	1.191
	No	Mean		37.45392	3.089817
		95% Confidence Interval for Mean	Lower Bound	31.18748	
			Upper Bound	43.72036	
		5% Trimmed Mean		35.37172	

		Median		35.41667	
		Variance		353.238	
		Std. Deviation		18.794622	
		Minimum		22.917	
		Maximum		100.000	
		Range		77.083	
		Interquartile Range		22.917	
		Skewness		1.604	0.388
		Kurtosis		2.556	0.759
	Yes	Mean		40.59058	2.191591
		95% Confidence Interval for Mean	Lower Bound	36.22565	
			Upper Bound	44.95551	
		5% Trimmed Mean		38.60293	
		Median		33.33333	
		Variance		369.837	
		Std. Deviation		19.231137	
		Minimum		22.917	
		Maximum		100.000	
		Range		77.083	
		Interquartile Range		27.083	
		Skewness		1.279	0.274
		Kurtosis		1.415	0.541

Normal Sleep Amount – Repeated Measures Linear Mixed Model

Type III Tests of Fixed Effects[a]

Source	Numerator df	Denominator df	F	Sig.
Normal Sleep	3	31.151	139.343	0.000

a. Dependent Variable: mYPAS Score.

Estimates of Fixed Effects[a]

Parameter	Estimate	Std. Error	df	t	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
ERR	24.699517	3.801890	23.687	6.497	0.000	16.847309	32.551726
No	25.650152	2.684907	34.849	9.553	0.000	20.198658	31.101645
Yes	27.331548	1.620247	39.938	16.869	0.000	24.056747	30.606349

a. Dependent Variable: mYPAS Score.

Information Criteria[a]

-2 Log Likelihood	1033.672
Akaike's Information Criterion (AIC)	1069.672
Hurvich and Tsai's Criterion (AICC)	1076.005
Bozdogan's Criterion (CAIC)	1138.867
Schwarz's Bayesian Criterion (BIC)	1120.867

The information criteria are displayed in smaller-is-better form.

a. Dependent Variable: mYPAS Score.

Univariate Tests[a]

Numerator df	Denominator df	F	Sig.
2	32.199	0.289	0.751

The F tests the effect of Normal Amount of Sleep. This test is based on the linearly independent pairwise comparisons among the estimated marginal means.
a. Dependent Variable: mYPAS Score.

Child's Mood

Case Processing Summary

Child's Mood		Cases					
		Valid		Missing		Total	
		N	Percent	N	Percent	N	Percent
mYPAS Score	3	9	100.0%	0	0.0%	9	100.0%
	4	16	100.0%	0	0.0%	16	100.0%
	5	102	100.0%	0	0.0%	102	100.0%

Descriptives

Child's Mood				Statistic	Std. Error
mYPAS Score	3	Mean		50.39063	7.954558
		95% Confidence Interval for Mean	Lower Bound	32.04738	
			Upper Bound	68.73387	
		5% Trimmed Mean		49.16088	
		Median		50.00000	
		Variance		569.475	
		Std. Deviation		23.863675	
		Minimum		22.917	
		Maximum		100.000	
		Range		77.083	
		Interquartile Range		31.250	
		Skewness		0.998	0.717
		Kurtosis		1.492	1.400

4	Mean		35.66406	4.407502
	95% Confidence Interval for Mean	Lower Bound	26.26969	
		Upper Bound	45.05843	
	5% Trimmed Mean		34.02488	
	Median		27.08333	
	Variance		310.817	
	Std. Deviation		17.630010	
	Minimum		22.917	
	Maximum		77.917	
	Range		55.000	
	Interquartile Range		22.135	
	Skewness		1.387	0.564
	Kurtosis		0.866	1.091
5	Mean		39.74339	1.887910
	95% Confidence Interval for Mean	Lower Bound	35.99829	
		Upper Bound	43.48850	
	5% Trimmed Mean		37.65061	
	Median		35.41667	
	Variance		363.549	
	Std. Deviation		19.066960	
	Minimum		22.917	
	Maximum		100.000	
	Range		77.083	
	Interquartile Range		27.083	
	Skewness		1.408	0.239
	Kurtosis		1.836	0.474

Child's Mood – Repeated Measures Linear Mixed Model

Type III Tests of Fixed Effects[a]

Source	Numerator df	Denominator df	F	Sig.
Child Mood	3	15.779	210.672	0.000

a. Dependent Variable: mYPAS Score.

Estimates of Fixed Effects[a]

Parameter	Estimate	Std. Error	df	t	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
[Child Mood=3]	44.255631	4.258874	10.654	10.391	0.000	34.844646	53.666616
[Child Mood=4]	23.054571	3.480207	19.630	6.624	0.000	15.786198	30.322945

[Child Mood=5]	26.126585	1.192321	24.003	21.912	0.000	23.665774	28.587396

a. Dependent Variable: mYPAS Score.

Information Criteria[a]

-2 Log Likelihood	1028.543
Akaike's Information Criterion (AIC)	1064.543
Hurvich and Tsai's Criterion (AICC)	1070.877
Bozdogan's Criterion (CAIC)	1133.739
Schwarz's Bayesian Criterion (BIC)	1115.739

The information criteria are displayed in smaller-is-better form.

a. Dependent Variable: mYPAS Score.

Univariate Tests[a]

Numerator df	Denominator df	F	Sig.
2	14.820	9.119	0.003

The F tests the effect of Child's Mood. This test is based on the linearly independent pairwise comparisons among the estimated marginal means.

a. Dependent Variable: mYPAS Score.

Pairwise Comparisons[a]

(I) Child's Mood		Mean Difference (I-J)	Std. Error	df	Sig.[c]	95% Confidence Interval for Difference[c]	
						Lower Bound	Upper Bound
3	4	21.201*	5.500	13.796	0.002	9.388	33.014
	5	18.129*	4.423	11.316	0.002	8.428	27.830
4	3	-21.201*	5.500	13.796	0.002	-33.014	-9.388
	5	-3.072	3.679	20.676	0.413	-10.730	4.586
5	3	-18.129*	4.423	11.316	0.002	-27.830	-8.428
	4	3.072	3.679	20.676	0.413	-4.586	10.730

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

a. Dependent Variable: mYPAS Score.

c. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Parent's Mood

Case Processing Summary

Parent's Mood		Cases					
		Valid		Missing		Total	
		N	Percent	N	Percent	N	Percent
mYPAS Score	3	25	100.0%	0	0.0%	25	100.0%
	4	12	100.0%	0	0.0%	12	100.0%

	5		90	100.0%	0	0.0%	90	100.0%

Descriptives

Parent's Mood				Statistic	Std. Error
mYPAS Score	3	Mean		40.96563	4.176769
		95% Confidence Interval for Mean	Lower Bound	32.34520	
			Upper Bound	49.58605	
		5% Trimmed Mean		38.93403	
		Median		33.33333	
		Variance		436.135	
		Std. Deviation		20.883844	
		Minimum		22.917	
		Maximum		100.000	
		Range		77.083	
		Interquartile Range		31.250	
		Skewness		1.213	0.464
		Kurtosis		1.127	0.902
	4	Mean		33.33333	6.159915
		95% Confidence Interval for Mean	Lower Bound	19.77545	
			Upper Bound	46.89121	
		5% Trimmed Mean		30.20833	
		Median		29.16667	
		Variance		455.335	
		Std. Deviation		21.338571	
		Minimum		22.917	
		Maximum		100.000	
		Range		77.083	
		Interquartile Range		6.250	
		Skewness		3.269	0.637
		Kurtosis		11.018	1.232
	5	Mean		40.59807	1.972057
		95% Confidence Interval for Mean	Lower Bound	36.67963	
			Upper Bound	44.51650	
		5% Trimmed Mean		38.75608	
		Median		37.50000	
		Variance		350.011	
		Std. Deviation		18.708574	
		Minimum		22.917	
		Maximum		100.000	
		Range		77.083	
		Interquartile Range		27.083	
		Skewness		1.220	0.254

Kurtosis	1.397	0.503

Parent's Mood – Repeated Measures Linear Mixed Model

Type III Tests of Fixed Effects[a]

Source	Numerator df	Denominator df	F	Sig.
Parent Mood	3	24.512	160.553	0.000

a. Dependent Variable: mYPAS Score.

