USING ANTHROPOMETRIC MEASUREMENTS TO DESIGN ERGONOMIC INFANT AND TODDLER GEAR

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USING ANTHROPOMETRIC MEASUREMENTS TO DESIGN

ERGONOMIC INFANT AND TODDLER GEAR

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

SUMMARY

Infants grow so quickly that gear can have a shockingly short life span. Parents often do a quick calculation before purchases: divide the cost by how many months it will be used. Thus, products that are meant to “grow-with-me” or last for multiple infant stages are extremely desirable. Infant-to-toddler rockers are an example of this type of product. However, the researchers have found that the current infant-to-toddler rocker models on the market could be improved. The goal of this project was to use anthropometric data of children to design an ergonomic infant-to-toddler rocker. Anthropometric data was collected on 58 children in order to properly size a new design for a rocker which lasts from 0 to 36 months old. Researchers also found based on parent interviews, a survey, and child interactions, that the needs of infants are very different from the needs of toddlers. Infants are still developing muscle tone, and it is important for them to be supported in a semi-reclined position. Toddlers are extremely active and need a device which allows them to ingress and egress independently. Concepts were developed, and prototypes built to demonstrate the new concepts. These prototypes were then tested with parents and children to gather feedback and improve designs. The final design is an ergonomic rocker which adjusts in size and recline angle to serve the infants that need to be secure and reclined, as well as the ambulatory toddlers.

CHAPTER 1

INTRODUCTION

Infants grow so rapidly that baby gear can have a shockingly short life span. A common anecdote is that parents do a quick calculation before such purchases: divide the cost by how many months it will be used. Infant gear describes products that are intended to “hold” the infant, such as high chairs, booster seats, bouncers, swings, etc, as opposed to toys which are played with by the infant. Thus, gear that is meant to “grow-with-me” or last for multiple infant stages is extremely desirable. The most common products to include this type of feature are the ones most essential; necessary for months if not years. Typical examples include high chairs, strollers, and car seats.

A rocker is traditionally a piece of infant gear that is meant to soothe infants when parents need to be hands-free in their home. Similar to a bouncer or a swing, children sit or lay in the device and the soothing action here comes from the rocking motion. At least four rockers currently on the market are advertised as infant-to-toddler. #44 on Amazon’s Bestseller list for Baby products is the Fisher-Price Infant-to-Toddler rocker, pictured in Figures 1 and 2.

Figure 1 & 2. Fisher-Price Infant-to-Toddler Rocker, Circus Celebration

This rocker is typical of the design of current products – a rocking base that includes a kickstand for optional stability, and a soft hammock seat. The infant configuration has a slight recline in the seat to back angle, and the toddler configuration includes the seat slightly more upright with the toy bar is removed.

This project is sponsored by Kids 2, whose own infant-to-toddler rocker is pictured below in Figure 3. This rocker is of similar construction to the Fisher-Price example, with a hammock seat and metal base. The task from Kids 2 was to design an ergonomic infant-to-toddler rocker for children up to 36 months old, in order to properly fit children of all shapes and sizes throughout their early developmental stages.

Figure 3. Kids 2 Baby Einstein Ocean Adventure Infant-to-Toddler Rocker

Ergonomics is the optimization of products for the human body. It is most often associated with adult office products, such as ergonomic desk chairs. However, any product can be designed ergonomically – this means it will be designed to work most efficiently for the human body's shape, size, and range of motion. For infant gear, this means that products are designed specifically for the body size, shape, and ability (or inability) to move of the infants. Ergonomic products should encourage proper development and support infants in proper posture because they are still developing muscle tone and are yet unable to support themselves.

In order to design an ergonomic rocker, data on the sizes of children is needed. The best resource is anthropometry, which is the study of human body segment sizes and proportions. Anthropometric measurements, or body segment measurements, give designers and engineers the specific dimensions needed to properly proportion products. In this project, anthropometric measurements were used to appropriately size the "chair" part of the rocker, and ensure that the device fit children comfortably for the entirety of the target age range.

The last extensive report of children's anthropometry was performed in the 1970's by the University of Michigan. This large data set is termed "Anthrokids" and can be accessed online. However, it was deemed necessary for this project to collect our own measurements because the data set is 40+ years old. Collecting anthropometric measurements would also give researchers time to interact with children of the age they were designing for and have informal conversations with parents, which was invaluable to understand children's mobility and rapid skill development.

The goal of this project was to design an ergonomic infant-to-toddler rocker to support children ages 0-36 months old. This was achieved by collecting anthropometric measurements from children 0-36 months old to inform design driving dimensions, issuing a survey and conducting parent interviews to understand design needs, and evaluating the fit and function of a prototype design.

CHAPTER 2

BACKGROUND

2.1 Literature Review

A literature review was conducted for the purposes of finding existing anthropometric data on children and gaining an understanding of methods for collecting anthropometric measures with infants and toddlers.

The most extensive resource on children's anthropometry comes from Snyder's 1975 and 1977 papers, which include extremely detailed procedure for each of the 45 measurements taken. These papers also included separate procedures for measurements of infants, which was particularly helpful for this project. Fewer measures (20) were taken with infants, but procedure with images was spelled out in the same level of detail. Resources from the CDC were also valuable to understand proper procedure of height, weight, and head circumference. NHANES Anthropometric Procedures videos, available on YouTube, were instructional as to the level of precision required in order to collect meaningful measures, though they are not specific to children.

In order to better understand the current state of knowledge, anthropometric data on children ages 7 or younger was compiled into a single spreadsheet. This was extremely useful as a tool to be able to quickly look up particular body segment measurements. Many sources focused on a few types of measurements, so it was useful to have them all in one place. This resource was referenced throughout the design process.

2.2 Prior Art Review

With any design project, an understanding of the current market of products is crucial. In preparation to design an infant-to-toddler rocker, other similar types of gear were researched. This included rockers, swings, bouncers, and infant seats, as well as similar products that were intended to “grow with me” which included high chairs and entertainers. Additionally, products in the rocker category which were advertised as ergonomic were assessed. A focus was placed on products with a seat because the primary goal of this project was to improve the ergonomics of the seat component of the rocker. A full list of relevant products with notes can be found in Appendix A.

In addition to researchers’ own notes on the features and apparent fit of various products, online customer reviews were used as a resource to understand strengths and weaknesses of products, which could inform future design decisions.

A major insight from this research was that the current rockers, even those advertised as infant-to-toddler, did not seem to fit the toddlers very well. Images of toddlers using the products often show them sitting upright, and not making contact with the back of the seat, which is reclined. This includes the current Kids 2 rocker, shown below in Figure 4. Often product photos are photoshopped, so customer reviews with pictures helped to understand how toddlers actually look in the rockers.

Figure 4. Kids 2 Baby Einstein Ocean Adventure Infant-to-Toddler Rocker

Some entertainers were inspirational in their smooth transition from infant to toddler. For example, the Sit-to-Stand Activity Center (pictured in Figures 5 and 6) from Fisher Price works as a sit-in entertainer, but is equally functional as an activity table that toddlers can cruise or walk around.

Figure 5 & 6. Fisher Price Sit-to-Stand Activity Center

Most products which were intended to be infant-to-toddler did not majorly adjust in size, but rather had various parts that added or removed for different ages. For example, high chairs which break down to become booster seats or “toddler chairs”. Some may have minor elements which adjust such as the harness, tray depth, or foot rest height, but the major chair components do not adjust. See the Kids 2 Ingenuity high chair below as a typical example.

Figure 7. Kids 2 Ingenuity Trio 3-in-1 High Chair

Very few products in the rocker category were advertised as being ergonomic or having postural support. BabyBjorn has built a brand around ergonomic gear, and their bouncer is advertised as such. However, the hammock construction and postural support does not seem to differ much from other products. (See image below in Figure 8.) While materials may be higher quality than the rockers and bouncers from Kids 2 and Fisher Price, the construction is the same hammock method. Shape may differ and offer better support, but no additional materials or bolsters are used for postural support.

Figure 8. BabyBjorn Bouncer Balance Soft

The most inspirational product was the Evomove Nomi Chair (Figure 9). This seat emphasizes proper support and active seated posture. The seat and foot rest have infinite adjustments, so the seat depth and seat height from the footrest can be changed as the infant grows. It is actually intended to grow even into a child's teenage years. Evomove emphasizes that the footrest is extremely important for support and comfort, and many high chairs do not include one (certainly not one which adjusts infinitely). The shape of the back is meant to encourage active sitting, and the harness piece can be removed when the toddler is mobile.

Figure 9. Evomove Nomi Chair

CHAPTER 3

ANTHROPOMETRY

Generally, the intent of this data collection is to gain a greater understanding of the shapes and sizes of children 0-36 months old for use in design of infant and toddler gear. Data gathered can also be compared to the Anthrokids data collected by Snyder, et al. in the 1970s to make conclusions about the accuracy of our own data collection or the possibility of differences in the sizes of children in the 40 years since.

Specifically in this project, the anthropometric data was used to inform driving dimensions of the infant-to-toddler rocker.

3.1 Preparation

The primary source for proper anthropometric procedures was found in Snyder (1975), as this large collection of anthropometric data was extremely comprehensive and offered detailed notes about measurement taking. Many of the measurements sought in this project are the same as those taken by Snyder. For common medical measurements such as head circumference, weight, and length/height, far more resources were available. The CDC NHANES manual was referenced most often, as well as the CDC NHANES reference videos for anthropometry procedures. However, the NHANES manual details adult anthropometry, which can be difficult to translate to infants. Techniques were more relevant for older toddlers, but often needed to be modified for infants.

In order to ensure familiarity with the measurement procedures, researchers practiced taking relevant dimensions on each other, as well as on a baby doll, to get more comfortable with the small size of the infant subjects. This practice was helpful to determine the order in which to take measurements for maximum efficiency, and therefore what the organization of the

data sheet should be. The data collection sheets were modified several times, particularly after pilot participants had been completed. Initially, the data sheets were separated by age, but researchers found that temperament and abilities were more important factors than age, so sheets were delineated by procedure for ambulatory children and non-ambulatory, although often children who had learned to walk were still measured in supine because of their high activity level, lack of stability, and disregard for instructions. In the end, two different sheets were created, one for “supine” procedure and one for “ambulatory.”

Further preparation included an effort to make the measurement room and tools as “child-friendly” as possible to put children at ease. This became particularly important after the pilot participants, where some children were quite nervous from the unfamiliar environment and strange or pointy tools. These efforts included having toys on hand to entertain or distract children and painting some tools bright colors to make them look more like toys.

3.2 Tools

Standard anthropometric tools were used for most measurements. Tools used include: stadiometer, infantometer, anthropometer with custom paddle attachments, fabric tape measure, transparent ruler, and scale with baby tray attachment.

Obtaining measurements from infants and toddlers can be quite difficult because the child must be positioned in a certain pose, and depending on the temperament and mood of the child, holding the pose long enough for researchers to take the measurement can be uncomfortable. Because of this, an effort was made to make measurement collection as easy, quick, and accurate as possible. Thus, a few affordances were constructed to assist with accuracy and ease of measurement. Custom tools are detailed in the table found in Appendix C.1. Further detail on use of these tools is provided below with each measurement’s procedure.

3.3 Methods

Upon the participant's arrival to the site for measurement, parents were first asked to complete consent forms and report some information about their child including gender, age, ethnicity, and shoe size. While this was handled by one of the researchers, the other researcher introduced themselves to the child or children by playing with blocks and toys, if they were of an age to do so. This helped the child feel more at ease with the space and the researchers. Parents were given a brief overview of the procedure for measurements, then asked to remove their child's shoes to begin.

When beginning to measure, a judgement call was made by the researchers as to whether to perform measurements using the supine or ambulatory protocol. This was done by assessing mood and activity level after interacting with the child. Supine procedure was based on the Snyder (1975) methods, and ambulatory procedure was extrapolated from the CDC manuals for anthropometric measurements, intended for adults.

Two researchers were almost always needed for taking measurements in order to hold the child in position, take the measurement, and record the measurement. Researchers typically kept the parent involved by having them calm or distract the child with toys or help hold the child in position. Whenever possible, researchers kept parents in control, and did not pick up children or remove clothes; parents helped with these tasks when needed.

Many children were measured using a hybrid of the supine and ambulatory procedures. A constant ability to adapt to the particular child and their preferences was necessary. Often children were not content to lay in supine once they had learned to roll, crawl, or walk. These children were kept in supine only for those measurements where it was absolutely necessary,

such as stature, shoulder height, and leg measurements. Other measurements could be done while the child sat on the table or stood on the table with the support of the parent.

The measurements collected are described in Table 1 below along with a description of the measurement. Specific procedures used for each measurement are detailed in Appendix C.2. The complete raw data set of anthropometric measurements can be found in Appendix C.3.

Table 1. Anthropometric Measurements and Descriptions

Measurement	**Description**
Weight	Weight in kg
Stature	Length from top of head to bottom of heels
Shoulder Height – Standing	Length from mid-point of shoulder between neck and acromion to bottom of heels
Seated Height	Length from seated surface to top of head with hips and knees at 90 degrees
Shoulder Height - Sitting	Length from seated surface to midpoint of shoulder between neck and acromion, with hips and knees at 90 degrees
Shoulder Breadth	Widest breadth of lateral edge of shoulders
Upper Arm Length	Length from superior surface of shoulder to inferior surface of elbow, elbow flexed at 90 degrees
Lower Arm Length	Length from posterior aspect of elbow to ulnar styloid, with elbow flexed at 90 degrees
Buttock to Knee Length	Length from posterior surface of buttocks to anterior surface of knee, with hips and knees at 90 degrees
Knee to Sole Length	Length from bottom of heel to top surface of knee, hips and knees at 90 degrees
Chest Breadth	Breadth of chest at the level of the nipples
Chest Circumference	Circumference of chest at the level of the nipples
Hip Breadth	Breadth of hips at widest point
Hip Circumference	Circumference of hips at widest point
Head Circumference	Circumference of head at most anterior protrusion of the forehead and most posterior protrusion of the back of the head (opisthrocranion)
Foot Length	Length from posterior edge of heel to carpal edge of toes
Hand Length	Length from tip of middle finger to wrist crease
Grip Circumference	Maximum circumference made by contacting thumb and middle finger
Functional Grip – Spheres	Largest sphere that could be lifted with one hand
Functional Grip – Cubes	Largest cube that could be lifted with one hand

CHAPTER 4

NEEDFINDING

Needfinding is the design activity of establishing the needs of users. For this project, the infants and toddlers, as well as their parents, were the critical users to address. Designing for infants and toddlers is a difficult task because the primary users (infants/toddlers) are unable to speak for themselves. Therefore, insights must come from observation and interviews with parents.

In this project, needs were established using a variety of methods. A survey was issued to gain a general understanding of parent use of similar gear, as well as parent priorities when choosing gear. Anthropometric measurements were used to create accurately sized and weighted manikins to use for future prototype testing. Additionally, interviews were conducted with parents and children during anthropometric measurement sessions and a pediatric occupational therapist.

4.1 Survey

The intent of this survey was to perform needfinding research about what types of products parents of infants and toddlers currently use or have retired, and draw insights about where design opportunities lie. The survey underwent multiple rounds of revisions, ultimately ending with two separate surveys for parents of infants (0-12 months old) and parents of toddlers (13-36 months old). The types of gear being asked about and the questions pertinent to these age groups were deemed different enough that two separate surveys were necessary. Not to mention that a great deal of confusion was predicted if parents had more than one child of different ages.

Overall, the survey covered basic demographic information, asked about general priorities for choosing to use gear, and then posed a series of questions per specific types of gear, including whether parents were currently using it, why they had chosen to use this item, and if they had retired this type of item and why. Types of gear asked about include: high chairs, booster seats (dining), bouncers/rockers, bath seats, and toddler armchairs (toddler survey only). The complete survey can be found in Appendix B.