Estimates of Fixed Effects[a]

Parameter	Estimate	Std. Error	df	t	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
[Parent Mood=3]	28.880824	3.407360	21.973	8.476	0.000	21.813896	35.947753
[Parent Mood=4]	21.061144	3.482300	19.511	6.048	0.000	13.785507	28.336780
[Parent Mood=5]	27.830574	1.440554	40.330	19.319	0.000	24.919848	30.741300

a. Dependent Variable: mYPAS Score.

Information Criteria[a]

-2 Log Likelihood	1030.969
Akaike's Information Criterion (AIC)	1066.969
Hurvich and Tsai's Criterion (AICC)	1073.302
Bozdogan's Criterion (CAIC)	1136.164
Schwarz's Bayesian Criterion (BIC)	1118.164

The information criteria are displayed in smaller-is-better form.

a. Dependent Variable: mYPAS Score.

Univariate Tests[a]

Numerator df	Denominator df	F	Sig.
2	28.902	1.769	0.189

The F tests the effect of Parent's Mood. This test is based on the linearly independent pairwise comparisons among the estimated marginal means.

a. Dependent Variable: mYPAS Score.

Appendix D: Supplemental Data Analysis Tables – Continuous Factors

Age

Case Processing Summary

Age		Cases					
		Valid		Missing		Total	
		N	Percent	N	Percent	N	Percent
mYPAS Score	1	9	100.0%	0	0.0%	9	100.0%
	2	12	100.0%	0	0.0%	12	100.0%
	3	26	100.0%	0	0.0%	26	100.0%
	4	18	100.0%	0	0.0%	18	100.0%
	5	12	100.0%	0	0.0%	12	100.0%
	6	7	100.0%	0	0.0%	7	100.0%
	8	10	100.0%	0	0.0%	10	100.0%
	9	33	100.0%	0	0.0%	33	100.0%

Descriptives

Age				Statistic	Std. Error
mYPAS Score	1	Mean		55.38194	9.681836
		95% Confidence Interval for Mean	Lower Bound	33.05559	
			Upper Bound	77.70830	
		5% Trimmed Mean		54.70679	
		Median		50.52083	
		Variance		843.641	
		Std. Deviation		29.045507	
		Minimum		22.917	
		Maximum		100.000	
		Range		77.083	
		Interquartile Range		57.292	
		Skewness		0.605	0.717
		Kurtosis		-1.202	1.400
	2	Mean		51.44097	3.227227
		95% Confidence Interval for Mean	Lower Bound	44.33789	
			Upper Bound	58.54405	
		5% Trimmed Mean		51.25386	
		Median		52.08333	
		Variance		124.980	
		Std. Deviation		11.179443	
		Minimum		33.333	
		Maximum		72.917	
		Range		39.583	

	Interquartile Range		17.656	
	Skewness		-0.005	0.637
	Kurtosis		0.068	1.232
3	Mean		36.78891	3.724887
	95% Confidence Interval for Mean	Lower Bound	29.11737	
		Upper Bound	44.46046	
	5% Trimmed Mean		34.44851	
	Median		27.08333	
	Variance		360.744	
	Std. Deviation		18.993270	
	Minimum		22.917	
	Maximum		100.000	
	Range		77.083	
	Interquartile Range		19.160	
	Skewness		1.904	0.456
	Kurtosis		3.831	0.887
4	Mean		47.52170	5.009566
	95% Confidence Interval for Mean	Lower Bound	36.95244	
		Upper Bound	58.09096	
	5% Trimmed Mean		45.97319	
	Median		44.98698	
	Variance		451.724	
	Std. Deviation		21.253788	
	Minimum		22.917	
	Maximum		100.000	
	Range		77.083	
	Interquartile Range		31.771	
	Skewness		0.845	0.536
	Kurtosis		0.622	1.038
5	Mean		33.33333	6.159915
	95% Confidence Interval for Mean	Lower Bound	19.77545	
		Upper Bound	46.89121	
	5% Trimmed Mean		30.20833	
	Median		29.16667	
	Variance		455.335	
	Std. Deviation		21.338571	
	Minimum		22.917	
	Maximum		100.000	
	Range		77.083	
	Interquartile Range		6.250	
	Skewness		3.269	0.637
	Kurtosis		11.018	1.232

6	Mean		24.10714	0.768449
	95% Confidence Interval for Mean	Lower Bound	22.22682	
		Upper Bound	25.98747	
	5% Trimmed Mean		24.00794	
	Median		22.91667	
	Variance		4.134	
	Std. Deviation		2.033125	
	Minimum		22.917	
	Maximum		27.083	
	Range		4.167	
	Interquartile Range		4.167	
	Skewness		1.230	0.794
	Kurtosis		-0.840	1.587
8	Mean		46.25000	0.747940
	95% Confidence Interval for Mean	Lower Bound	44.55804	
		Upper Bound	47.94196	
	5% Trimmed Mean		46.29630	
	Median		45.83333	
	Variance		5.594	
	Std. Deviation		2.365193	
	Minimum		41.667	
	Maximum		50.000	
	Range		8.333	
	Interquartile Range		1.042	
	Skewness		0.091	0.687
	Kurtosis		1.498	1.334
9	Mean		33.91167	2.821747
	95% Confidence Interval for Mean	Lower Bound	28.16396	
		Upper Bound	39.65938	
	5% Trimmed Mean		32.12407	
	Median		22.91667	
	Variance		262.754	
	Std. Deviation		16.209701	
	Minimum		22.917	
	Maximum		77.083	
	Range		54.167	
	Interquartile Range		20.306	
	Skewness		1.514	0.409
	Kurtosis		1.500	0.798

Time Since Last Nap

Case Processing Summary

Time Since Last Nap		Cases					
		Valid		Missing		Total	
		N	Percent	N	Percent	N	Percent
mYPAS Score	2:18	12	100.0%	0	0.0%	12	100.0%
	2:32	9	100.0%	0	0.0%	9	100.0%
	3:15	9	100.0%	0	0.0%	9	100.0%
	4:15	11	100.0%	0	0.0%	11	100.0%
	4:25	10	100.0%	0	0.0%	10	100.0%
	4:56	10	100.0%	0	0.0%	10	100.0%
	5:42	13	100.0%	0	0.0%	13	100.0%
	6:23	12	100.0%	0	0.0%	12	100.0%
	7:54	12	100.0%	0	0.0%	12	100.0%
	7:55	9	100.0%	0	0.0%	9	100.0%
	8:36	7	100.0%	0	0.0%	7	100.0%
	9:24	13	100.0%	0	0.0%	13	100.0%