Participants were recruited for this survey through Qualtrics. It was deemed most efficient to source respondents through Qualtrics in order to receive a large number of responses in a short period of time. Each survey had a minimum of 100 responses, and parents were not allowed to complete both, even if they had a child in both age ranges.

4.1.1 Survey Analysis

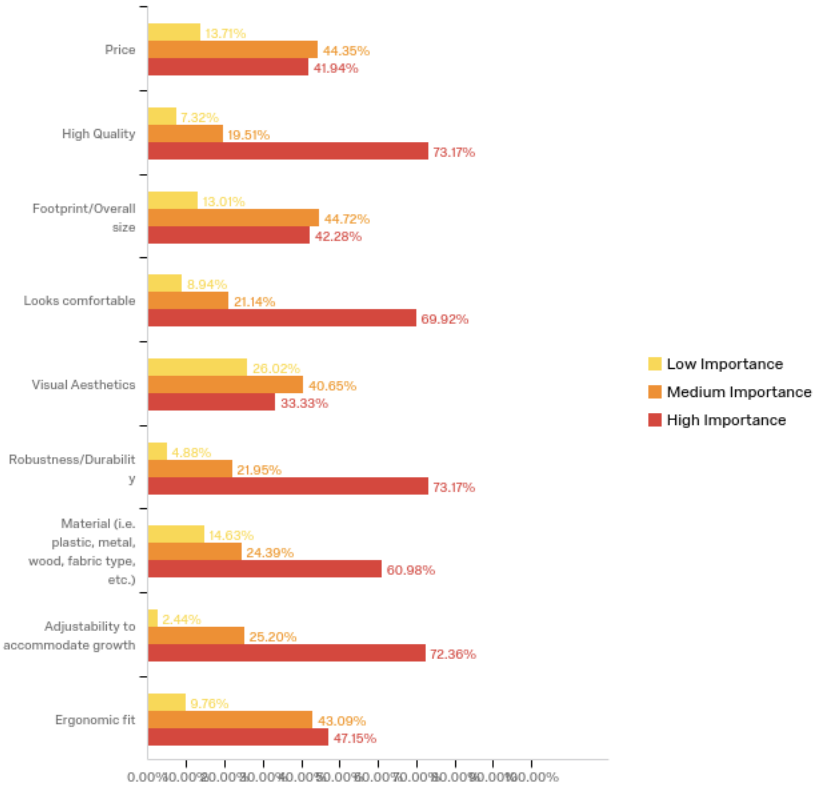
The infant survey received 160 responses, and the toddler survey received 130 responses. All incomplete responses were removed from the dataset for evaluation. This survey was created in the survey software Qualtrics, which offers relatively sophisticated analysis tools. As such, most analysis was done within Qualtrics. All demographic questions were cross-tabulated with questions of general priorities and the reasons for use of specific products to determine if any difference existed in the demographic groups. Following that, the general priorities were compared to the reasons for use of each specific product, and the reasons for use between types of products were compared. Reasons for use of each type of product were compared to reasons for retirement of that type of product. Analysis was also conducted outside of Qualtrics in order to compare or combine results from the two separate surveys. In these cases, chi-square tests were performed to determine associations of the responses between the two surveys. The reasons for choosing to use specific products and reasons for retirement were combined and compared, and the general priorities were compared between the two surveys.

Short answer questions were organized based on categories of responses using the text tool within Qualtrics.

4.1.2 Survey Results

When analyzing parents' general priorities when choosing to use infant gear, it was found that parents of infants place a high importance on many factors; quality, comfortable appearance, durability, and adjustability were all ranked "high importance" by 70% or more people. Price, product footprint, aesthetics, and ergonomics, were more solidly "medium importance" for both infant and toddler parents. See Figure 10 below for specific percentages for each item.

Infant (0-12 months)



Toddler (13-16 months)

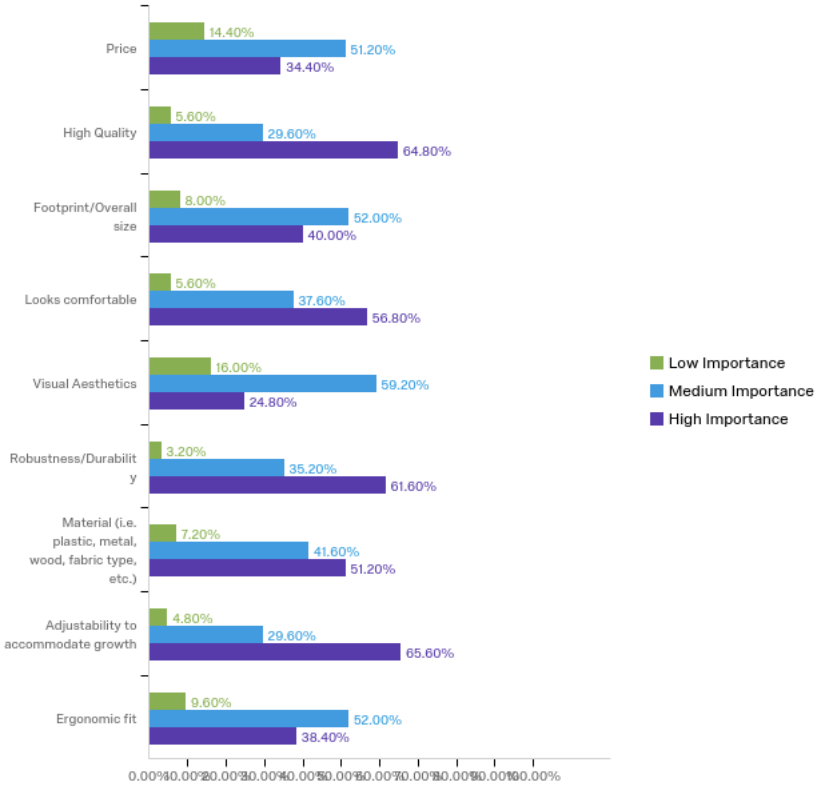


Fig 10. General Priorities. "Rank the importance of each of the following factors when choosing to use infant gear, from low importance to high importance."

It was found that comfortable appearance was one of the most important factor for choosing to use specific products, which does not correlate with the large variety of factors rated "high importance" in the general priorities. Further, although one might assume that "looks comfortable" and "ergonomic fit" would be linked, comfortable appearance was the number one reason for choosing to use specific products, while ergonomic fit was consistently one of the least cited reasons. It is of note to this project that "ergonomic fit" was only chosen by 11% or fewer parents for all types of products.

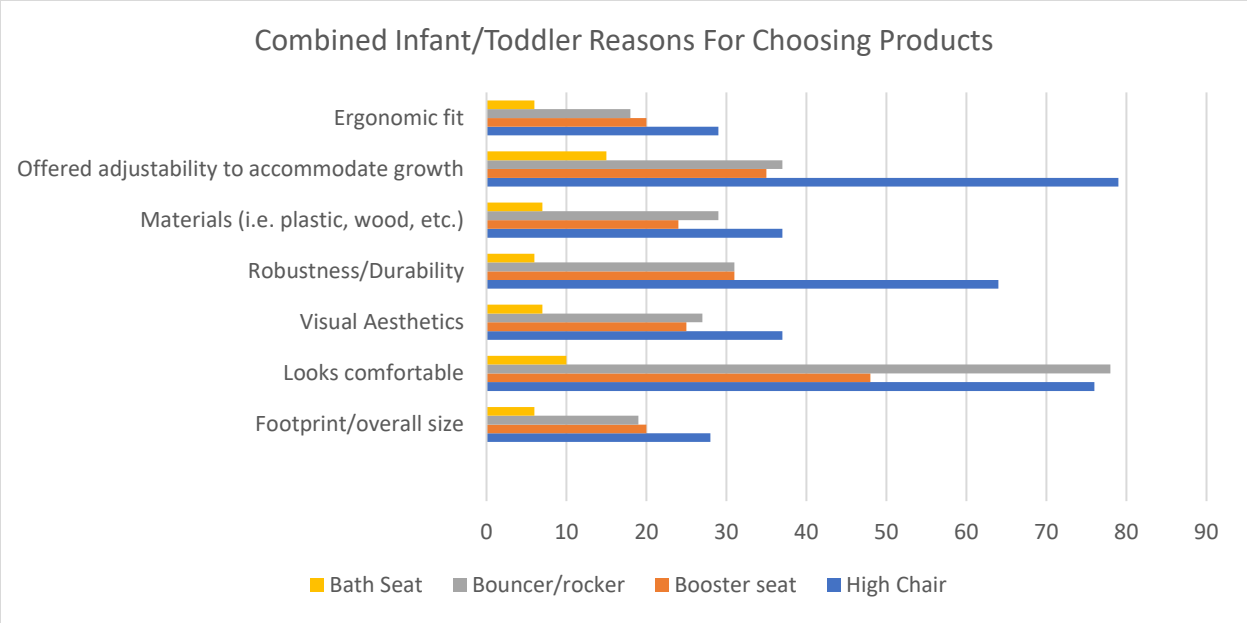


Fig 11. Combined Infant and Toddler Reasons for Choosing Specific Products. "What were your primary reasons for choosing to use this___ for your child? Please select all that apply. (If you have used more than one ____, please answer based on the one you used the longest)"

Table 2. Combined Infant and Toddler Reasons for Choosing Specific Products. "What were your primary reasons for choosing to use this___ for your child? Please select all that apply. (If you have used more than one ____, please answer based on the one you used the longest)"

	High Chair	**Booster seat**	**Bouncer/rocker**	**Bath Seat**
Answer				
Footprint/overall size	8%	10%	8%	11%
Looks comfortable	22%	24%	33%	18%
Visual Aesthetics	11%	12%	11%	12%
Robustness/Durability	18%	15%	13%	11%
Materials (i.e. plastic, wood, etc.)	11%	12%	12%	12%
Offered adjustability to accommodate growth	23%	17%	15%	26%
Ergonomic fit	8%	10%	8%	11%
Total	350	203	239	57

One of the primary reasons for use of a product was “looks comfortable,” however, this does not correspond with the relatively low response rate for perceived uncomfortable-ness as a reason for retirement. Another primary reason parents cited for choosing to use a product was “adjustability to accommodate growth,” however, “my child no longer fit” was the number one reason parents chose to stop using a product. These findings begin to question whether there is a disconnect between parents’ reasons for use versus reasons for retirement of products.

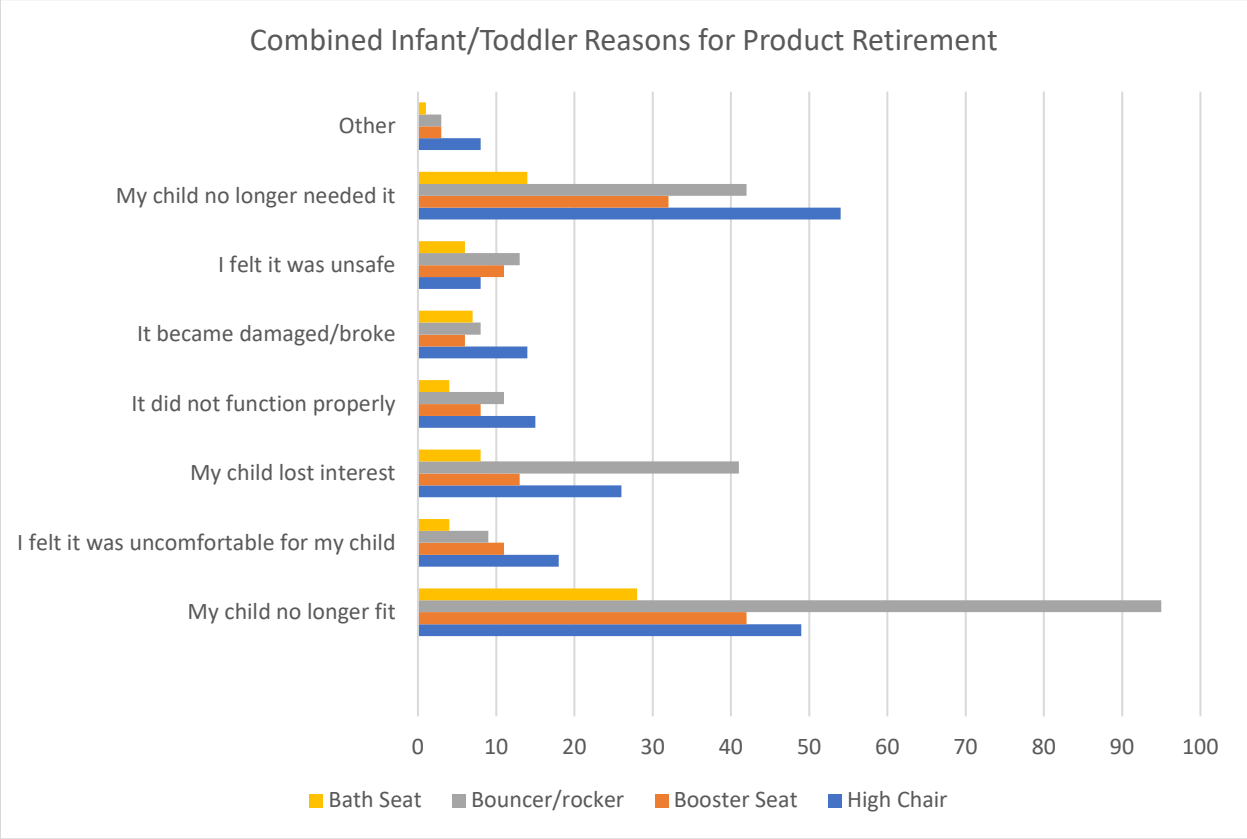


Fig 12. Combined Infant and Toddler Reasons for Product Retirement. “What was the primary reason your child stopped using the ____? Check all that apply.”

Table 3. Combined Infant and Toddler Reasons for Product Retirement. "What was the primary reason your child stopped using the ____? Check all that apply."

	High Chair	**Booster Seat**	**Bouncer/rocker**	**Bath Seat**
Answer				
My child no longer fit	26%	33%	43%	39%
I felt it was uncomfortable for my child	9%	9%	4%	6%
My child lost interest	14%	10%	18%	11%
It did not function properly	8%	6%	5%	6%
It became damaged/broke	7%	5%	4%	10%
I felt it was unsafe	4%	9%	6%	8%
My child no longer needed it	28%	25%	19%	19%
Other	4%	2%	1%	1%
Total	192	126	222	72

Chi Square analysis was used to identify the associations of ratings between the infant and toddler surveys. This allowed for an assessment of whether parents of infants reported similar rankings as parents of toddlers. Most of the factors resulted in similar ratings between the two sets of parents, with three factors, comfortable appearance, aesthetics and material, evoking different ratings based upon a significant Chi Square. In these three cases, it was found that parents of toddlers placed lower importance on these factors. See Tables 4-6 below, which demonstrate the Chi Square analysis. The red cells indicate that these values are significantly different than the green "All" column.

Tables 4-6. Tables of Combined Infant and Toddler General Priorities. "Rank the importance of each of the following factors when choosing to use infant gear, from low importance to high importance."

Table 4.

Rank- Looks Comfortable			
	Infant	Toddler	All
Low	9	5	14
	8.18	4.5	6.33
Medium	22	42	64
	20	37.84	28.96
High	79	64	143
	71.82	57.66	64.71
All	110	111	221

Table 5.

Rank- Visual Aesthetics			
	Infant	Toddler	All
Low	30	19	49
	27.27	17.12	22.17
Medium	45	64	109
	40.91	57.66	49.32
High	35	28	63
	31.82	25.23	28.51
All	110	111	221

Table 6.

Rank - Material			
	Infant	Toddler	All
Low	17	8	25
	15.45	7.21	11.31
Medium	24	43	67
	21.82	38.74	30.32
High	69	60	129
	62.73	54.05	58.37
All	110	111	221

4.2 Manikins

In order to test materials and prototypes, it was deemed necessary to create accurately sized and weighted manikins to represent children. Because products being “infant-to-toddler” has been a focus of the project, two manikins of different “ages” were constructed. One was based on data of 4-6-month-olds, and the other on 19-24-month-olds in an effort to capture the size and weight of a completely non-ambulatory child and a completely ambulatory child.