Descriptives

Time Since Last Nap				Statistic	Std. Error
mYPAS Score	2:18	Mean		51.44097	3.227227
		95% Confidence Interval for Mean	Lower Bound	44.33789	
			Upper Bound	58.54405	
		5% Trimmed Mean		51.25386	
		Median		52.08333	
		Variance		124.980	
		Std. Deviation		11.179443	
		Minimum		33.333	
		Maximum		72.917	
		Range		39.583	
		Interquartile Range		17.656	
		Skewness		-0.005	0.637
		Kurtosis		0.068	1.232
	2:32	Mean		55.38194	9.681836
		95% Confidence Interval for Mean	Lower Bound	33.05559	
			Upper Bound	77.70830	
		5% Trimmed Mean		54.70679	
		Median		50.52083	
		Variance		843.641	
		Std. Deviation		29.045507	
		Minimum		22.917	

	Maximum		100.000	
	Range		77.083	
	Interquartile Range		57.292	
	Skewness		0.605	0.717
	Kurtosis		-1.202	1.400
3:15	Mean		50.39063	7.954558
	95% Confidence Interval for Mean	Lower Bound	32.04738	
		Upper Bound	68.73387	
	5% Trimmed Mean		49.16088	
	Median		50.00000	
	Variance		569.475	
	Std. Deviation		23.863675	
	Minimum		22.917	
	Maximum		100.000	
	Range		77.083	
	Interquartile Range		31.250	
	Skewness		0.998	0.717
	Kurtosis		1.492	1.400
4:15	Mean		32.76515	6.606564
	95% Confidence Interval for Mean	Lower Bound	18.04481	
		Upper Bound	47.48549	
	5% Trimmed Mean		30.85017	
	Median		22.91667	
	Variance		480.114	
	Std. Deviation		21.911496	
	Minimum		22.917	
	Maximum		77.083	
	Range		54.167	
	Interquartile Range		0.000	
	Skewness		1.923	0.661
	Kurtosis		2.037	1.279
4:25	Mean		46.25000	0.747940
	95% Confidence Interval for Mean	Lower Bound	44.55804	
		Upper Bound	47.94196	
	5% Trimmed Mean		46.29630	
	Median		45.83333	
	Variance		5.594	
	Std. Deviation		2.365193	
	Minimum		41.667	
	Maximum		50.000	
	Range		8.333	
	Interquartile Range		1.042	

	Skewness		0.091	0.687
	Kurtosis		1.498	1.334
4:56	Mean		40.31127	1.693677
	95% Confidence Interval for Mean	Lower Bound	36.47991	
		Upper Bound	44.14264	
	5% Trimmed Mean		40.16068	
	Median		38.75000	
	Variance		28.685	
	Std. Deviation		5.355877	
	Minimum		35.417	
	Maximum		47.917	
	Range		12.500	
	Interquartile Range		10.417	
	Skewness		0.237	0.687
	Kurtosis		-2.123	1.334
5:42	Mean		43.59207	6.179534
	95% Confidence Interval for Mean	Lower Bound	30.12803	
		Upper Bound	57.05612	
	5% Trimmed Mean		41.60693	
	Median		37.50000	
	Variance		496.426	
	Std. Deviation		22.280628	
	Minimum		22.917	
	Maximum		100.000	
	Range		77.083	
	Interquartile Range		33.333	
	Skewness		1.422	0.616
	Kurtosis		2.343	1.191
6:23	Mean		29.62963	4.526686
	95% Confidence Interval for Mean	Lower Bound	19.66646	
		Upper Bound	39.59280	
	5% Trimmed Mean		28.09928	
	Median		22.91667	
	Variance		245.891	
	Std. Deviation		15.680900	
	Minimum		22.917	
	Maximum		63.889	
	Range		40.972	
	Interquartile Range		0.000	
	Skewness		2.057	0.637
	Kurtosis		2.652	1.232
7:54	Mean		33.33333	6.159915

	95% Confidence Interval for Mean	Lower Bound	19.77545	
		Upper Bound	46.89121	
	5% Trimmed Mean		30.20833	
	Median		29.16667	
	Variance		455.335	
	Std. Deviation		21.338571	
	Minimum		22.917	
	Maximum		100.000	
	Range		77.083	
	Interquartile Range		6.250	
	Skewness		3.269	0.637
	Kurtosis		11.018	1.232
7:55	Mean		44.65278	6.428395
	95% Confidence Interval for Mean	Lower Bound	29.82887	
		Upper Bound	59.47668	
	5% Trimmed Mean		44.01235	
	Median		39.58333	
	Variance		371.918	
	Std. Deviation		19.285186	
	Minimum		22.917	
	Maximum		77.917	
	Range		55.000	
	Interquartile Range		34.375	
	Skewness		0.552	0.717
	Kurtosis		-0.878	1.400
8:36	Mean		24.10714	0.768449
	95% Confidence Interval for Mean	Lower Bound	22.22682	
		Upper Bound	25.98747	
	5% Trimmed Mean		24.00794	
	Median		22.91667	
	Variance		4.134	
	Std. Deviation		2.033125	
	Minimum		22.917	
	Maximum		27.083	
	Range		4.167	
	Interquartile Range		4.167	
	Skewness		1.230	0.794
	Kurtosis		-0.840	1.587
9:24	Mean		29.98575	3.451248
	95% Confidence Interval for Mean	Lower Bound	22.46613	
		Upper Bound	37.50538	
	5% Trimmed Mean		28.22491	

	Median	27.08333	
	Variance	154.844	
	Std. Deviation	12.443651	
	Minimum	22.917	
	Maximum	68.750	
	Range	45.833	
	Interquartile Range	4.167	
	Skewness	2.945	0.616
	Kurtosis	9.171	1.191

Number of Eye Exams

Case Processing Summary

Number of Eye Exams		Cases					
		Valid		Missing		Total	
		N	Percent	N	Percent	N	Percent
mYPAS Score	0	43	100.0%	0	0.0%	43	100.0%
	2	19	100.0%	0	0.0%	19	100.0%
	3	13	100.0%	0	0.0%	13	100.0%
	4	12	100.0%	0	0.0%	12	100.0%
	5	10	100.0%	0	0.0%	10	100.0%
	6	11	100.0%	0	0.0%	11	100.0%
	7	12	100.0%	0	0.0%	12	100.0%
	45	7	100.0%	0	0.0%	7	100.0%

Descriptives

Number of Eye Exams				Statistic	Std. Error
mYPAS Score	0	Mean		47.42742	2.919735
		95% Confidence Interval for Mean	Lower Bound	41.53516	
			Upper Bound	53.31969	
		5% Trimmed Mean		45.95403	
		Median		48.86364	
		Variance		366.569	
		Std. Deviation		19.145985	
		Minimum		22.917	
		Maximum		100.000	
		Range		77.083	
		Interquartile Range		25.625	
		Skewness		0.827	0.361
		Kurtosis		0.898	0.709

2	Mean		47.45001	4.861580
	95% Confidence Interval for Mean	Lower Bound	37.23621	
		Upper Bound	57.66381	
	5% Trimmed Mean		45.89353	
	Median		42.08333	
	Variance		449.064	
	Std. Deviation		21.191136	
	Minimum		22.917	
	Maximum		100.000	
	Range		77.083	
	Interquartile Range		15.104	
	Skewness		1.621	0.524
	Kurtosis		2.034	1.014
3	Mean		29.98575	3.451248
	95% Confidence Interval for Mean	Lower Bound	22.46613	
		Upper Bound	37.50538	
	5% Trimmed Mean		28.22491	
	Median		27.08333	
	Variance		154.844	
	Std. Deviation		12.443651	
	Minimum		22.917	
	Maximum		68.750	
	Range		45.833	
	Interquartile Range		4.167	
	Skewness		2.945	0.616
	Kurtosis		9.171	1.191
4	Mean		33.33333	6.159915
	95% Confidence Interval for Mean	Lower Bound	19.77545	
		Upper Bound	46.89121	
	5% Trimmed Mean		30.20833	
	Median		29.16667	
	Variance		455.335	
	Std. Deviation		21.338571	
	Minimum		22.917	
	Maximum		100.000	
	Range		77.083	
	Interquartile Range		6.250	
	Skewness		3.269	0.637
	Kurtosis		11.018	1.232
5	Mean		46.25000	0.747940
	95% Confidence Interval for Mean	Lower Bound	44.55804	
		Upper Bound	47.94196	

	5% Trimmed Mean		46.29630	
	Median		45.83333	
	Variance		5.594	
	Std. Deviation		2.365193	
	Minimum		41.667	
	Maximum		50.000	
	Range		8.333	
	Interquartile Range		1.042	
	Skewness		0.091	0.687
	Kurtosis		1.498	1.334
6	Mean		32.76515	6.606564
	95% Confidence Interval for Mean	Lower Bound	18.04481	
		Upper Bound	47.48549	
	5% Trimmed Mean		30.85017	
	Median		22.91667	
	Variance		480.114	
	Std. Deviation		21.911496	
	Minimum		22.917	
	Maximum		77.083	
	Range		54.167	
	Interquartile Range		0.000	
	Skewness		1.923	0.661
	Kurtosis		2.037	1.279
7	Mean		29.62963	4.526686
	95% Confidence Interval for Mean	Lower Bound	19.66646	
		Upper Bound	39.59280	
	5% Trimmed Mean		28.09928	
	Median		22.91667	
	Variance		245.891	
	Std. Deviation		15.680900	
	Minimum		22.917	
	Maximum		63.889	
	Range		40.972	
	Interquartile Range		0.000	
	Skewness		2.057	0.637
	Kurtosis		2.652	1.232
45	Mean		24.10714	0.768449
	95% Confidence Interval for Mean	Lower Bound	22.22682	
		Upper Bound	25.98747	
	5% Trimmed Mean		24.00794	
	Median		22.91667	
	Variance		4.134	

	Std. Deviation	2.033125	
	Minimum	22.917	
	Maximum	27.083	
	Range	4.167	
	Interquartile Range	4.167	
	Skewness	1.230	0.794
	Kurtosis	-0.840	1.587

Max Number of People in Exam Room

Case Processing Summary

Max Number of People in Exam Room		Cases					
		Valid		Missing		Total	
		N	Percent	N	Percent	N	Percent
mYPAS Score	3	7	100.0%	0	0.0%	7	100.0%
	4	24	100.0%	0	0.0%	24	100.0%
	5	33	100.0%	0	0.0%	33	100.0%
	6	54	100.0%	0	0.0%	54	100.0%
	7	9	100.0%	0	0.0%	9	100.0%

Descriptives

Max Number of People in Exam Room				Statistic	Std. Error
mYPAS Score	3	Mean		24.10714	0.768449
		95% Confidence Interval for Mean	Lower Bound	22.22682	
			Upper Bound	25.98747	
		5% Trimmed Mean		24.00794	
		Median		22.91667	
		Variance		4.134	
		Std. Deviation		2.033125	
		Minimum		22.917	
		Maximum		27.083	
		Range		4.167	
		Interquartile Range		4.167	
		Skewness		1.230	0.794
		Kurtosis		-0.840	1.587
	4	Mean		40.53530	3.544230
		95% Confidence Interval for Mean	Lower Bound	33.20350	
			Upper Bound	47.86710	
		5% Trimmed Mean		39.79874	
		Median		37.50000	

	Variance		301.478	
	Std. Deviation		17.363110	
	Minimum		22.917	
	Maximum		72.917	
	Range		50.000	
	Interquartile Range		33.333	
	Skewness		0.264	0.472
	Kurtosis		-1.541	0.918
5	Mean		38.04326	1.880824
	95% Confidence Interval for Mean	Lower Bound	34.21215	
		Upper Bound	41.87437	
	5% Trimmed Mean		37.58805	
	Median		39.81481	
	Variance		116.737	
	Std. Deviation		10.804510	
	Minimum		22.917	
	Maximum		68.750	
	Range		45.833	
	Interquartile Range		18.750	
	Skewness		0.391	0.409
	Kurtosis		0.253	0.798
6	Mean		40.41675	2.998490
	95% Confidence Interval for Mean	Lower Bound	34.40254	
		Upper Bound	46.43095	
	5% Trimmed Mean		38.07879	
	Median		31.25000	
	Variance		485.511	
	Std. Deviation		22.034308	
	Minimum		22.917	
	Maximum		100.000	
	Range		77.083	
	Interquartile Range		28.125	
	Skewness		1.356	0.325
	Kurtosis		1.063	0.639
7	Mean		55.38194	9.681836
	95% Confidence Interval for Mean	Lower Bound	33.05559	
		Upper Bound	77.70830	
	5% Trimmed Mean		54.70679	
	Median		50.52083	
	Variance		843.641	
	Std. Deviation		29.045507	
	Minimum		22.917	

Maximum	100.000	
Range	77.083	
Interquartile Range	57.292	
Skewness	0.605	0.717
Kurtosis	-1.202	1.400

Appendix E: Supplemental Resources for Qualitative Data Analysis

Key of Descriptive Codes

C1. Chair is too big
C2. Child moves occluder
C3. Signs of child being tired
C4. Doctor verbally redefining procedures
C5. Use of TV to capture attention
C6. Use of parents to control
C7. Lowest anxiety score when parents are not present
C8. Doctor shows tools/prepares the child for what is about to happen
C9. Doctor using speech inflections to make procedures fun
C10. Doctor struggling to use the remote or TV
C11. Parents helping with occlusion
C12. Doctors using verbal reinforcement and encouragement
C13. Child runs away from doctor
C14. Lowest anxiety score when doctors are not present
C15. High anxiety score while lights are off
C16. Use of phones to capture attention
C17. Language barriers
C18. Parents using verbal reinforcement and encouragement
C19. High anxiety score while administering eye drops
C20. High anxiety from child injuring themselves
C21. Use of stickers to soothe
C22. Use of silly gestures or contact to soothe
C23. Significant interest in gyroscope toy
C24. Use of noises or singing to capture attention
C25. High anxiety when using occluders
C26. High anxiety when completing Denver
C27. High anxiety when completing retinoscopy
C28. High anxiety when using the binocular indirect ophthalmoscope
C29. High anxiety when using the transilluminator
C30. High anxiety when completing stereopsis
C31. High anxiety when using the slit lamp
C32. High anxiety when using the Teller cards
C33. Child rubs eyes after drop administration
C34. Child rubs eyes after iCare
C35. Child almost hits themselves on standard slit lamp
C36. Special finding: Faculty member explains that if glasses squish [the child's] eyelashes, he will want to take them off.
C37. Use of conversation to soothe
C38. High anxiety when interacting with parent
C39. Use of doctors to control
C40. Special finding: Mom mentions the child had her eyes dilated 2 days ago
C41. Use of parents to soothe
C42. Use of toys from home
C43. Child forcing eyes shut
C44. Special finding: Resident confirms that resting the slit lamp by poking the chest and its bright light causes discomfort
C45. Special finding: Student doctor observer says common TV tasks include pressing play, switching charts or movie, and making the charts full screen
C46. High anxiety when entering the room
C47. Doctor occludes with hands
C48. Doctor opens eyelids with fingers
C49. Use of the little chair
C50. Child squirms
C51. High anxiety when using the pachymeter
C52. Child occludes themselves
C53. Doctor drops an item
C54. Special finding: Placing stereo glasses on top of normal glasses is generally not an issue
C55. Special finding: SASP completion varies with age and this child had to redo the test due to poor instruction from doctor
C56. High anxiety when using iCare
C57. Child helps with eye drop administration
C58. Lowest anxiety score when child and family take a break to dilate
C59. Child and family offered a break to dilate
C60. Child covers eyes
C61. Parent corrects/yells at child
C62. Signs of child being sick
C63. High anxiety score while being restricted
C64. Use of shame to coerce (instead of soothing)
C65. Parents wait in the reception area