4.2.1 Data

Infant and toddler body segment sizes were gathered from Snyder’s 1975 survey of anthropometric data. This corresponded with the data used for the body segment parameters, as Jackson (2017) utilized the Snyder data for reference when creating the regression equation for segment mass. All masses were calculated using Jackson’s regression equation and then body segments were sized and weighted accordingly. In a few instances, Snyder had not reported the specific measurement needed, and so data from another reference was substituted.

The Jackson paper defined the regression equation for toddler body segment parameters as %mass = age(a) + b, with coefficients for each segment. The equation was used to calculate segment mass based on the age buckets from the Snyder data, so the mean of 4-6 months (5) was used as well as the mean of 19-24 months (21.5).

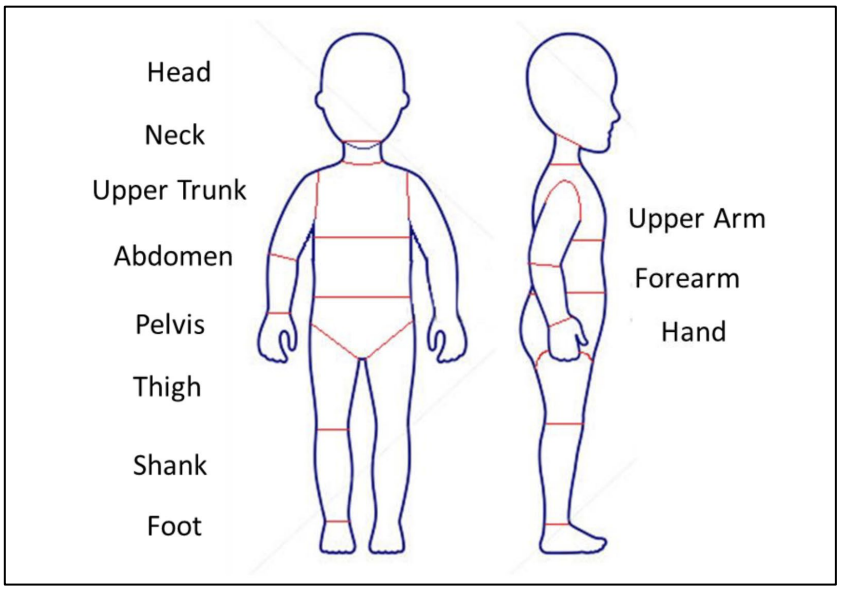


Figure 13. Segmentation boundaries as defined by Jackson (2017)

Table 5: Mass proportion and age linear regression coefficients for males and females combined. %mass = age (a) + b

Segment	a	b	R^2	Correlation
Head	-1.9204	22.321	0.29	-0.54
Neck	-0.0932	1.879	0.02	-0.14
Upper Trunk	0.8415	11.486	0.10	0.31
Abdomen	-0.784	19.371	0.05	-0.21
Pelvis	-0.4769	16.331	0.02	-0.15
Trunk	-0.4195	47.188	0.02	-0.13
Upper Arm	0.3428	1.4884	0.21	0.46
Forearm	0.0152	1.6107	0.001	0.04
Hand	-0.0666	1.0416	0.01	-0.11
Thigh	0.7183	5.0317	0.15	0.38
Shank	0.1834	3.5615	0.12	0.34
Foot	0.0234	1.572	0.001	0.03

Figure 14. Mass proportions and age linear regression coefficients from Jackson (2017)

Table 7. Mean 4-6 Month Manikin Parameters

Segment	Weight (g)	Circumference (cm)	Length (cm)
Head	1506	42.5	14.9
Neck	129	22.1*	6.4**
Trunk	3291	41.1	29.0*
Upper Arm	114	12.9	12.6
Forearm	113	13.1	9.3
Hand	71	4.1**	7.6
Thigh	373	21.6	16.3
Shank	255	15.8	16.7
Foot	111	4.0**	9.4

Table 8. Mean 19-24 Month Manikin Parameters

Segment	Weight (g)	Circumference (cm)	Length (cm)
Head	2228	48.8	17.2
Neck	202	23.4*	6.9**
Trunk	5479	48.2	32*
Upper Arm	248	14.8	17.0
Forearm	193	15.0	12.7
Hand	109	4.9**	9.8
Thigh	746	25.0	23.8
Shank	459	19.3	23.6
Foot	190	5.2**	12.8

**Measurements from Weber (1985)*
***Circumference measurement substituted by width measurement*

Notes for Tables 7 & 8: Manikin parameters for 4-6 month old and 19-24 month old. Ages used to determine weight were 5 and 21.5 months respectively, and circumference and length measurements are the reported mean from the Snyder data.

4.2.2 Construction

Manikins were constructed primarily using heavy duty plastic sheeting, packing tape, and sand. The plastic sheeting was easy to cut using typical scissors into desired shapes, and packing tape adhered well. Sand was typically the correct density and was used to achieve proper weight. When the sand was too dense to fill the required volume, polystyrene beads were used to fill the remaining volume. Lead shot was on hand in case the sand was ever not dense enough, but it was never used.

Using the Snyder data for critical dimensions of segment lengths and circumferences or widths, rectangular “bags” were cut and taped together using the plastic sheeting and packing tape. The bags were left open on one side. Sand was measured out in cups to the appropriate weight (based on Jackson regression) and then poured into the bags. All weights are within 5 grams of weight noted in reference chart, and all lengths are within 0.5cm. If the sand did not fill the bag completely, polystyrene beads were used to fill the remaining volume.

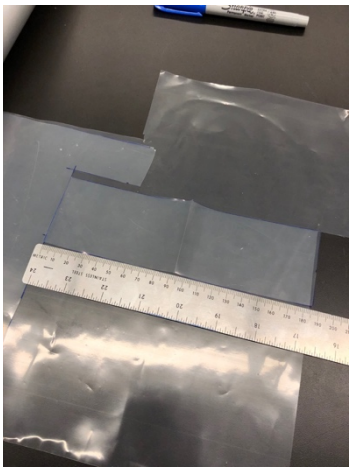


Figure 15. Measuring plastic sheeting

Figure 16. Confirming dimensions after bag is sealed

The bags were then sealed with tape on the final side and weighed once more to confirm the final weight. Each segment was constructed independently and then taped together at “joints,” leaving enough room for bending to occur, simulating a realistic joint.

Figure 17. Weighing sealed bag

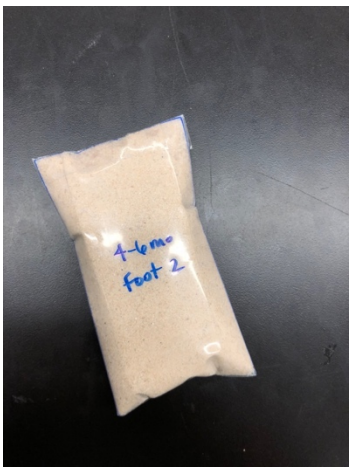


Figure 18. Labeled bag

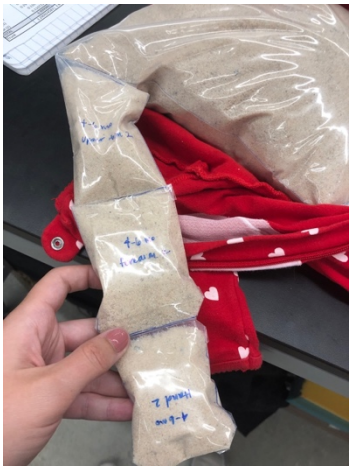


Figure 19. Bags taped together at joints

The head and neck were constructed slightly differently as more shaping was deemed necessary. The neck was constructed as a cylinder, with two circles of the proper circumference and then a long rectangle which was wrapped around and cut to appropriate height. The head was made with a flat pattern with “petals” that were taped together to create a sphere. Generous amounts of tape were used on the head and neck, particularly because the shaping seemed to allow for more sand leakage. Once all segments were constructed and attached together, the mannequins were dressed in onesies with socks over the hands, to contain any small sand leaks as well as protect users from the sharp tape corners.

Figure 20 & 21. Completed manikins- note polystyrene beads in legs and head

Figure 22 & 23. Clothed manikins

4.3 Interviews

4.3.1 Parents and Children

A major additional benefit of collecting anthropometric measurements was the opportunity to interact with parents and children. During or after measurement sessions, parents were asked unstructured interview questions about their experience with rocker-type products. The Kids 2 rocker and a similar Fisher Price rocker were placed in the measurement room in order for parents and children to interact with them. Parents were typically asked whether they did or had ever owned a rocker, how they liked it, and how long they had used it. Children who were not too tired after the measurements were placed in or asked to sit in the rocker.

Most parents had used some product similar to the Kids 2 rocker. If they had not used a rocker, they had a bouncer or swing. The vast majority of parents reported that they stopped using the product (no matter what type) when their child began to sit up and roll over by themselves. Parents were concerned about children being able to roll out or roll over to be face-down. At this stage, around 6 months old, parents typically stop using the product.

It was extremely informative to be able to interact with children during the measurements and view them in the rocker. Taking the measurements allowed researchers to experience the various temperaments and activity levels of children at different ages, abilities, times of day, or moods. Very few children were content to lay still on the measuring table, even very young infants. Children around 12 months old were extremely active. These children had recently learned to walk, and they did not like to be slowed down. The independence and high activity level were of great importance to note. These children were highly mobile but also highly unstable. They were typically able to get in and out of the rocker themselves, but often went in “head first,” as seen in the figures below, rather than sitting down as an adult would, with the chair behind them.

Figures 24-26. 13-month-old child interacting with Fisher Price rocker

4.3.2 Pediatric Occupational Therapist

To supplement the reported experiences of parents, an expert in child development was consulted. Dr. Jaclyn Maxwell, PT, DPT, of Sunshine Pediatric Therapy, LLC, a pediatric occupational therapist, was interviewed. Dr. Maxwell's experience was particularly useful to understand what physical milestones a typically developing child would be meeting, and what affordances might be useful for infants with low muscle tone. Dr. Maxwell explained that the natural progression of development for infants is to gain head and neck control, then the ability to sit up, the ability to roll and bring upright into a sit, then the ability to crawl, then cruise, then walk. She emphasized two important takeaways: children who are able to use certain muscles should be encouraged to use them and further develop muscle control, and children who have not yet gained the muscle strength and control should be positioned properly to encourage proper and even development. For example, once children have gained the neck muscle to control the head, they should practice this skill by having the head unsupported for some periods of time. Alternatively, infants who have not yet gained the neck strength to hold up their head should be supported in a symmetrical posture, so that muscles develop evenly on both sides of the neck.

Other helpful feedback included advice on the mobility of toddlers. Toddlers should be encouraged to be independent when possible so they continue to learn new skills. In sitting, this means they should be supported with an upright back and knees bent with feet on the floor, so they can learn to "back into" a chair as an adult does.

CHAPTER 5

DESIGN

5.1 Stakeholders

Stakeholders were revisited before beginning conceptual development. Identifying key stakeholders and their roles also helped when determining design criteria. This was particularly useful in this project because the primary users of the device being designed (infants and toddlers) are not the purchasers and therefore the perception of the parent is extremely important for the success of the device. Parents are the purchasers but also will use the device adjustments and will be responsible for cleaning, maintaining, and positioning the device. Though the infants and toddlers are the ones actually sitting in the rocker, the parents must be considered as equally important because of the dependent nature of the children's use.

Kids 2, as the manufacturer, must also have its input and needs considered. While this project is meant to be an improvement and a departure from the current infant-to-toddler rocker design, Kids 2's manufacturing methods and market insights must be included when making design decisions. Below is a table which details the involved stakeholders, including children, parents, and the manufacturer.

Table 9. Stakeholders and their Role

Stakeholder	**Role**
Infants and toddlers	Primary user of rocker, will sit and play in rocker, sizing and features based on infant and toddler anthropometry and activities. Requirements must be considered for size and development of children 0-36 months old
Parents	Purchasers of rocker, user of rocker adjustments, may transport rocker. Parent usability and perception must be considered in design criteria, since they will be electing to use the device and will need to adjust and position it properly for their child
Siblings	May use rocker even if too old, may adjust or move rocker. Particularly older siblings must be considered when designing for stability and safety
Kids 2	Manufacturer. Input related to manufacturing methods, marketing strategies, cost, and brand language must be considered

5.2 Design Criteria and Requirements

5.2.1 Design Criteria

Design criteria were established based on the information gathered during needfinding. This included interviews with parents, observations of children and their interactions with toys and gear, survey data, and expert interviews. The criteria were divided into categories and ranked in importance. See the list below of all design criteria. Criteria were vetted by the project contact at Kids 2. Suggested changes included reducing focus from cost, and homing in on which criteria were most important to the project goals.

<u>Design Criteria</u>

Legend:
** = High Importance
* = Medium Importance

User Criteria
- Infants and toddlers
  - ** Accommodates children within the age range of 0-36 months old
  - ** Allows for independent ingress and egress of toddlers
- Parents
  - Easy to assemble
  - Easy for parents to secure infants with one hand
  - ** Easy for parents to adjust device when transitioning from infant to toddler (and back to infant)

Market Criteria
- Product should be priced competitively with other Kids 2 or Fisher Price products of a similar type

Ergonomic Criteria
- ** Utilizes existing and self-collected anthropometric data for proper seat dimensions
- ** Provides postural support for infants in semi-recumbent stable position, including prevention of rolling over
- * Provides head support to prevent plagiocephaly of infants, particularly those with low tone or developmental delays
- ** Provides functional upright, active seated posture for toddlers
- Adjustable support for children of different sizes

Functional Criteria
- Minimize removable components
- Offers stable base across child size and body mass
- Offers comfortable recumbent posture for infants, i.e. different angles of recline to accommodate different levels of postural and head control

- Allows for independent ingress and egress of toddlers
- Provides rocking motion within both infant and toddler configurations
- ** Able to adjust from infant-to-toddler configuration and toddler-to-infant configuration

Material and Physical Criteria

- * Easily cleanable
- Fabrics are soft to the touch
- Breathable (does not retain body heat)
- Minimize footprint without compromising stability
- Easily collapsible for storage or relocation
- Lightweight

Manufacturing/Production Criteria

- Compatible with flat-pack shipping
- Utilizes existing Kids 2 manufacturing techniques

Aesthetic/Emotive Criteria

- Appears comfortable to parents
- Appealing to toddlers
- Utilizes Kids 2 visual brand language

Jurisdictional Criteria

- Consumer Product Safety Commission references several:
- ASTM F3084—18 Standard Consumer Safety Specification for Infant and Infant/Toddler Rockers
- ASTM F2613—17a Standard Consumer Safety Specification for Children's Chairs and Stools
- 16 CFR Part 1501 - Method for identifying toys and other articles intended for use by children under 3 years of age which present choking, aspiration, or ingestion hazards because of small parts

5.2.2 Design Requirements

Design criteria were distilled into the design requirements after careful consideration of what was most imperative for the seat function. While the design criteria were broader, and about the device in general, design requirements were very specific and focused on the seat itself, as this is the focus of this project. See Table 10 for the list of design requirements. The table is divided into the requirements for infants and toddlers. Often the requirements for the two age groups were in opposition. For example, infants require full leg support to accommodate long sitting, while toddlers require a seat depth which supports short sitting, with knees able to bend comfortably and feet contacting the floor.