Most Frequently Used Codes

Code and Description	Frequency
C50. Child squirms	26
C6. Use of parents to control	19
C14. Lowest anxiety score when doctors are not present	17
C41. Use of parents to soothe	17
C3. Signs of child being tired	15
C19. High anxiety score while administering eye drops	13
C8. Doctor shows tools/prepares the child for what is about to happen	12
C37. Use of conversation to soothe	12
C42. Use of toys from home	12
C5. Use of TV to capture attention	10
C61. Parent corrects/yells at child	10
C63. High anxiety score while being restrained	9
C15. High anxiety score while lights are off	9
C16. Use of phones to capture attention	8
C25. High anxiety when using occluders	8
C12. Doctors using verbal reinforcement and encouragement	7
C13. Child runs away from doctor	7
C49. Use of the little chair	7
C9. Doctor using speech inflections to make procedures fun	6
C23. Significant interest in gyroscope toy	6
C59. Child and family offered a break to dilate	6
C52. Child occludes themselves	5
C58. Lowest anxiety score when child and family take a break to dilate	5
C4. Doctor verbally redefining procedures	4
C10. Doctor struggling to use the remote or TV	4
C11. Parents helping with occlusion	4
C17. Language barriers	4
C24. Use of noises or singing to capture attention	4
C27. High anxiety when completing retinoscopy	4
C28. High anxiety when using BIO	4
C43. Child forcing eyes shut	4
C21. Use of stickers to soothe	3
C22. Use of silly gestures or contact to soothe	3
C29. High anxiety when using the transilluminator	3
C31. High anxiety when using the slit lamp	3
C33. Child rubs eyes after drop administration	3
C39. Use of doctors to control	3
C48. Doctor opens eyelids with fingers	3
C18. Parents using verbal reinforcement and encouragement	2
C32. High anxiety when using the Teller cards	2
C47. Doctor occludes with hands	2

C53. Doctor drops an item	2
C60. Child covers eyes	2
C62. Signs of child being sick	2
C65. Parents wait in the reception area	2
C1. Chair is too big	1
C2. Child moves occluder	1
C7. Lowest anxiety score when parents are not present	1
C20. High anxiety from child injuring themselves	1
C26. High anxiety when completing Denver	1
C30. High anxiety when completing stereopsis	1
C34. Child rubs eyes after iCare	1
C35. Child almost hits themselves on standard slit lamp	1
C36. Special: If glasses squish [the child's] eyelashes, [then the child] will want to take them off.	1
C38. High anxiety when interacting with parent	1
C40. Special: Child had eyes dilated 2 days ago so they know what to expect	1
C44. Special: Resting the slit lamp by poking the chest and its bright light contribute to discomfort	1
C45. Special: Common TV tasks include pressing play, switching charts or movie, and making the charts full screen	1
C46. High anxiety when entering the room	1
C51. High anxiety when using the pachymeter	1
C54. Special: placing stereo glasses on top of normal glasses is generally not an issue	1
C55. Special: SASP completion varies with age and this child had to redo the test due to poor instruction from doctor	1
C56. High anxiety when using iCare	1
C57. Child helps with eye drop administration	1
C64. Use of shame to coerce (instead of soothing)	1
Total	333

Most Prevalent Codes

Code and Description	Number of exams	% Total Exams	Frequency	% Total Codes
C50. Child squirms	9	75%	26	8%
C41. Use of parents to soothe	9	75%	17	5%
C19. High anxiety score while administering eye drops	9	75%	13	4%
C14. Lowest anxiety score when doctors are not present	8	67%	17	5%
C3. Signs of child being tired	8	67%	15	5%
C6. Use of parents to control	7	58%	19	6%
C8. Doctor shows tools/prepares the child for what is about to happen	7	58%	12	4%
C63. High anxiety score while being restrained	6	50%	9	3%
C5. Use of TV to capture attention	5	42%	10	3%
C15. High anxiety score while lights are off	5	42%	9	3%

C59. Child and family offered a break to dilate	5	42%	6	2%
C52. Child occludes themselves	5	42%	5	2%
C37. Use of conversation to soothe	4	33%	12	4%
C25. High anxiety when using occluders	4	33%	8	2%
C13. Child runs away from doctor	4	33%	7	2%
C49. Use of the little chair	4	33%	7	2%
C58. Lowest anxiety score when child and family take a break to dilate	4	33%	5	2%
C28. High anxiety when using BIO	4	33%	4	1%
C42. Use of toys from home	3	25%	12	4%
C61. Parent corrects/yells at child	3	25%	10	3%
C16. Use of phones to capture attention	3	25%	8	2%
C12. Doctors using verbal reinforcement and encouragement	3	25%	7	2%
C9. Doctor using speech inflections to make procedures fun	3	25%	6	2%
C10. Doctor struggling to use the remote or TV	3	25%	4	1%
C27. High anxiety when completing retinoscopy	3	25%	4	1%
C43. Child forcing eyes shut	3	25%	4	1%
C31. High anxiety when using the slit lamp	3	25%	3	1%
C33. Child rubs eyes after drop administration	3	25%	3	1%
C23. Significant interest in gyroscope toy	2	17%	6	2%
C4. Doctor verbally redefining procedures	2	17%	4	1%
C11. Parents helping with occlusion	2	17%	4	1%
C17. Language barriers	2	17%	4	1%
C21. Use of stickers to soothe	2	17%	3	1%
C22. Use of silly gestures or contact to soothe	2	17%	3	1%
C29. High anxiety when using the transilluminator	2	17%	3	1%
C39. Use of doctors to control	2	17%	3	1%
C48. Doctor opens eyelids with fingers	2	17%	3	1%
C47. Doctor occludes with hands	2	17%	2	1%
C53. Doctor drops an item	2	17%	2	1%
C60. Child covers eyes	2	17%	2	1%
C65. Parents wait in the reception area	2	17%	2	1%
C24. Use of noises or singing to capture attention	1	8%	4	1%
C18. Parents using verbal reinforcement and encouragement	1	8%	2	1%
C32. High anxiety when using the Teller cards	1	8%	2	1%
C62. Signs of child being sick	1	8%	2	1%
C1. Chair is too big	1	8%	1	0%
C2. Child moves occluder	1	8%	1	0%
C7. Lowest anxiety score when parents are not present	1	8%	1	0%
C20. High anxiety from child injuring themselves	1	8%	1	0%
C26. High anxiety when completing Denver	1	8%	1	0%
C30. High anxiety when completing stereopsis	1	8%	1	0%
C34. Child rubs eyes after iCare	1	8%	1	0%
C35. Child almost hits themselves on standard slit lamp	1	8%	1	0%
C36. Special: If glasses squish [the child's] eyelashes, [then the child] will want to take them off.	1	8%	1	0%

C38. High anxiety when interacting with parent	1	8%	1	0%
C40. Special: Child had eyes dilated 2 days ago so they know what to expect	1	8%	1	0%
C44. Special: Resting the slit lamp by poking the chest and its bright light contribute to discomfort	1	8%	1	0%
C45. Special: Common TV tasks include pressing play, switching charts or movie, and making the charts full screen	1	8%	1	0%
C46. High anxiety when entering the room	1	8%	1	0%
C51. High anxiety when using the pachymeter	1	8%	1	0%
C54. Special: placing stereo glasses on top of normal glasses is generally not an issue	1	8%	1	0%
C55. Special: SASP completion varies with age and this child had to redo the test due to poor instruction from doctor	1	8%	1	0%
C56. High anxiety when using iCare	1	8%	1	0%
C57. Child helps with eye drop administration	1	8%	1	0%
C64. Use of shame to coerce (instead of soothing)	1	8%	1	0%

Appendix F: Design Development Resources

Brief 1: Redefining Experiences

Redefining Experiences

How might we help optometrists gamify or create distractions while administering dilation drops?

How might we help optometrists and parents restrict a child's arms and/or legs while making it a fun/positive experience?

How can we redefine this experience to make it fun or stress-free?

Undoubtedly, administering eye drops is the most common stressful procedure performed during an eye exam. The optometrists need to use the drops in order to dilate the size of the pupils so that they can fully examine the health of the optic nerve and retina at the back of the eye. Often times, multiple drugs are used, each in a separate bottle. Each drop stings due to the pH of the solutions, you become light sensitive, and your vision gets blurry. Also, having your eye lids pulled open and having a bottle up close to your eye can be scary to kids, especially if it is their first eye exam. When they start to squirm or kick, children are held down by parents and optometrists, which further increases distress.

Consider the following:

- *What are interesting ways to open the eye lids or to drip eye drops?*
- *Could we be sneaky or lie to the kids?*
- *Could restriction be comfortable or fun?*
- *How do we keep kids from rubbing their eyes so the drops stay in?*
- *Could we manage pain and anxiety without medications?*
- *How do we help kids open their eyes through the pain?*
- *Could we keep kids engaged after the first drop goes in?*
- *What do kids like or enjoy?*
- *How do we incorporate this product seamlessly?*

Brainstorming Session Brief 1

Agile Eye Drops

How might we help optometrists administer drops to both eyes at the same time while the child is oblivious to the procedure?

How might we help optometrists ensure that the drops went in and took effect while the child cries, squirms, and rubs their eyes?

How can we make this procedure faster, simpler, and more intuitive?

Undoubtedly, administering eye drops is the most common stressful procedure performed during an eye exam. The optometrists need to use the drops in order to dilate the size of the pupils so that they can fully examine the health of the optic nerve and retina at the back of the eye. Currently, it takes two hands to administer drops—one to hold open the eye and another to squeeze the bottle. Often times, multiple drugs are used, each in a separate bottle, and drops need to go in each eye. Children hate that each drop stings due to the pH of the solutions, you become light sensitive, and your vision gets blurry. The faster you get this procedure done, the better.

Consider the following:

- *Could we use a simple mechanism to deliver the drops?*
- *What type of feedback could we provide when the drops go in?*
- *Could we mix different drops while maintaining correct concentrations?*
- *What ergonomic forms are relevant for this procedure?*
- *Could we take advantage of facial anatomy?*
- *Could we not occlude the eyes to allow us to see where the drops land?*
- *How do we fit different face shapes and sizes?*

Comfortable Exams

How might we help young children trust their optometrist during their first eye exam?

How might we help anxious children be more comfortable throughout the exam?

My data analysis shows that being new to a clinic or having few eye exams results in higher overall anxiety throughout an eye exam. Optometrists that work in pediatrics do their best to be personable and they generally engage patients throughout the exam. They do not wear their white coats when working with kids to remove formality. Still, kids fear new experiences, new people and weird tools.

Consider the following:

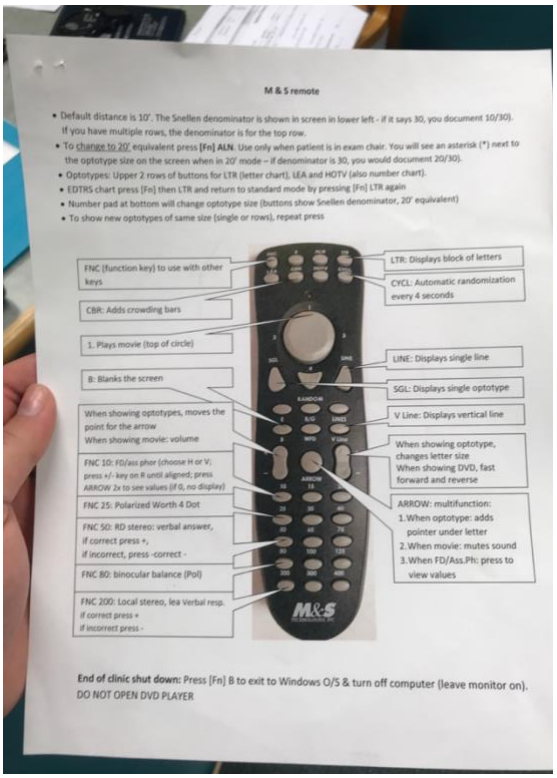
- *What do young children base trust on?*
- *How could we take into account developmental, personality, and cultural differences?*
- *What types of products engender trust or provide comfort?*
- *How do we fit different face shapes and sizes?*
- *What do kids like or enjoy?*

Tool Key

"TV" (COMPUTER)