Table 10. Design Requirements

Infants	**Toddlers**
Envelopment	Ability to crawl in or cruise around
Full head support	Head clears seat frame
Full leg support for children up to ~12 m/o	Seat depth supports feet on floor/short sitting
Maintain axis of symmetry (trunk and head)	No popliteal pressure
Semi-recumbent posture	Seat height facilitates independent ingress/egress
Avoid “slipping down” in seat	Active sitting posture
145 degree maximum seat-back angle	105-110 degrees seat-back angle

5.3 Materials Research

Materials research was conducted into various options for postural support materials. These materials were explored to find a solution which offered a high level of envelopment for the infants but was not too restrictive for the toddlers. EPP beads, foam, and viscous fluid were the main materials investigated. The EPP beads were found to have a good compression under weight (even low weight) and the fluid was very successful in the ability to mold or be molded around a body. Viscous fluid was mixed by the researchers, in 2- or 3-part combinations. Most tests included mineral oil, glass microballoons, and EPP beads. Materials were tested with the weighted manikins.

Figure 27. EPP beads

Figure 28. 2- and 3-part fluid tests

5.4 Concept Development

5.4.1 Concept Generation

Concept generation began in earnest after the solidification of the design requirements. The ideas were informed by the requirements, but also by all the insights gained from the interviews with parents and experts, survey results, and interactions with children. In particular, the observations of children in the current Kids 2 rocker were extremely inspirational. The researchers noted that the current product did not seem to serve the toddlers nearly as well as the infants, and many concepts had to do with improving the design to better serve toddlers.

Ideation was paired with sketching and rapid prototyping. All ideas were documented in visual form with a sketch, and many concepts which involved moving parts were quickly modeled with cardboard or foam core. At this stage, no ideas were ruled out and all concepts were considered. Requirements of size were not taken into account at this time, and researchers focused on the more basic functional aspects, such as how it would move and basic shapes.

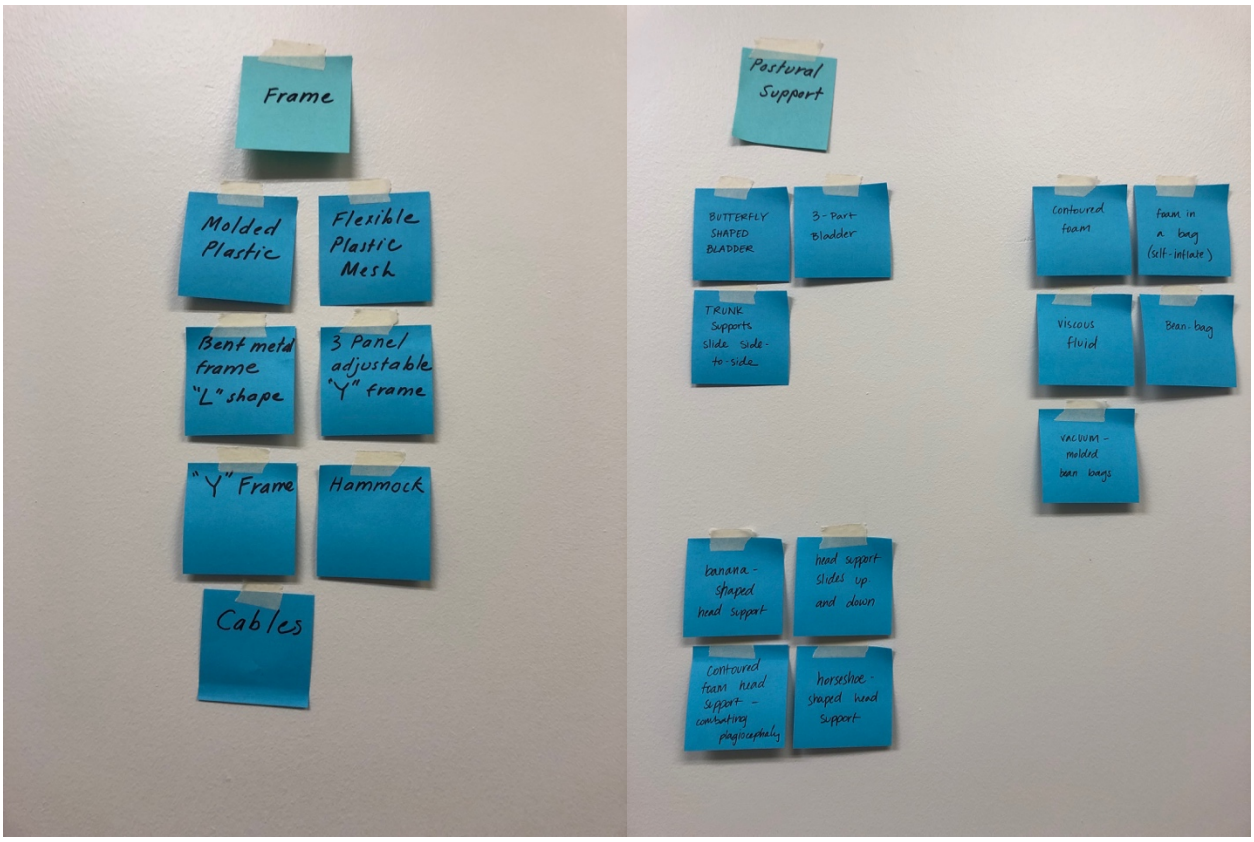
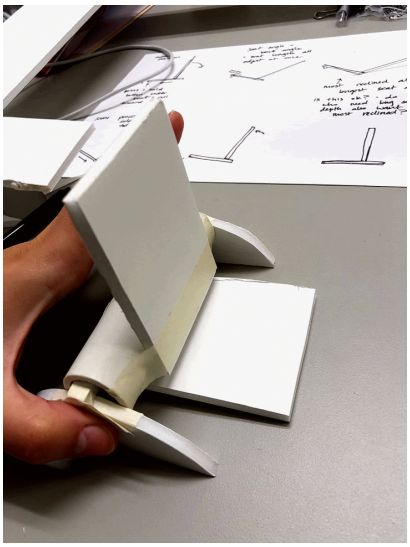
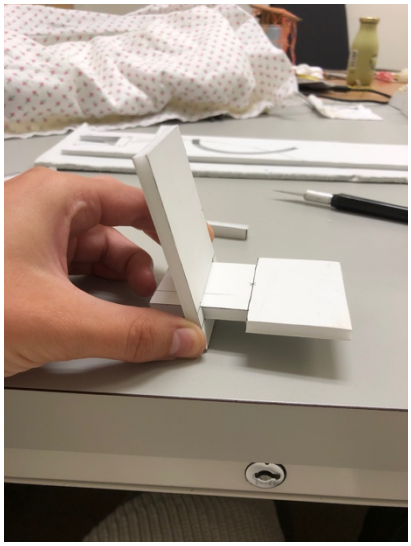


Figure 29. Ideation with sticky notes





Figures 30-32. Low fidelity prototypes

5.4.2 Concept Organization

Most concepts focused on one aspect of the design, and researchers found it useful to categorize the ideas. Concepts were divided into three main categories: frame, postural support, and size or angle adjustments.

Figure 33. Sketches organized into categories

The frame category refers to concepts about the structure of the seat and how it integrates with the rockers. The current product has a very clear delineation of frame and soft goods, where the rockers and overall seat shape are constructed of bent aluminum tubing and the seat itself is constructed of a soft hammock. Frame concepts explored whether this method

was most successful and what options would be available if other materials were used. Particularly, what if the seat had more underlying structure? How would this integrate into the frame which connects to the rockers?

The postural support concepts explored potential materials, as well as shapes and placement of supportive bladders. Material exploration had been taking place for some time prior, but the focus up to this point had been on testing various recipes for two- or three-part viscous fluid. At this time, material exploration expanded to include other materials like EPP and foam. Also, size, shape and placement of the bladders was iterated upon. Models of these concepts were often made at full-size in order to be tested with the weighted manikins in the current Kids 2 rocker.

Figure 34. Foam postural support with manikin

Figure 35. EPP bladder/hammock concept

Figure 36. Segmented EPP and foam bladder

Figure 37. Thermarest lumbar support pillow

Figure 38. Space Saver bag filled with EPP beads

Adjustments was the category which was most challenging to researchers but also perhaps the most crucial to meeting the design requirements. This is because the requirements for infant and toddler were often the complete opposite. This meant solutions involved major size adjustments in order to accommodate both infants and toddlers. Angle adjustments were more straightforward, but ideas were generated as to how the adjustment might work.

Figure 39. Foldable kickstand concept

5.4.3 Concept Refinement

After concepts were categorized, ideas from each category were synthesized into two complete seat concepts. One was a structured hammock design, and one was a rigid base design. Both concepts included the same size adjustments and angle adjustments, but the two concepts used different frame construction and postural support.

At this time, parallel prototyping began. The rigid base concept was pursued by Caitlin Ryan, and the structured hammock prototype is what will be discussed for the remainder of this paper.

The structured hammock was a frame made of telescoping tubes to adjust size, and postural support bladders filled with EPP beads. This concept was partly inspired by a wheelchair design which had a structured but flexible back which could fold down in order to change the size. (Figure 40.) The rationale behind this type of construction method is that the hammock would deform enough to wrap around the body of the infants and provide adequate envelopment, but be sturdy enough to maintain a symmetrical posture and accommodate the active sitting of toddlers. Initial proof-of-concept models were constructed out of PVC pipes. (Figure 41.)

Figure 40. Wheelchair inspiration for structured hammock concept

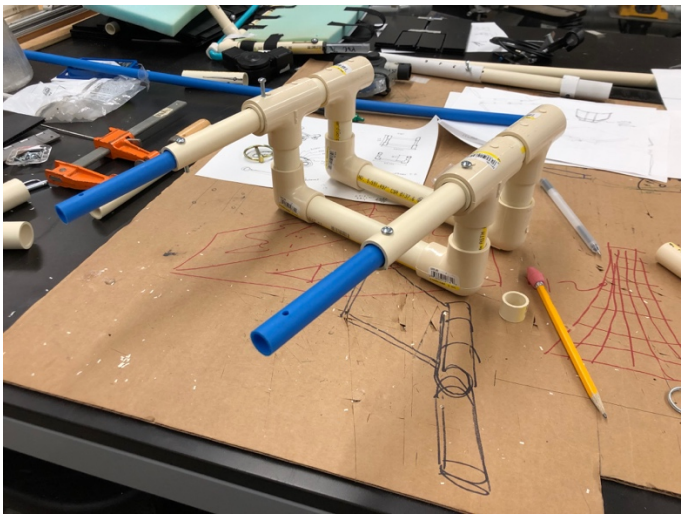


Figure 41. PVC concept model for telescoping frame

5.5 Prototype

When beginning to construct the prototype, it was necessary to revisit the anthropometry to ensure proper sizing was used. Each critical seat dimension was based on anthropometric data. Data collected by the researchers was used whenever possible, however, some necessary measurements were not collected during this project. The aggregated data file of child anthropometric measures, which was created at the start of this project, was consulted whenever additional measurements were needed.

Three sizes for the back and the seat were tested. The smallest size was intended for the toddlers, who require a seat which allows their feet to rest comfortably on the floor, the medium size was for very small infants, and the largest size was for the larger infants who still need full head and leg support.

The prototype was constructed with the intent to test seat and adjustment sizing with children. Thus, the focus of this prototype was that the basic seat size and shape were correct in order to evaluate with children. The prototype was constructed in the shop within the

REARlab; no parts were digitally fabricated at this time. Key features besides critical dimensions included frame and seat construction materials and postural support bladders.

Postural support bladders were manufactured by Applied Rf Technologies (ART) per our specifications. Urethane bladders were used to house the EPP beads, although this may not be necessary in production.

The prototype did not include soft goods. The seat base was topped with postural support bladders, and no additional sleeve was added at this time, in order to better view child fit in the bladders during evaluation. Rockers from a Fisher-Price rocker were used to create the sides of prototype, but rocking motion was halted with stops in order to only analyze the seat fit during testing.

The prototype did include size and angle adjustments, but not at production fidelity. Parent usability was not tested in this round of evaluation; only child fit and parent perception of fit were evaluated.

Figure 42. Structured hammock prototype in infant (largest) size

Figure 43. Detail of back – telescoping tubes visible

CHAPTER 6

PROTOTYPE EVALUATION

The purpose of prototype evaluation at this stage was to test the efficacy of the prototype materials, i.e. structured hammock with EPP bladders and the size and angles, including adjustments. The goal was to be able to move forward to a final design after observing children in the predicted size and shapes; additionally, parent feedback could be used to improve designs.

As stated previously, the driving factor in the prototype creation was use of the anticipated materials and careful consideration of seat dimensions, in order to evaluate if sizing was correct, as well as whether the included size and angle adjustments were necessary. Much of this evaluation could be performed simply by researcher observation of children in the devices. For example: do infants have full head and leg support and maintain a symmetrical position? Are toddlers able to get in and out independently and have feet resting comfortably on the floor while seated? However, it is also extremely important to gather parent feedback of their perception of children in the rocker. While infants and toddlers are the primary user, parents are the ones who make the purchasing decisions and choose which products to use for their child. If parents do not believe the rocker looks comfortable, it will not be bought or used. Therefore, it is important during evaluations for researchers to take notes on whether sizing is correct, but also to ask parents how they think their child looks in the device, as well as how likely they are to use the provided size and angle adjustments.

6.1 Prototype Evaluation Methods

Before participant arrival, the evaluation room was arranged properly. At this time, the other prototype which had been being constructed in parallel was also tested in order to be most efficient. The Kids 2 rocker and both prototypes were displayed prominently in the room with room for children to get in and out. A smartphone which was used for filming was situated so that it would be able to capture images of all three devices.

Figure 44. Room set-up for prototype evaluations

When parents arrived, the information sheet was talked through and photo and video consent form signed. These documents had previously been emailed to participants for review before their arrival. The information sheet explained basic procedures, that children would be either placed or asked to sit in the Kids 2 rocker and the two prototypes, and parents would be

asked unstructured interview questions about their observations or predicted use of the devices. Once any parent questions about procedure were answered, protocol could commence.

For infants, parents were asked to place their child in the Kids 2 rocker and position them so they looked comfortable. Toddlers were encouraged to get in on their own. Parents were then asked how they thought their child fit in the rocker and whether they looked comfortable. This basic procedure was repeated for the two prototypes. For the prototypes, parents were walked through the size and angle adjustments, and the devices were adjusted by the researchers based on the child's age.

Parents were asked about their perception of fit and comfort while their child was in each seat. Additionally, parents were asked about their anticipated use of the size adjustments and angle adjustments. Interview topics also covered how long they anticipated their child using the device, whether they would keep it around for a second child, and whether they would prefer integrated adjustments or breakaway modular pieces for the size adjustments. Bladder materials were presented to parents in order to get feedback, and samples of surface materials were discussed. Researchers also tried to tease out what the term ergonomics meant to the parents and how this term might influence their perception of the product.

6.2 Prototype Evaluation Conclusions

Based on this testing, many design decisions were solidified. Dimensions were able to be confirmed in order to move forward, and parents provided feedback about perception of comfort which could inform the overall shape of the device.

Based on observations, and parents' expression of fit, the size adjustments were reduced to two instead of three. The infants fit properly with head and feet support in the largest size. Toddlers fit properly in the smallest size of the seat, but the medium size was more appropriate for back height. There was no evidence to suggest that parents desired the third size for small infants.

Figure 45. 6-month-old infant in structured hammock prototype, largest size, back most upright

Figure 46. 24-month-old child in structured hammock prototype, back at smallest size and most upright

Seat height was deemed appropriate based on toddler use, and parents seemed to notice this as a distinct advantage for ingress and egress over the Kids 2 rocker. Seat width needed to be somewhere in between the two prototypes, but the gap between the seat and rockers, which was simply due to prototype construction methods, may have affected parent perception. Parents responded positively to the angle adjustment options, particularly for infants who were around 6 months, who were trying to sit up on their own. The upright angle with the long leg length allowed them to remain secure, and parents to feel they were stable, but allowed the infants to look around the room.

CHAPTER 7

DESIGN CONCLUSIONS

7.1 Design Specifications

The prototype evaluation allowed the dimensions and requirements of the seat to be solidified. The size adjustments were reduced to two each for the seat and back instead of three, and the seat width was adjusted slightly. Seat height and angles were found to be successful during testing and remained unchanged. Final design specifications are found in Table 11 below.

Table 11. Final Design Specifications

Seat Part		**Seat Measurement**	**Anthropometric Measurement**	**Rationale**
Seat depth	Infant	40cm	Rump to sole*, 10-12 m/o: mean: 34.5 (std dev: 1.6)	Used 10-12 m/o 95th %tile is 36.8 cm + 3 cm ease
	Toddler	20cm	Buttock to popliteal**, 9-11.9 m/o: mean: 16.8 cm (std dev: 2.0) 2.0-2.9 y/o: mean: 24.4 cm (std dev: 1.7)	Used average of 10-12 m/o and 2 y/o mean = 20.6 cm; erring on the small side to avoid popliteal discomfort in smaller children
Seat back height	Infant	41cm	Seated Height, 7-12 m/o: mean: 47.2 cm (std dev: 2.3)	Used maximum reported measure from 7-12 m/o; 51 cm; size reduced based on manikin testing
	Toddler	30cm	Seated shoulder height, 13-18 m/o: mean: 31.3 cm (std dev: 1.4)	Used minimum reported measure from 13-18 m/o; 29.5cm; size adjusted based on prototype evaluations
Seat height from floor		17cm	Popliteal height**, 12-14.9 m/o: mean: 15.7 cm (std dev: 1.2) Popliteal height seated**, 2.0-2.9 y/o: mean: 22.4 cm (std dev: 1.6)	Used average of 12-15 m/o and 2 y/o mean = 19.1 cm; 2 cm less than average to increase ease of ingress/egress for younger, unsteady walkers

Seat width	34cm	Hip breadth, 31-36 m/o: mean: 18.7 cm (std dev: 1.0)	Used maximum reported measure from 31-36 m/o; 20 cm; + 7 cm ease on both sides; size adjusted based on prototype evaluations
Back width	34cm	Chest breadth, 31-36 m/o: mean: 17.5 cm (std dev: 1.3)	Used maximum reported measure from 0-36 m/o; 19.4 cm; + 7.25 cm ease on both sides; aligns with width of seat
Seat to back angle	3 positions within 108 (upright) – 144 (semi recumbent) degrees		105 degrees = standard upright chair; 145 degrees = max recline recommended for infants
Seat angle (toddler)	5 degrees		10 degrees = max for upright active sitting

*Data from 1975 Anthrokids; this measure not collected during this project
**Data from 1993 Steenbekkers; this measure not collected during this project

7.2 Parent Usability

At this point, the sizing in relation to the infants had been finalized, so the mechanisms for parent usability of the adjustments must be considered. The prototype evaluations focused on proper sizing and adjustment for the children, and did not attempt to resolve the issue of parent usability of the adjustments.

The rocker was modeled in cardboard in accurate final dimensions in order to quickly mock up the adjustment interactions. Parent ease of use was considered highly important for the success of the product. The carboard model allowed researchers to “practice” using the adjustments and make fast changes. The interactions that needed to be addressed were the angle adjustment and the size adjustment. The angle adjustment was anticipated to be used more frequently, and so usability priority was placed on the angle adjustment over the size adjustment. The size adjustment would be used very infrequently, only when the child outgrows the infant size, or it needs to be positioned back to infant mode for a different child. See Figure

47 below of the carboard model with foam affordances, created to understand the hand positioning required for angle adjustment.

Figure 47. Carboard Model of Angle Adjustment Interaction

Regarding the angle adjustment, the most important factor was the parent maintaining control of the back as it moved. Figure 47 shows the concept of moving the release button to the rear side of the chair back, so that parents could release the mechanism while also holding onto the back.

The size adjustment had more flexibility in the mechanism aside from telescoping now that it had been reduced to two sizes instead of three. Thus, a folding part was deemed simpler and less likely to become jammed over time. The folding mechanism was also mocked up in cardboard so researchers could test the interaction. (See Figure 48 below.)

Figure 48. Carboard Model of Size Adjustment

7.3 Design Conclusion

The final design was a culmination of insights from the survey, interviews, and prototype evaluation, as well as final concepts related to parent usability. The final design is a rocker which adjusts in size and seat-to-back angle to accommodate infants and toddlers and their respective mobility levels. It is easily adjusted by parents and is simple to transition from infant to toddler and back to infant.

The final design includes a tubular metal seat frame, which attached to wooden rockers. The metal frame holds a nylon hammock, which is bolstered by thin sheets of semi-rigid plastic.

The EPP bladders are Velcro-ed on top, and the entire seat is covered by a slip cover. See Figure 49 and 50 of the rocker with and without the slip cover.

Figure 49. Rocker without slip cover; nylon hammock, plastic sheets, and EPP bladders visible

Figure 50. Rocker with slip cover

The angle adjustments are attached to the seat back, so that parents have a secure grasp of the seat back as it is reclined. See Figure 51 below. The yellow button is depressed to release the locking mechanism, and it indexes into 3 different angles.

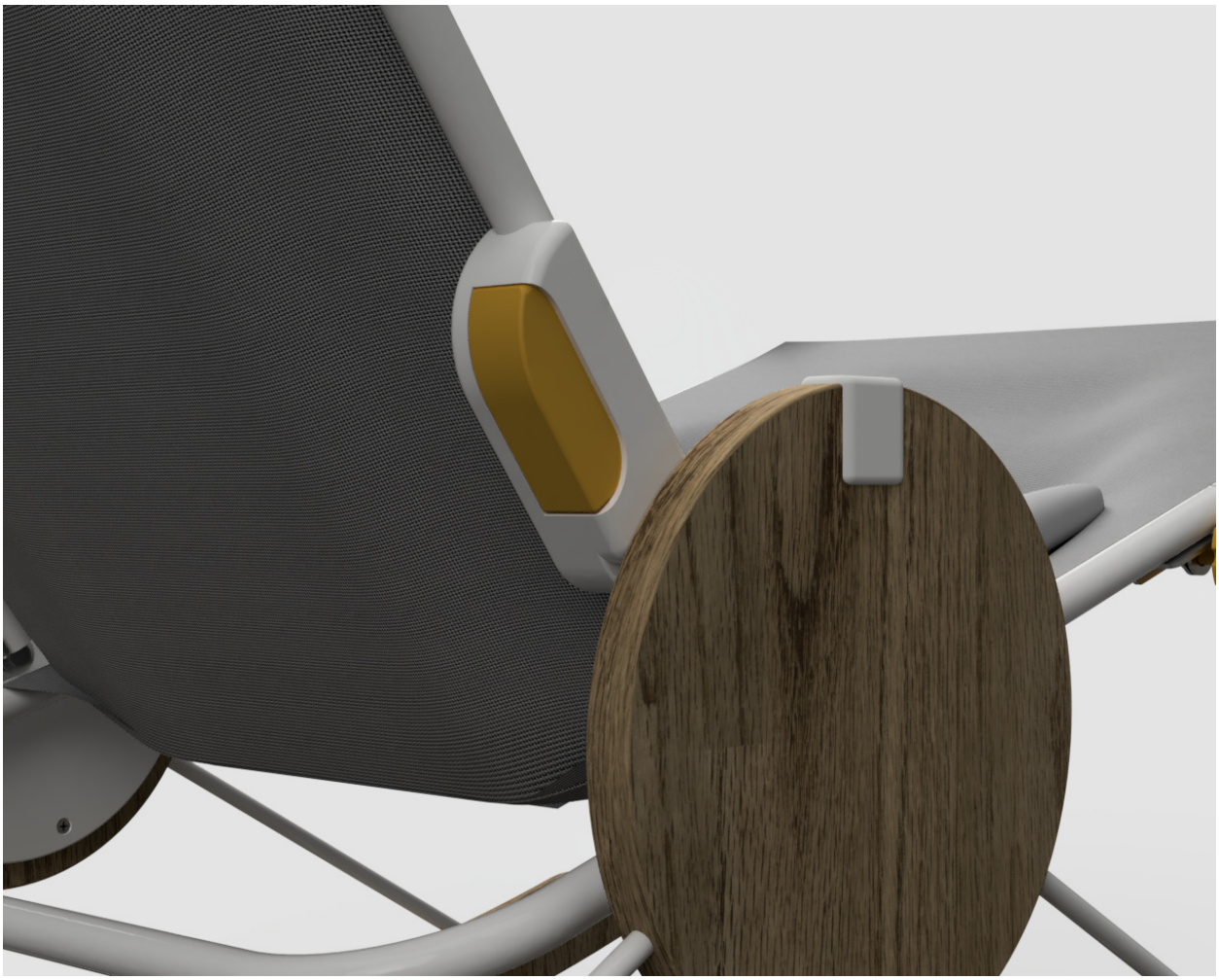


Figure 51. Rocker angle adjustment handle

In the final design, the toddler positioning is meant to be used in conjunction with the kickstand, which will decrease the seat angle and ensure stability for unsteady walkers or crawlers.

A “works-like” prototype was constructed in order to demonstrate the moving adjustments. This prototype has similar mechanisms to the final design, and is constructed using similar materials. No slip cover was made for the prototype. The figures below demonstrate how the adjustments work, for both the angle and the back and seat sizes. Prototype was constructed using design specifications, so sizing is accurate.

Figure 52. Rocker prototype in infant configuration: large sized seat and back, maximum recline

Figure 53. Rocker prototype in toddler configuration: small sized seat and back, most upright back position, kickstand engaged

Figure 54. Rocker prototype demonstrating parent use of back angle adjustment

7.4 Future Considerations

If more work was able to be completed on this project, it would be ideal to do further user testing, and have greater input from the sponsor and manufacturer, Kids 2, on manufacturing methods. In order to take this product to market, further user testing should be performed with a high fidelity prototype which can also be used to test the parent usability of adjustments and parent perception of the final visual of the product. Kids 2 should be consulted in order to understand the feasibility of proposed materials and mechanisms in manufacturing. Also,

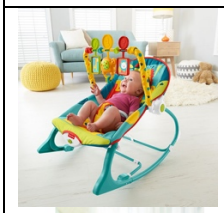
engineers and safety teams should be contacted to ensure that proposed adjustment mechanisms could not be improved or use existing Kids 2 parts. A pinch point was identified in the prototype and corrected in the CAD model, but a thorough safety check should be undertaken.

APPENDIX A

PRIOR ART

Table 12. Prior Art Review of Infant and Toddler Seating Gear

Product Image	Product Name	Manufa-cturer	Product Info	Notes
	Nomi Baby/High chair/Chair	Evomove	- From newborn to teenager - Including baby in family mealtime (no tray) - Adjustable height foot rest and seat - Designed by Peter Opsvik - Promotes active sitting	- Very large age range - Focus on support and positioning – footrest and infinite adjustment knobs - “Active” sitting – appropriate for toddlers
	Tripp Trapp Chair	Stokke	- From newborn to toddler, supports up to 242 lbs - Including baby in family mealtime - Adjustable height foot rest - Designed by Peter Opsvik	- Very large age range - Easy adjustment without tools
	Trio 3-in-1 High Chair™ - Moreland™	Ingenuity Kids 2	- 6 months to 5 years old - Booster and toddler chair – accommodates two children at once - Up to 50 lbs	- Infant to toddler - Modular pieces fit together/come apart for different ages/multiple children

	Table2Table ™ Premier Fold 7-in-1 Highchair	Graco	- Stage 1: Infant highchair reclines - Stage 2: Fully featured highchair with a machine washable seat pad - Stage 3: Infant Booster - Stage 4: Portable toddler booster - Stage 5: Toddler Chair - Stage 6: Toddler table and chair - Stage 7: Toddler Chair and Booster allow you to seat 2 children simultaneously - Foldable for storage - High Chair – 40 lbs limit - Booster/toddler chair – 60 lbs	- Infant to toddler - Lots of modularity - Accommodates two children at once
 	Infant-to-Toddler Rocker	Fisher-Price	- Infant to toddler - Max weight: 40 lbs - Kickstand fixes in full recline	- Infant to toddler - Toddler not touching back rest/sitting forward
 	Infant-to-Toddler Rocker	Fisher-Price	- Infant to toddler - Max weight 40 lbs - Kickstand fixes in full recline	- Infant to toddler - Toddler not touching back rest/sitting forward

	Winnie the Pooh Happy As Can Bee Infant to Toddler Rocker™ from Bright Starts	Bright Starts Disney Baby Kids 2	- Infant to Toddler - Up to 40 lbs - 2 recline positions for baby - Kickstand fixes seat upright	- Infant to toddler - Too reclined for active toddler
	Bouncer Bliss	BabyBjorn	- 8-29 lbs, about 0-2 years - Ergonomic design – “gives good support to your baby’s back, neck and head. The fitted fabric seat distributes your baby’s weight evenly, which is particularly important for newborn babies” - 3 recline angles/positions - turn fabric cover around when baby has outgrown harness	- Advertised as ergonomic and supportive - Infant to toddler but max age/weight is younger than other models - Too reclined for active toddler - Issues with toddler getting in and out independently because of solid base/ feet not touching floor
	Floor Seat	Bumbo	- 3-12 months old, for babies who cannot sit up unaided - “deep seating surface, elevated leg openings, gently reclines baby”	- Extremely short lifespan – only meant for children learning to sit up
	Sit-Me-Up Floor Seat - Frog	Fisher-Price	- “Use only with a child who is able to hold head up unassisted and who is not able to climb out or walk.” - Max weight 25 lbs - Foldable/portable	- Short period of use – only intended for children who are learning to sit

   	3-in-1 Spin & Sort Activity Center	Fisher-Price	- Seat spins - 3 stages of use – sit-in, detached toys for floor sitting, table with shape sorting for walking children - Moveable/removable toys	- Positive reviews about stages of use – older children/sibilings are still interested - Raised but sit-in aimed at children not even sitting up independently, whereas jumpers seem designed for those who can already sit - Note room around baby in aerial photo
  	4-in-1 Step 'n Play Piano	Fisher-Price	- 4 stages – play mat, spinning seat entertainer, spinning and “walking” entertainer, seat removed for free walking -Use when child can hold head up unassisted, do not use seat once child can walk/climb out - “Developing coordination and gross motor skills”	- Online review from mom with hypotonic child: wishes seat height was adjustable, her child needed the seat support longer, but developmentally was good - Truly meant to accommodate the transition from infant to toddler
  	3-in-1 Sit-to-Stand Activity Center	Fisher-Price	- 3 stages – floor mat, sit-in spinning seat entertainer, slide attachment to replace seat for toddlers - 3 adjustable height positions - Removable legs for storage	- Transition from sitting/spinning to cruising around the exterior of table

	Explore & More Baby's View 3-Stage Activity Center	Skip Hop	- 4 months + - 3 stages - “Floor” is height adjustable - Toys are clip-on, easily movable/removable - Seat spins 360 degrees - Includes suction snack bowl -Legs removable for storage - Foot piano buttons	- Foot support adjusts height rather than seat height changing - Foot support platform is not bouncy according to online reviews - Transitions past activities for cruisers – have toddler chairs to match once changed to empty table

APPENDIX B

SURVEY

Infant (0-12 months) Survey

Start of Block: Intro

This survey is being released by graduate students in the School of Industrial Design at Georgia Institute of Technology. It aims to gather information about children 0-12 months in order to improve the ergonomic design of infant gear. In this survey, infant gear refers to products in which your child sits or lies; for example, bouncers, rockers, high chairs, and bath seats.

This survey will take 10 minutes or less to complete and your responses will be completely anonymous.

If you have any questions or concerns related to the survey or the project please email **rearlab@design.gatech.edu**.

End of Block: Intro

Start of Block: Preliminary Question

Q1 Do you have a child between the ages of 0-12 months?

- ○ Yes (1)
- ○ No (2)

Skip To: End of Block If Do you have a child between the ages of 0-12 months? = No

End of Block: Preliminary Question

Start of Block: Demographics

Q2 What is your age?

- 18 or younger (1)
- 19-25 (2)
- 26-35 (3)
- 36-45 (4)
- 46-55 (5)
- 56-65 (6)
- 65 or older (7)

Skip To: End of Block If What is your age? = 18 or younger

Q5 What is your preferred gender identification?