RECEIVER, CONNECTED TO COMPUTER VIA USB

REMOTE

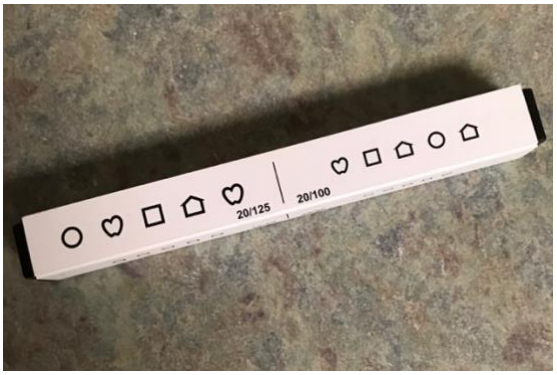


REMOTE GUIDE

EXAM CHAIR

HAND SNELLEN CHART

HOTV CHART



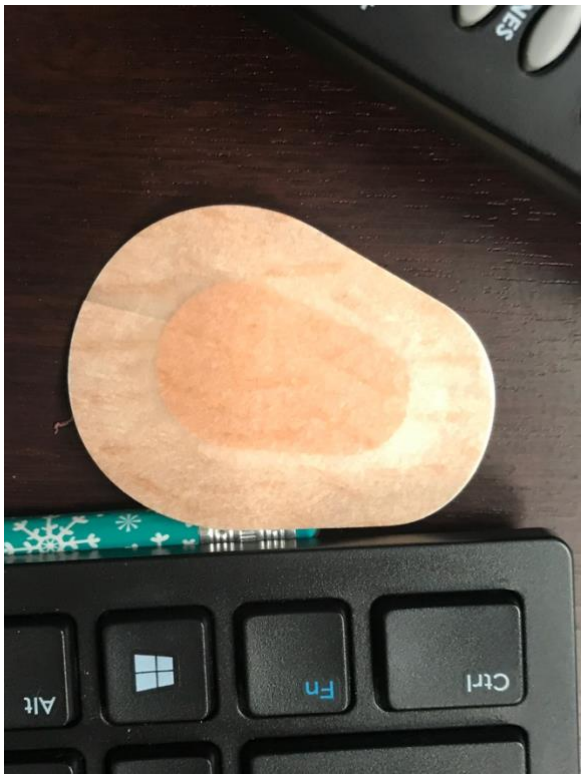
LEA CHART ON RATTLE

TELLER ACUITY CARDS

CARDIFF ACUITY CARDS

OCCLUDER

MASK OCCLUDER



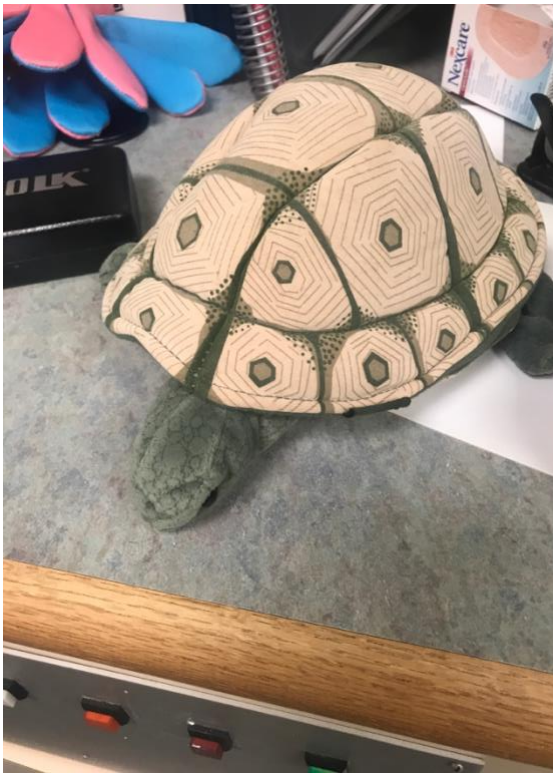
BANDAGE, USED AS OCCLUDER

LITTLE GREEN CHAIR

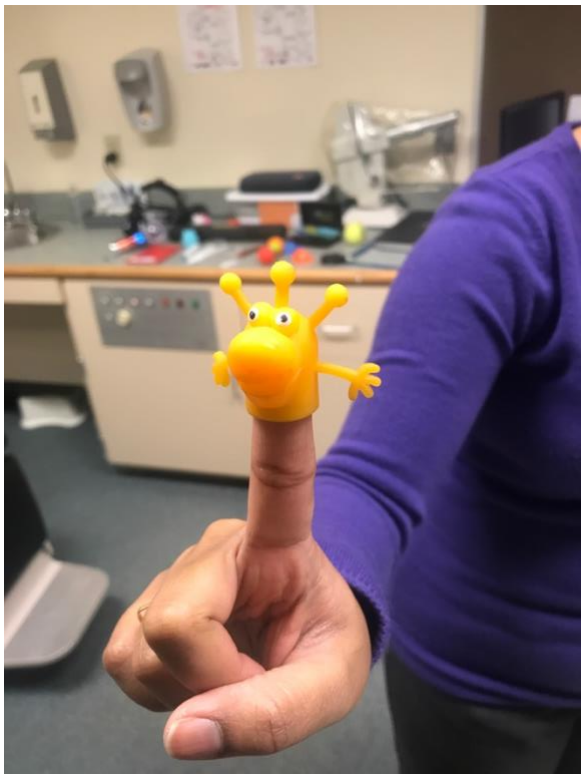
TRANSILLUMINATOR, INSIDE CASE

POPSICLE STICK IMAGE TARGET

PURPLE WAND TOY, USED AS IMAGE TARGET



STUFFED TURTLE TOY, USED AS IMAGE TARGET



FINGER PUPPET, USED AS IMAGE TARGET

STUFFED OCTOPUS TOY, USED AS IMAGE TARGET

WAND/GYROSCOPE TOY, USED AS IMAGE TARGET

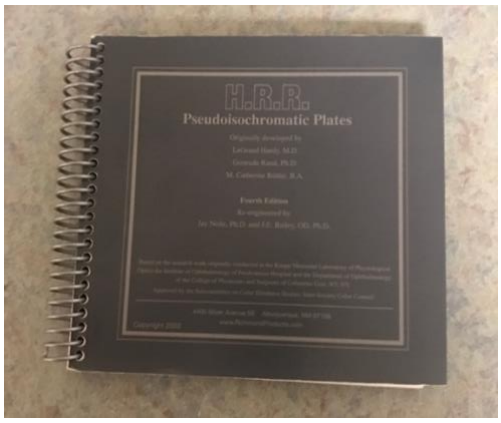
RATTLE, USED AS IMAGE TARGET

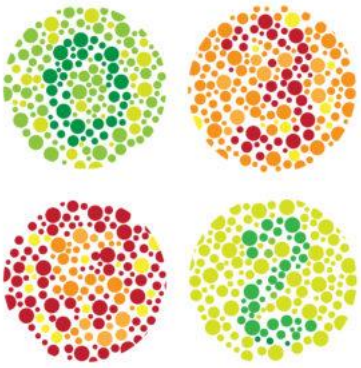
PRISM BAR

LOOSE PRISMS

RANDOT STEREOPSIS TEST

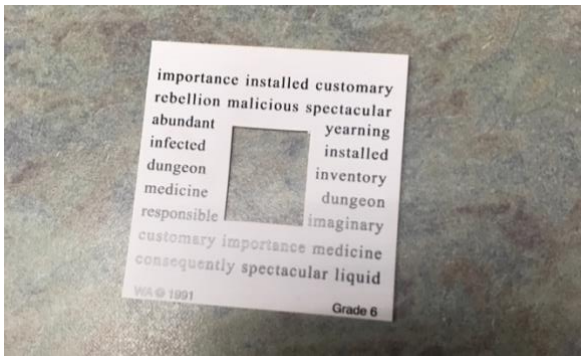
STEREO SMILE TEST





PSEUDOISOCHROMATIC PLATES (COLORBLINDNESS TEST)