- Male (1)
- Female (2)
- Non-binary (3)
- Prefer not to answer (4)

Q4 What is your current marital status?

- Single, never married (1)
- Married or domestic partnership (2)
- Widowed (3)
- Divorced or separated (4)

Q6 What is your highest level of education completed?

- ○ Less than high school degree (1)
- ○ High school degree or equivalent (e.g., GED) (3)
- ○ Some college but no degree (4)
- ○ Associate degree (11)
- ○ Bachelor degree (7)
- ○ Graduate degree (8)

Q7 How many children do you have?

- ○ 1 (1)
- ○ 2 (2)
- ○ 3 (3)
- ○ 4 (4)
- ○ 5 (5)
- ○ 6 or more (6)

End of Block: Demographics

Start of Block: Children Demographics

Q96
For the duration of this survey, please focus on answering about your child who is between the ages of 0-12 months, even if you have other children outside of this age range.

Q8 How old is your child?

- 0-3 months (1)
- 4-6 months (2)
- 7-9 months (3)
- 10-12 months (4)

Q96 Has your child started walking independently?

- Yes (1)
- No (2)

Q9 Has your child had any developmental delays that affect their postural stability? (i.e. delays that have affected their ability to sit or stand up)

- Yes (1)
- No (2)
- I'm not sure (3)

End of Block: Children Demographics

Start of Block: Important Factors

Q13 Rank the importance of each of the following factors when choosing to use infant gear, from low importance to high importance.

	Low Importance (1)	Medium Importance (2)	High Importance (3)
Price (1)	○	○	○
High Quality (5)	○	○	○
Footprint/Overall size (2)	○	○	○
Looks comfortable (3)	○	○	○
Visual Aesthetics (4)	○	○	○
Robustness/Durability (6)	○	○	○
Material (i.e. plastic, metal, wood, fabric type, etc.) (7)	○	○	○
Adjustability to accommodate growth (8)	○	○	○
Ergonomic fit (9)	○	○	○

End of Block: Important Factors

Start of Block: Gear - High Chair

Q51

Q21 Are you currently using a high chair for your 0-12 month old child? (Example pictured above)

- ○ Yes (1)
- ○ No (2)

Skip To: Q97 If Are you currently using a high chair for your 0-12 month old child? (Example pictured above) = No

Q88 Approximately what age was your child when you began using the high chair?

- ○ 0-3 months (1)
- ○ 4-6 months (2)
- ○ 7-9 months (3)
- ○ 10-12 months (4)

Q22 Approximately how long has your child used the high chair?

- ○ Less than a month (1)
- ○ 1-2 months (2)
- ○ 3-6 months (3)
- ○ 7-12 months (4)

Q65 What were your primary reasons for choosing to use this high chair for your child? Please select all that apply. (If you have used more than one high chair, please answer based on the one you used the longest)

- ☐ Footprint/overall size (1)
- ☐ Looks comfortable (3)
- ☐ Visual Aesthetics (4)
- ☐ Robustness/Durability (5)
- ☐ Materials (i.e. plastic, wood, etc.) (2)
- ☐ Offered adjustability to accommodate growth (6)
- ☐ Ergonomic fit (7)

Q25 How did you obtain the high chair?

- ○ I purchased it (1)
- ○ It was given to me (as a gift, hand-me-down, etc.) (2)

Q97 In the past, have you ever used a high chair that you later stopped using?

- ○ Yes (1)
- ○ No (2)

Display This Question:

If In the past, have you ever used a high chair that you later stopped using? = Yes

Q98 What was the primary reason you chose to stop using the high chair? Check all that apply.

- ☐ My child no longer fit (1)
- ☐ I felt it was uncomfortable for my child (2)
- ☐ My child lost interest (3)
- ☐ It did not function properly (4)
- ☐ It became damaged/broke (5)
- ☐ I felt it was unsafe (6)
- ☐ My child no longer needed it (7)
- ☐ Other (8)

Q57 Please leave any additional comments about the high chair(s) you have used below. (Particularly about the length of time your child used this product, reasons you stopped using it, or any adjustable features it had to accommodate growth)

_____

_____

_____

End of Block: Gear - High Chair

Start of Block: Gear - Booster Seat

Q71

Q72 Are you currently using a booster seat for your 0-12 month old child? (Example pictured above)

**Please select "no" for this question if the booster seat you use is a part of a high chair set (i.e. 3-in-1 high chair or similar model)

- Yes (1)
- No (2)

Skip To: Q75 If Are you currently using a booster seat for your 0-12 month old child? (Example pictured above) ... = No

Q89 Approximately what age was your child when you began using the booster seat?

- 0-3 months (1)
- 4-6 months (2)
- 7-9 months (3)
- 10-12 months (4)

Q73 Approximately how long has your child used the booster seat?

- Less than a month (1)
- 1 -2 months (2)
- 3-6 months (3)
- 7-12 months (4)

Q74 What were your primary reasons for choosing to use this booster seat for your child? Please select all that apply. (If you have used more than one booster seat, please answer based on the one you used the longest)

- Footprint/overall size (1)
- Looks comfortable (3)
- Visual Aesthetics (4)
- Robustness/Durability (5)
- Materials (i.e. plastic, wood, etc.) (2)
- Offered adjustability to accommodate growth (6)
- Ergonomic fit (7)

Q77 How did you obtain the booster seat?

- I purchased it (1)
- It was given to me (as a gift, hand-me-down, etc.) (2)

Q75 In the past, have you ever used a booster seat that you later stopped using?

- ○ Yes (1)
- ○ No (2)

Display This Question:

If In the past, have you ever used a booster seat that you later stopped using? = Yes

Q76 What was the primary reason your child stopped using the booster seat? Check all that apply.

- ☐ My child no longer fit (1)
- ☐ I felt it was uncomfortable for my child (2)
- ☐ My child lost interest (3)
- ☐ It did not function properly (4)
- ☐ It became damaged/broke (5)
- ☐ I felt it was unsafe (6)
- ☐ My child no longer needs it (7)
- ☐ Other (8)

Q78 Please leave any additional comments about the booster seat(s) you have used below. (Particularly about the length of time your child used this product, reasons you stopped using it, or any adjustable features it had to accommodate growth)

_____

_____

_____

End of Block: Gear - Booster Seat

Start of Block: Gear - Bouncer/Rocker

Q87

Q88 Are you currently using a bouncer/rocker for your 0-12 month old child? (Example pictured above)

- Yes (1)
- No (2)

Skip To: Q91 If Are you currently using a bouncer/rocker for your 0-12 month old child? (Example pictured above) = No

Q91 Approximately what age was your child when you began using the bouncer/rocker?

- 0-3 months (1)
- 4-6 months (2)
- 7-9 months (3)
- 10-12 months (4)

Q89 Approximately how long has your child used the bouncer/rocker?

- Less than a month (1)
- 1- 2 months (2)
- 3-6 months (3)
- 7-12 months (4)

Q90 What were your primary reasons for choosing to use this bouncer/rocker for your child? Please select all that apply. (If you have used more than one bouncer/rocker, please answer based on the one you used the longest)

- Footprint/overall size (1)
- Looks comfortable (3)
- Visual Aesthetics (4)
- Robustness/Durability (5)
- Materials (i.e. plastic, wood, etc.) (2)
- Offered adjustability to accommodate growth (6)
- Ergonomic fit (7)

Q93 How did you obtain the bouncer/rocker?

- I purchased it (1)
- It was given to me (as a gift, hand-me-down, etc.) (2)

Q91 In the past, have you ever used a bouncer/rocker that you later stopped using?

- ○ Yes (1)
- ○ No (2)

Display This Question:

If In the past, have you ever used a bouncer/rocker that you later stopped using? = Yes

Q92 What was the primary reason your child stopped using the bouncer/rocker? Check all that apply.

- ☐ My child no longer fit (1)
- ☐ I felt it was uncomfortable for my child (2)
- ☐ My child lost interest (3)
- ☐ It did not function properly (4)
- ☐ It became damaged/broke (5)
- ☐ I felt it was unsafe (6)
- ☐ My child no longer needs it (7)
- ☐ Other (8)

Q94 Please leave any additional comments about the bouncer/rocker(s) you have used below. (Particularly about the length of time your child used this product, reasons you stopped using it, or any adjustable features it had to accommodate growth)

_____

_____

_____

_____

End of Block: Gear - Bouncer/Rocker

Start of Block: Gear - Bath Seat

Q79

Q80 Are you currently using a bath seat for your 0-12 month old child? (Example pictured above)

- Yes (1)
- No (2)

Skip To: Q83 If Are you currently using a bath seat for your 0-12 month old child? (Example pictured above) = No

Q90 Approximately what age was your child when you began using the bath seat?

- 0-3 months (1)
- 3-6 months (2)
- 7-9 months (3)
- 10-12 months (4)

Q81 Approximately how long has your child used the bath seat?

- Less than a month (1)
- 1-2 months (2)
- 3-6 months (3)
- 7-12 months (4)

Q82 What were your primary reasons for choosing to use this bath seat for your child? Please select all that apply. (If you have used more than one bath seat, please answer based on the one you used the longest)

- Footprint/overall size (1)
- Looks comfortable (3)
- Visual Aesthetics (4)
- Robustness/Durability (5)
- Materials (i.e. plastic, wood, etc.) (2)
- Offered adjustability to accommodate growth (6)
- Ergonomic fit (7)

Q85 How did you obtain the bath seat?

- I purchased it (1)
- It was given to me (as a gift, hand-me-down, etc.) (2)

Q83 In the past, have you ever used a bath seat that you later stopped using? Check all that apply.

- ○ Yes (1)
- ○ No (2)

Display This Question:

If In the past, have you ever used a bath seat that you later stopped using? Check all that apply. = Yes

Q84 What was the primary reason your child stopped using the bath seat?

- ☐ My child no longer fit (1)
- ☐ I felt it was uncomfortable for my child (2)
- ☐ My child lost interest (3)
- ☐ It did not function properly (4)
- ☐ It became damaged/broke (5)
- ☐ I felt it was unsafe (6)
- ☐ My child no longer needs it (7)
- ☐ Other (8)

Q86 Please leave any additional comments about the bath seat(s) you have used below. (Particularly about the length of time your child used this product, reasons you stopped using it, or any adjustable features it had to accommodate growth)

_____

_____

_____

End of Block: Gear - Bath Seat

Start of Block: Open-Ended Questions

Q66 How do you determine when your child has outgrown a product?

_____

_____

_____

Q68 Are there any products that your child used for less time than you expected? If so, why?

_____

_____

_____

Q18 If you have any additional feedback about infant gear your child has used, please describe below.

_____

_____

_____

End of Block: Open-Ended Questions

Toddler (13-36 months) Survey

Start of Block: Block 10

This survey is being released by graduate students in the School of Industrial Design at Georgia Institute of Technology. It aims to gather information about children 13-36 months in order to improve the ergonomic design of infant and toddler gear. In this survey, infant/toddler gear refers to products in which your child sits or lies; for example, bouncers, rockers, high chairs, bath seats and toddler chairs.

This survey will take 10 minutes or less to complete and your responses will be completely anonymous.

If you have any questions or concerns related to the survey or the project please email **rearlab@design.gatech.edu**.

End of Block: Block 10

Start of Block: Preliminary Question

Q1 Do you have a child between the ages of 13-36 months?

- ○ Yes (1)
- ○ No (2)

Skip To: End of Block If Do you have a child between the ages of 13-36 months? = No

End of Block: Preliminary Question

Start of Block: Demographics

Q2 What is your age?

- 18 or younger (1)
- 19-25 (2)
- 26-35 (3)
- 36-45 (4)
- 46-55 (5)
- 56-65 (6)
- 65 or older (7)

Skip To: End of Block If What is your age? = 18 or younger

Q5 What is your preferred gender identification?

- Male (1)
- Female (2)
- Non-binary (3)
- Prefer not to answer (4)

Q4 What is your current marital status?

- Single, never married (1)
- Married or domestic partnership (2)
- Widowed (3)
- Divorced or separated (4)

Q6 What is your highest level of education completed?

- ○ Less than high school degree (1)
- ○ High school degree or equivalent (e.g., GED) (3)
- ○ Some college but no degree (4)
- ○ Associate degree (11)
- ○ Bachelor degree (7)
- ○ Graduate degree (8)

Q7 How many children do you have?

- ○ 1 (1)
- ○ 2 (2)
- ○ 3 (3)
- ○ 4 (4)
- ○ 5 (5)
- ○ 6 or more (6)

End of Block: Demographics

Start of Block: Children Demographics

Q93
For the duration of this survey, please focus on answering about your child who is between the ages of 13-36 months, even if you have other children outside of this age range. If you have more than one child between 13-36 months, please answer based off the oldest child.

Q8 How old is your child?

- 13-18 months (1-1.5 years) (1)
- 19-24 months (1.5-2 years) (2)
- 25-30 months (2-2.5 years) (3)
- 31-36 months (2.5-3 years) (4)

Q94 Has your child started walking independently?

- Yes (1)
- No (2)

Q9 Has your child had any developmental delays that affect their postural stability? (i.e. delays that have affected their ability to sit or stand up)

- Yes (1)
- No (2)
- I'm not sure (3)

End of Block: Children Demographics

Start of Block: Important Factors

Q13 Rank the importance of each of the following factors when choosing to use infant/toddler gear, from low importance to high importance.

	Low Importance (1)	Medium Importance (2)	High Importance (3)
Price (1)	○	○	○
High Quality (5)	○	○	○
Footprint/Overall size (2)	○	○	○
Looks comfortable (3)	○	○	○
Visual Aesthetics (4)	○	○	○
Robustness/Durability (6)	○	○	○
Material (i.e. plastic, metal, wood, fabric type, etc.) (7)	○	○	○
Adjustability to accommodate growth (8)	○	○	○
Ergonomic fit (9)	○	○	○

End of Block: Important Factors

Start of Block: Gear - High Chair

Q51

Q21 Are you currently using a high chair for your 13-36 month old child? (Example pictured above)

- Yes (1)
- No (2)

Skip To: Q64 If Are you currently using a high chair for your 13-36 month old child? (Example pictured above) = No

Q88 Approximately what age was your child when you began using the high chair?

- 0-3 months (1)
- 4-6 months (2)
- 7-12 months (3)
- 1-1.5 years (4)
- 1.5-2 years (5)
- 2-2.5 years (6)
- 2.5-3 years (7)

Q22 Approximately how long has your child used the high chair?

- ○ Less than a month (1)
- ○ 1-2 months (2)
- ○ 3-6 months (4)
- ○ 7-12 months (5)
- ○ 1-1.5 years (6)
- ○ 1.5-2 years (7)
- ○ More than 2 years (9)

Q65 What were your primary reasons for choosing to use this high chair for your child? Please select all that apply. (If you have used more than one high chair, please answer based on the one you used the longest)

- ☐ Footprint/overall size (1)
- ☐ Looks comfortable (3)
- ☐ Visual Aesthetics (4)
- ☐ Robustness/Durability (5)
- ☐ Materials (i.e. plastic, wood, etc.) (2)
- ☐ Offered adjustability to accommodate growth (6)
- ☐ Ergonomic fit (7)

Q25 How did you obtain the high chair?

- ○ I purchased it (1)
- ○ It was given to me (as a gift, hand-me-down, etc.) (2)

Q64 In the past, have you ever used a high chair that you later stopped using?

- ○ Yes (1)
- ○ No (2)

Display This Question:

If In the past, have you ever used a high chair that you later stopped using? = Yes

Q23 What was the primary reason your child stopped using the high chair? Check all that apply.