RETINOSCOPE

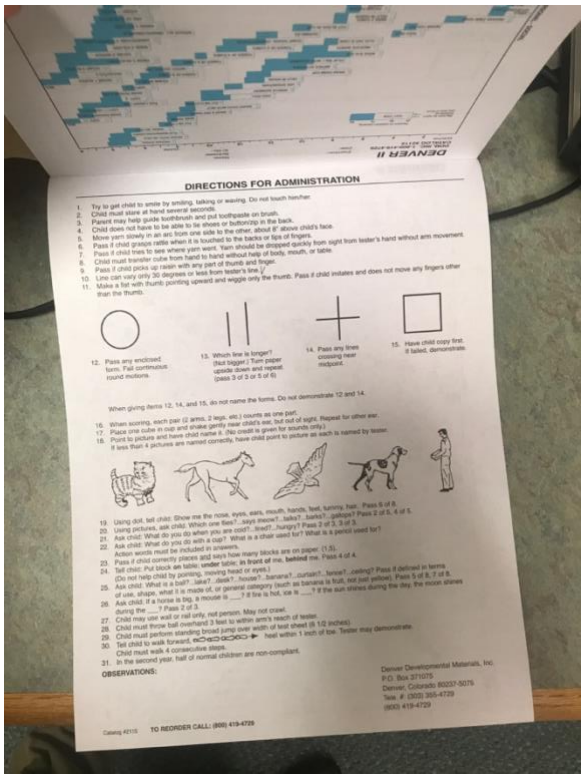


ATTACHABLE RETINOSCOPE CHARTS

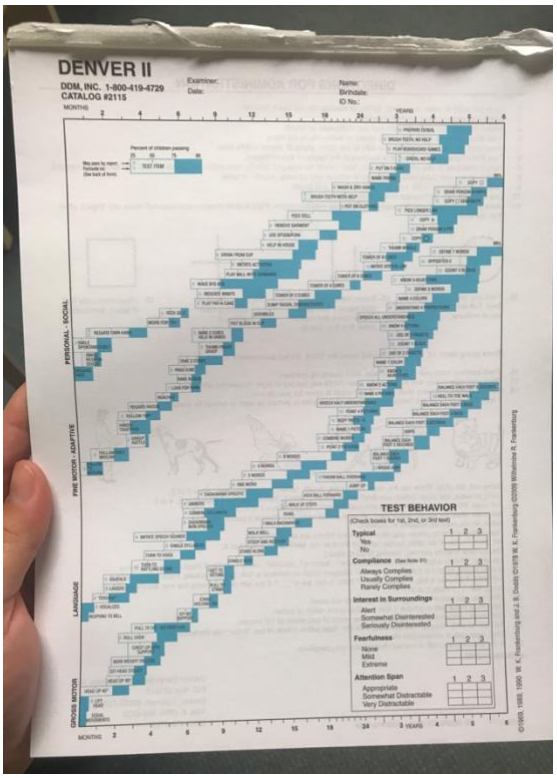
LOOSE LENSES

PHOROPTER

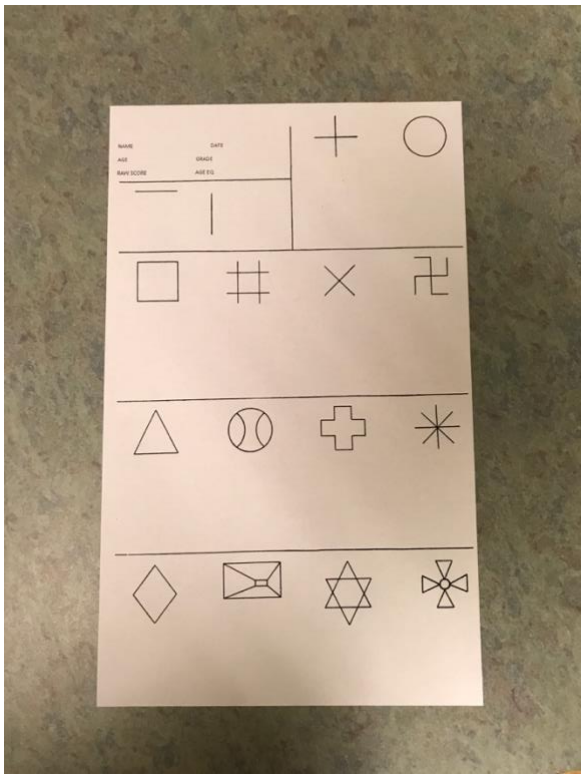
PHOROPTER WITH ATTACHABLE SNELLEN CHART



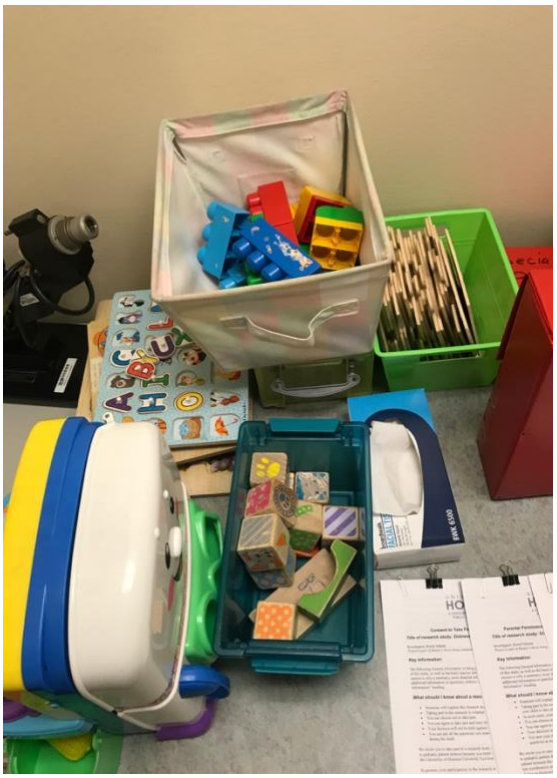
DENVER DEVELOPMENTAL TEST



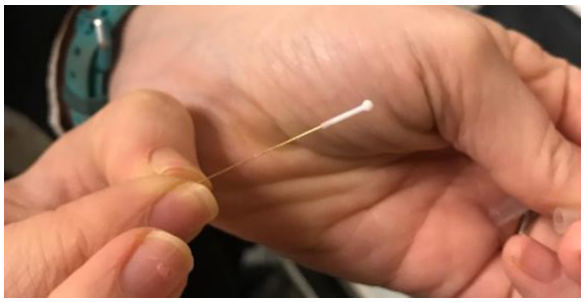
DENVER SCORE SHEET



RUTGERS DRAWING TEST



BLOCKS & MISC. TOYS



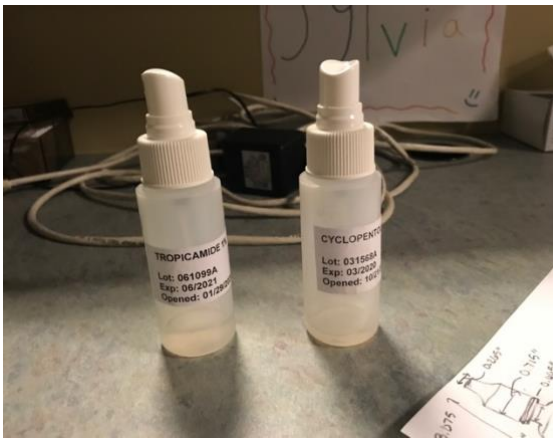
iCARE TONOMETER

STANDARD TONOMETER

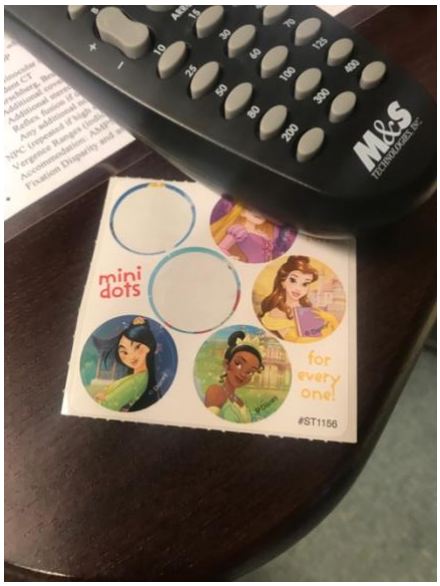
HANDHELD SLIT LAMP

STANDARD SLIT LAMP

DILATION & NUMBING DROPS



GENERIC SPRAY BOTTLES FOR DILATION DROPS



STICKERS, USED TO REWARD

DIRECT OPHTHALMOSCOPE

BINOCULAR INDIRECT OPTHALMOSCOPE (BIO)

LENSOMETER

PACHYMETER