- ☐ My child no longer fit (1)
- ☐ I felt it was uncomfortable for my child (2)
- ☐ My child lost interest (3)
- ☐ It did not function properly (4)
- ☐ It became damaged/broke (5)
- ☐ I felt it was unsafe (6)
- ☐ My child no longer needed it (7)
- ☐ Other (8)

Q57 Please leave any additional comments about the high chair(s) you have used below. (Particularly about the length of time your child used this product, reasons you stopped using it, or any adjustable features it had to accommodate growth)

_____

_____

_____

_____

_____

End of Block: Gear - High Chair

Start of Block: Gear - Booster Seat

Q71

Q72 Are you currently using a booster seat for your 13-16 month old child? (Example pictured above)

**Please select "no" for this question if the booster seat you use is a part of a high chair set (i.e. 3-in-1 high chair or similar model)

- Yes (1)
- No (2)

*Skip To: Q75 If Are you currently using a booster seat for your 13-16 month old child? (Example pictured above) *... = No*

Q89 Approximately what age was your child when you began using the booster seat?

- 0-3 months (1)
- 4-6 months (2)
- 7-12 months (3)
- 1-1.5 years (4)
- 1.5-2 years (5)
- 2-2.5 years (6)
- 2.5-3 years (7)

Q73 Approximately how long has your child used the booster seat?

- Less than a month (1)
- 1-2 months (2)
- 3-6 months (4)
- 7-12 months (5)
- 1-1.5 years (6)
- 1.5-2 years (7)
- More than 2 years (10)

Q74 What were your primary reasons for choosing to use this booster seat for your child? Please select all that apply. (If you have used more than one booster seat, please answer based on the one you used the longest)

- [ ] Footprint/overall size (1)
- [ ] Looks comfortable (3)
- [ ] Visual Aesthetics (4)
- [ ] Robustness/Durability (5)
- [ ] Materials (i.e. plastic, wood, etc.) (2)
- [ ] Offered adjustability to accommodate growth (6)
- [ ] Ergonomic fit (7)

Q77 How did you obtain the booster seat?

- ○ I purchased it (1)
- ○ It was given to me (as a gift, hand-me-down, etc.) (2)

Q75 In the past, have you ever used a booster seat that you later stopped using?

- ○ Yes (1)
- ○ No (2)

Display This Question:

If In the past, have you ever used a booster seat that you later stopped using? = Yes

Q76 What was the primary reason your child stopped using the booster seat? Check all that apply.

- [ ] My child no longer fit (1)
- [ ] I felt it was uncomfortable for my child (2)
- [ ] My child lost interest (3)
- [ ] It did not function properly (4)
- [ ] It became damaged/broke (5)
- [ ] I felt it was unsafe (6)
- [ ] My child no longer needed it (7)
- [ ] Other (8)

Q78 Please leave any additional comments about the booster seat(s) you have used below. (Particularly about the length of time your child used this product, reasons you stopped using it, or any adjustable features it had to accommodate growth)

_____

_____

_____

End of Block: Gear - Booster Seat

Start of Block: Gear - Bouncer/Rocker

Q87

Q88 Are you currently using a bouncer/rocker for your 13-36 month old child? (Example pictured above)

- Yes (1)
- No (2)

Skip To: Q91 If Are you currently using a bouncer/rocker for your 13-36 month old child? (Example pictured above) = No

Q91 Approximately what age was your child when you began using the bouncer/rocker?

- 0-3 months (1)
- 4-6 months (2)
- 7-12 months (3)
- 1-1.5 years (4)
- 1.5-2 years (5)
- 2-2.5 years (6)
- 2.5-3 years (7)

Q89 Approximately how long has your child used the bouncer/rocker?

- ○ Less than a month (1)
- ○ 1- 2 months (2)
- ○ 3-6 months (4)
- ○ 7-12 months (5)
- ○ 1-1.5 years (6)
- ○ 1.5-2 years (7)
- ○ More than 2 years (10)

Q90 What were your primary reasons for choosing to use this bouncer/rocker for your child? Please select all that apply. (If you have used more than one bouncer/rocker, please answer based on the one you used the longest)

- ☐ Footprint/overall size (1)
- ☐ Looks comfortable (3)
- ☐ Visual Aesthetics (4)
- ☐ Robustness/Durability (5)
- ☐ Materials (i.e. plastic, wood, etc.) (2)
- ☐ Offered adjustability to accommodate growth (6)
- ☐ Ergonomic fit (7)

Q93 How did you obtain the bouncer/rocker?

- I purchased it (1)
- It was given to me (as a gift, hand-me-down, etc.) (2)

Q91 In the past, have you ever used a bouncer/rocker that you later stopped using?

- Yes (1)
- No (2)

Display This Question:

If In the past, have you ever used a bouncer/rocker that you later stopped using? = Yes

Q92 What was the primary reason your child stopped using the bouncer/rocker? Check all that apply.

- My child no longer fit (1)
- I felt it was uncomfortable for my child (2)
- My child lost interest (3)
- It did not function properly (4)
- It became damaged/broke (5)
- I felt it was unsafe (6)
- My child no longer needed it (7)
- Other (8)

Q94 Please leave any additional comments about the bouncer/rocker(s) you have used below. (Particularly about the length of time your child used this product, reasons you stopped using it, or any adjustable features it had to accommodate growth)

_____

_____

_____

_____

_____

End of Block: Gear - Bouncer/Rocker

Start of Block: Gear - Bath Seat

Q79

Q80 Are you currently using a bath seat for your 13-36 month old child? (Example pictured above)

- Yes (1)
- No (2)

Skip To: Q83 If Are you currently using a bath seat for your 13-36 month old child? (Example pictured above) = No

Q90 Approximately what age was your child when you began using the bath seat?

- 0-3 months (1)
- 4-6 months (2)
- 7-12 months (3)
- 1-1.5 years (4)
- 1.5-2 years (5)
- 2-2.5 years (6)
- 2.5-3 years (7)

Q81 Approximately how long has your child used the bath seat?

- Less than a month (1)
- 1-2 months (2)
- 3-6 months (4)
- 7-12 months (5)
- 1-1.5 years (6)
- 1.5-2 years (7)
- More than 2 years (10)

Q82 What were your primary reasons for choosing to use this bath seat for your child? Please select all that apply. (If you have used more than one bath seat, please answer based on the one you used the longest)

- [ ] Footprint/overall size (1)
- [ ] Looks comfortable (3)
- [ ] Visual Aesthetics (4)
- [ ] Robustness/Durability (5)
- [ ] Materials (i.e. plastic, wood, etc.) (2)
- [ ] Offered adjustability to accommodate growth (6)
- [ ] Ergonomic fit (7)

Q85 How did you obtain the bath seat?

- ○ I purchased it (1)
- ○ It was given to me (as a gift, hand-me-down, etc.) (2)

Q83 In the past, have you ever used a bath seat that you later stopped using?

- ○ Yes (1)
- ○ No (2)

Display This Question:

If In the past, have you ever used a bath seat that you later stopped using? = Yes

Q84 What was the primary reason your child stopped using the bath seat? Check all that apply.

- [ ] My child no longer fit (1)
- [ ] I felt it was uncomfortable for my child (2)
- [ ] My child lost interest (3)
- [ ] It did not function properly (4)
- [ ] It became damaged/broke (5)
- [ ] I felt it was unsafe (6)
- [ ] My child no longer needed it (7)
- [ ] Other (8)

Q86 Please leave any additional comments about the bath seat(s) you have used below. (Particularly about the length of time your child used this product, reasons you stopped using it, or any adjustable features it had to accommodate growth)

_____

_____

_____

End of Block: Gear - Bath Seat

Start of Block: Gear - Toddler Armchair

Q95

Q96 Are you currently using a toddler armchair for your 13-36 month old child? (Example pictured above)

- Yes (1)
- No (2)

Skip To: Q99 If Are you currently using a toddler armchair for your 13-36 month old child? (Example pictured above) = No

Q92 Approximately what age was your child when you began using the toddler arm chair?

- 0- 3 months (1)
- 4-6 months (2)
- 7-12 months (3)
- 1-1.5 years (4)
- 1.5-2 years (5)
- 2-2.5 years (6)
- 2.5-3 years (7)

Q97 Approximately how long did your child use the toddler arm chair?

- ○ Less than a month (1)
- ○ 1- 2 months (2)
- ○ 3-6 months (4)
- ○ 7-12 months (5)
- ○ 1-1.5 years (6)
- ○ 1.5-2 years (7)
- ○ More than 2 years (10)

Q98 What were your primary reasons for choosing to use this toddler armchair for your child? Please select all that apply. (If you have used more than one toddler armchair, please answer based on the one you used the longest)

- ☐ Footprint/overall size (1)
- ☐ Looks comfortable (3)
- ☐ Visual Aesthetics (4)
- ☐ Robustness/Durability (5)
- ☐ Materials (i.e. plastic, wood, etc.) (2)
- ☐ Offered adjustability to accommodate growth (6)
- ☐ Ergonomic fit (7)

Q101 How did you obtain the toddler armchair?

- I purchased it (1)
- It was given to me (as a gift, hand-me-down, etc.) (2)

Q99 In the past, have you ever used a toddler armchair that you later stopped using?

- Yes (1)
- No (2)

Display This Question:

If In the past, have you ever used a toddler armchair that you later stopped using? = Yes

Q100 What was the primary reason your child stopped using the toddler armchair? Check all that apply.

- My child no longer fit (1)
- I felt it was uncomfortable for my child (2)
- My child lost interest (3)
- It did not function properly (4)
- It became damaged/broke (5)
- I felt it was unsafe (6)
- My child no longer needed it (7)
- Other (8)

Q102 Please leave any additional comments about the toddler armchair(s) you have used below. (Particularly about the length of time your child used this product, reasons you stopped using it, or any adjustable features it had to accommodate growth)

_____

_____

_____

End of Block: Gear - Toddler Armchair

Start of Block: Open-Ended Questions

Q66 How do you determine when your child has outgrown a product?

_____

_____

_____

Q68 Are there any products that your child used for less time than you expected? If so, why?

_____

_____

_____

Q67 Has your toddler ever lost interest in a product before they physically grew out of it? If so, what type of product was it?

_____

_____

_____

Q18 If you have any additional feedback about infant/toddler gear your child has used, please describe below.

_____

_____

_____

End of Block: Open-Ended Questions

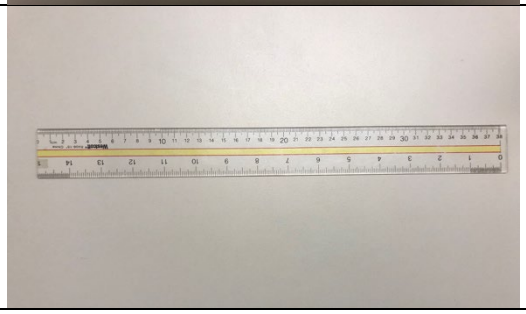
APPENDIX C

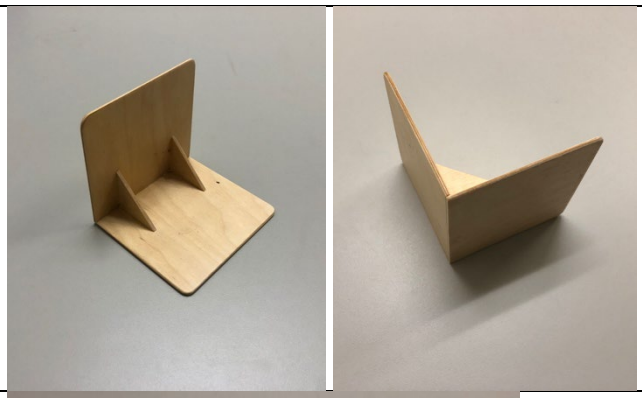
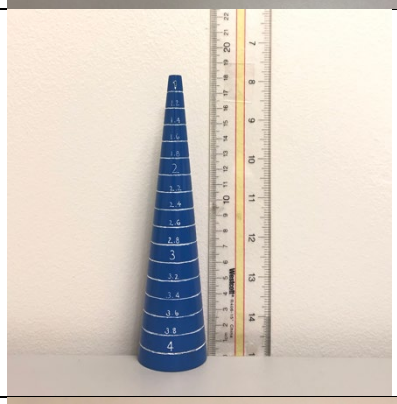
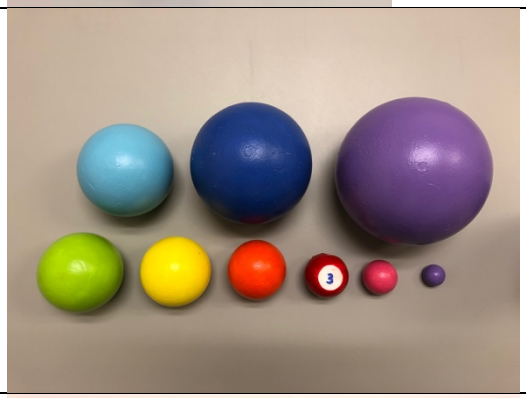
ANTHROPOMETRY

C.1 Anthropometry Tools

Table 13. Tools Used in Anthropometry Data Collection

Tool	Photograph of Tool	Description
Stadiometer		Used to measure standing and sitting height for toddlers
Stool		Custom made using plywood and used to position children for seated measurements. Slot at back which the stadiometer slides into for seated height measure

Infantometer		Used to measure children in supine
Anthropometer with custom paddles	 	Paddles custom made to allow easier and safer measurement taking. 3D printed and painted. Deemed necessary after pilot subjects were afraid of the traditional anthropometer jaws and upon reviewing Anthrokids tools
Fabric tape measure		Cut to 100cm length
Transparent ruler		Cut end so that 0cm is the edge of the ruler

Square		Fabricated with plywood to use for shoulder measurements and in conjunction with the ruler
Shoulder level		Fabricated to ensure level tool when taking shoulder height measure
Grip Cone		3D printed and painted. Other grip cones were too large for infant hands
Functional grip spheres		Polystyrene spheres, one side sanded flat to avoid rolling, painted bright colors and numbered
Functional grip cubes		Heavy cardboard nesting blocks, weighted on the inside to

Pneumatic adjustable squeeze dynamometer			Smallest bulb used for grip strength measurement and only done with children 24 months or older

C.2 Child Anthropometry Procedures

C.2.1 Weight

Procedure

Supine
Subject is placed in supine or seated on scale with baby tray attachment; investigator ensures hands and feet are within tray and not resting on table; all toys or objects are removed from infant's hands; "hold" button is pressed.

Ambulatory
Subject stands erect on scale; all toys or objects are removed from child's hands; "hold" button on scale is pressed.

Notes
For fussy children, parents were given the option to weigh the children while they held them. Parent stands on scale; "tare" button is pressed; child is handed to parent; hold button is pressed.

Figure 55. Weight measurement

C.2.2 Stature

Procedure

Supine
Head against top surface of infantometer, head looking straight up; legs and knees straight; feet flat against bottom surface of infantometer

Ambulatory
Child stands erect with heels together; heels, buttocks, scapula, head make contact with back surface of stadiometer; head aligned in Frankfort horizontal plane; arms down at sides; head board lowered to contact head

Notes
In supine, investigator can use only the right leg instead of both if child is fussy. In standing, toys were sometimes needed to direct the child's attention and get them to look straight ahead so head was properly positioned

Figure 56. Length measurement

C.2.3 Shoulder Height - Standing

Procedure

Supine
Maintain position from stature measure; arms down at sides; use flat surface to note shoulder height mid-way between neck and acromion; measure of top of head to shoulder is subtracted from stature

Ambulatory
Maintain standing position from stature measure; height measured from floor to superior aspect of shoulder, mid-way between neck and acromion

Notes
Custom tools were constructed in order to be able to use the stadiometer or infantometer to measure shoulder height. For ambulatory, bubble level was placed on top of a plywood ruler to ensure plane from shoulder to stadiometer was accurate. In supine, square was used to measure shoulder location from top of head on measurements marked on infantometer

Figure 57. Shoulder height standing measurement

C.2.4 Seated Height

Procedure

Supine
Child in supine with head against top surface of infantometer; hips flexed to 90 degrees; knees flexed to 90 degrees; place bottom surface of infantometer firmly against the buttocks, compressing the diaper; measure between two surfaces of infantometer

Ambulatory
Child sits erect with knees supported at 90 degrees; hands on thighs; head in the Frankfort plane; record measure on stadiometer and subtract height of stool

Notes
Ambulatory procedure for all seated measures included use of the custom-built stool. Child sits upright on the stool and feet are supported by risers, so knees are at 90 degrees.

Figure 58. Seated height measurement

C.2.5 Shoulder Height - Sitting

Procedure

Supine
Distance of top of head to shoulder, which was previously measured, is subtracted from seated height measure

Ambulatory
Child sits erect with knees flexed to 90 degrees; hands on thighs; measure distance from sitting surface to top of shoulder, mid-way between neck and acromion

Notes

Figure 59. Shoulder height sitting measurement

C.2.6 Shoulder Breadth

Procedure

Supine
Child in supine; position upper arms straight down at sides; elbows flexed to 90 degrees; measure widest breadth of lateral edge of shoulders

Ambulatory
Child stands erect; position upper arms straight down at sides; elbows flexed to 90 degrees; measure widest breadth of lateral edge of shoulders

Notes
This measure was taken sitting, standing or supine if children were unhappy with other poses.

Figure 60. Shoulder breadth measurement

C.2.7 Upper Arm Length

Procedure

Supine
Child in supine; position upper arms straight down at sides; elbows flexed to 90 degrees; measure from superior surface of shoulder to inferior surface of elbow

Ambulatory
Child stands erect; position upper arms straight down at sides; elbows flexed to 90 degrees; measure from superior surface of shoulder to inferior surface of elbow

Notes
This measure was taken sitting, standing or supine if children were unhappy with other poses.

Figure 61. Upper arm length measurement

C.2.8 Lower Arm Length

Procedure

Supine
Mark ulnar styloid with washable pen. Child in supine; position upper arms straight down at sides; elbows flexed to 90 degrees; measure from posterior aspect of elbow to ulnar styloid

Ambulatory
Mark ulnar styloid with washable pen. Child stands erect; position upper arms straight down at sides; elbows flexed to 90 degrees; measure from posterior aspect of elbow to ulnar styloid

Notes
This measure was taken sitting, standing or supine if children were unhappy with other poses.

Figure 62. Lower arm length measurement

C.2.9 Buttock to Knee Length

Procedure

Supine
Child in supine; hips flexed to 90 degrees; knees flexed to 90 degrees; measure distance from posterior surface of buttocks to anterior surface of knee

Ambulatory
Child sits erect with knees supported at 90 degrees; hands on thighs; measure distance from posterior surface of buttocks to anterior surface of knee

Notes
This measure was taken using the ruler and square in supine but with the anthropometer for ambulatory children.

Figure 63. Buttock to knee measurement

C.2.10 Knee to Sole Length

Procedure

Supine
Child in supine; hips flexed to 90 degrees; knees flexed to 90 degrees; measure distance from the bottom of the heel of the foot to the top surface of the knee, just behind the patella

Ambulatory
Child sits erect with knees supported at 90 degrees; measure distance from the bottom of the heel of the foot to the top surface of the knee, just behind the patella

Notes
This measure was taken using the anthropometer in supine but with the ruler and square for ambulatory children.

Figure 64. Knee to sole length measurement

C.2.11 Chest Breadth

Procedure

Supine
Remove clothing from upper body; child in supine with arms held down at sides; measure breadth of the chest at the level of the nipples

Ambulatory
Remove clothing from upper body; child stands erect with arms down at sides; measure breadth of the chest at the level of the nipples

Notes
This measure was taken sitting or standing if child was unhappy in supine.

Figure 65. Chest breadth measurement

C.2.12 Chest Circumference

Procedure

Supine
Remove clothing from upper body; arms held down at sides; wrap tape around chest at level of nipples; child should be breathing normally

Ambulatory
Remove clothing from upper body; arms held down at sides; wrap tape around chest at level of nipples; child should be breathing normally

Notes
If children were crying when this measurement was being taken, tape was positioned, and measurements were read out only when child was not gasping or had relaxed. Measurement taken in standing or sitting if child was unhappy in supine.

Figure 66. Chest circumference measurement

C.2.13 Hip Breadth (with and without diaper)

Procedure

Supine
Child in supine; legs straight down; diaper and clothing remain; measure breadth of hips at widest point. Repeat measure with diaper removed.

Ambulatory
Child stands erect; diaper and clothing remain in place; hip breadth measured at widest point. Repeat measure with diaper removed.

Notes
This measurement “with diaper” was not always recorded as often the widest point of the hips fell outside of the child’s diaper and onesie, and therefore the diaper and clothing were not interfering with the measurement. Measurement taken in standing if child was unhappy in supine.

Figure 67. Hip breadth with diaper measurement

C.2.14 Hip Circumference (with and without diaper)

Procedure

Supine
Child in supine; legs straight down; diaper and clothing remain; wrap tape around hips at widest point. Repeat measure with diaper removed.

Ambulatory
Child stands erect; diaper and clothing remain in place; wrap tape around hips at widest point. Repeat measure with diaper removed.

Notes
Measurement taken in standing if child was unhappy in supine. If children were extremely fussy, it was deemed that the measure without the diaper was most important so sometimes the measure was not recorded with diaper on.

Figure 68. Hip circumference with diaper measurement

C.2.15 Head Circumference

Procedure

Wrap tape around head at the most anterior protrusion of the forehead (right above the eyebrows) and most posterior protrusion of the back of the head (opisthrocranion)

Notes
This measure could be performed standing, sitting, or while child was being held by parent.

Figure 69. Head circumference measurement

C.2.16 Foot Length

Procedure

Foot flat on paper, mark posterior edge and carpal edge and measure marks

Notes
Children measured in supine had foot pressed down onto paper, children walking were asked to step onto the piece of paper to be measured.

During pilots, feet were measured with this method as well as with calipers. The measurements recorded were identical and the marking method was quicker for researchers and less intimidating to children, so this was deemed appropriate procedure for the remainder of participants.

Figure 70. Foot length measurement

C.2.17 Hand Length

Procedure

Child is held seated in parent's lap; child's hand is pressed or positioned flat on paper; hand is marked at tip of middle finger and wrist crease.

Notes
During pilots, hands were measured with this method as well as with calipers. The measurements recorded were identical and the marking method was quicker for researchers and less intimidating to children, so this was deemed appropriate procedure for the remainder of participants.

Figure 71. Hand length measurement

C.2.18 Grip Circumference

Procedure

Using a grip cone, measure the maximum circumference made by the thumb and middle finger; middle finger and thumb must touch fingertip to fingertip

Notes
Typically for adults or older children, this is an active measure where they position their hands around the grip cone. Because this was not possible for infants and toddlers, it was a passive measurement, and the researcher positioned their hands around the grip cone in the appropriate manner.

Figure 72. Grip circumference measurement

C.2.19 Functional Grip – Spheres

Procedure

Child sits on parent's lap, at desk. Sphere is presented to the child on the flat surface of desk. Child is prompted to pick up the sphere with one hand. This is repeated with increasingly larger spheres until the child fails to lift it off the table surface.

Notes
To get the child to use only one hand, often something was put in the other hand for them to hold. This could be the grip cone, other spheres, or snacks. If they were uninterested in holding something else, the parent was asked to hold their other hand.

This measurement was filmed by researchers if parents had consented.

Figure 73. Functional grip with spheres measurement

C.2.20 Functional Grip – Cubes

Procedure

Child sits on parent's lap, at desk. Cube is presented to the child on the flat surface of desk with the open side facing down. Child is prompted to pick up the cube with one hand. This is repeated with increasingly larger cubes until the child fails to lift it off the table surface.

Notes
To get the child to use only one hand, often something was put in the other hand for them to hold. This could be the grip cone, other spheres, cubes, or snacks. If they were uninterested in holding something else, the parent was asked to hold their other hand.

Sometimes children would engage with cubes by swiping or sliding them instead of lifting. Because they are nesting, a smaller cube was placed underneath to entice the child to lift up the cube if necessary.

This measurement was filmed by researchers if parents had consented.

Figure 74. Functional grip with cubes measurement

C.2.21 Grip Strength

Procedure

Measurement only performed with children about 24 months or older, judgement call about child ability and temperament was made.

Child sits on parent's lap, at desk. Smallest bulb of dynamometer is used. Bulb is placed in upward facing open hand. Child is instructed to squeeze bulb as hard as they can and quickly. Measurement is recorded. Device is reset and test repeated 2 more times.

Notes
Sometimes this measure was repeated more than three times if researchers felt the child was not using their full effort.

This measurement was filmed by researchers if parents had consented.

C.3 Child Anthropometric Data

Table 14. Raw Data - Child Anthropometric Measurements – 0-36 months old

Code	Anthro58	Anthro29	Anthro35	Anthro22	Anthro23	Anthro13	Anthro28	Anthro57	Anthro40
Gender	F	F	F	M	F	M	F	F	F
Ethnicity	W	M	W	AI	AI	W	W	W	A
Age (months)	2	3	3	4	4	6	6	6	7
Shoe Size	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Stature/ Length (cm)	56.5	60	63	64	65.5	66	65	70.5	65.5
Shoulder Height Standing (cm)	43	47	48	49.5	52	50	49.5	54	52.5
Sitting Height (cm)	41	40	42.5	42.5	44.5	44	42	46	42
Shoulder Height Sitting (cm)	27.5	27	27.5	28	31	28	26.5	29.5	29
Foot Length (cm)	8	8.4	9.3	9.2	9.4	10	8.9	10.8	9.6
Buttock to Knee (cm)	16.8	17.1	19.45	18.1	18.2	18.3	17.7	21	18.9
Knee to Sole (cm)	13.9	15.17	15.55	16.05	16.7	16.8	15.4	19.03	17.35
Shoulder Breadth (cm)	15.2	17.9	18.3	18	19.55	17.4	19.8	20	16.8
Upper Arm Length (cm)	10.5	10.6	12.2	11.67	11.77	13.3	12.3	13.1	12.5
Lower Arm Length (cm)	8.8	8.23	8.4	8.7	8.7	8.4	8.6	10.4	9.05
Hip Width (diaper) (cm)	14.5	16.2		15.8	17.1	14.4	14.7	19.1	
Hip Circumference (diaper) (cm)	43.4	44.2	47.65	44.37	46.6	44.27	43.1	53.6	42.5
Hip Width (no diaper) (cm)	14.9	16.2	17.3	15.15	15.65	14.4	14.5	19.1	16.6
Hip Circumference (no diaper)	36.5	39.77	43.15	38.6	42.9	39.4	39.5	49.8	39.4
Chest Circumference (cm)	37.4	41.5	45.47	42.15	43.1	41.23	40.8	45.37	40.6
Chest Breadth (cm)	11.6	12.6	14.2	12.77	13.35	13	13.2	14.3	13.13
Weight (kg)	4.54	6.36	7.58	5.23	6.19	6.66	6.09	9.13	6.34
Head Circumference (cm)	39.4	38.9	42.6	43.5	44.2	44.6	41.4	44.9	43.5
Hand Length (cm)	6.8	7.2	7.3	7.4	7.9	7.3	7.1	8.3	7.4
Functional Grasp - Spheres (cm)		3.7	3.7	4.7	4.7	4.7	4.7	9.7	4.7
Functional Grasp - Cubes (cm)		0	0	4.9	4	4.9	4	7.2	4
Grip Circumference (cm)	1.6	1.8	1.8	1.8	2	1.8	1.6	2.2	2
Grip Strength (PSI)									

Anthro34	Anthro06	Anthro54	Anthro50	Anthro49	Anthro48	Anthro39	Anthro21	Anthro11	Anthro33	Anthro15	Anthro51	Anthro18	Anthro02
F	M	M	F	F	F	M	F	F	M	M	F	M	F
W	M	W	M	M	M	M	W	W	W	H	M	W	M
13	13	12	12	12	12	12	12	12	11	11	10	10	9
4.5	N/A	N/A	N/A	N/A	N/A	4	3	4	N/A	4	N/A	2	2
73	78	79	72.5	73.5	73.5	75.5	78.5	73.5	74.5	76.5	73.5	72.5	70
56.5	58	60	55.5	56	56	57	61.5	58.5	58	59.5	56.5	57.5	53
46	49.5	50	45.5	45.5	46.5	48.5	51	48	48.5	49.5	47	47	45
29.5	29.5	31	28.5	28	29	30	34	33	32	32.5	30	32	28.5
11.6	11.5	12.4	11	11	11.2	11.4	10.9	11.3	11.2	12.1	10.8	10.2	10.4
21.5	21.5	22.7	23.5	22.75	22.15	22.5	23.1	22.4	21.6	22.2	22.9	20.6	20.5
19.7	21.6	20.6	19.5	19.8	19.9	20.1	21	20.9	19.57	20.8	19.5	18.23	17.4
19.83	21	23.3	19.6	21.07	20	21.4	21.8	19.15	20.6	21.25	21.4	19.37	21.5
13.4	15.05	14.03	14	13.97	14.35	14.75	15.1	13.8	14.5	15.05	14.4	13.1	13.1
10.85	11.55	11.47	10.3	11.2	11.3	11.4	11.43	10.4	10.8	11.63	10.4	10.1	11
	17.6	18.5				16.9	20.55	16.95	19.4	17.9	19.8	17.7	17.1
51.55	51.95	53.8	46.97	48.3	46	50.65	59	50.75	52.6	52.57	51.6	51	49.35
19.1	16.55	18.65	16.4	16.8	16.73	17.25	20.95	15.75	19.9	17.53	20.1	17.63	16.8
47.5	42.8	47.1	43.6	43.2	45.5	47.05	53.45	43.1	49.3	47.35	49.8	43.95	46.5
49.8	44.6	50.83	46	45.4	45	48.6	47	43.2	48.6	47.67	47.87	47.07	42.8
15.37	15.4	17	15.35	14.23	15.3	15.45	15.9	14.05	16.1	15.6	16.6	15.4	
9.44	9.16	10.39	7.17	7.51	7.07	9.33	10.18	8.77	10.37	10.66	9.87	9.11	8.03
46.6	47.1	46.5	45.1	43.6	45.3	46.6	45.2	43.8	47.2	47.6	46.9	45.7	43.6
9.5	9.3	9.3	8.9	8.6	8.7	9.5	8.9	9	8.2	9.3	8.8	8	7.7
12.4	9.7	14.6	9.7	9.7	9.7	9.7	8.3	9.7	7.3	9.7	9.7	9.7	12.4
9.5	7.2	7.2	8.3	8.3	8.3	8.3	7.3	9.5	10.5	8.3	10.5	7.2	5.9
2.4	2.4	2.2	2.2	2.2	2	2.2	2.2	2	2.2	2.2	2	2	2

Anthro45	Anthro32	Anthro31	Anthro47	Anthro46	Anthro36	Anthro09	Anthro53	Anthro52	Anthro55	Anthro16	Anthro04	Anthro56	Anthro38
M	M	F	F	M	F	M	M	M	F	M	M	M	M
A	W	W	W	W	A	A	H	H	W	W	W	W	W
20	19	19	18	18	18	18	16	16	14	14	14	13	13
5	3	3	5	5	5	7	5	5	3.5	4	6	N/A	6.5
86.5	79	79.5	83	80	84	83.4	79	78.5	75	80.5	85.5	76	83
69	61	62	65	62.5	65	64.9	60	60.5	57.5	61.5	65.5	59.5	63.5
53	49	50.5	52.5	49.5	50	50.5	49	48.5	47.5	50	50.4	46	51
35.5	31	33	34.5	32	31	32	30	30.5	30	31	32.47	29.5	31.5
13.6	12.1	11.8	12.3	12.7	13.6	14.4	12.5	12.5	10.6	12.3	13.2	11.7	12.4
25.15	22.9	23	23.5	24.6	25.1	25.1	22.9	22.5	22.77	22.3	22.43	23.2	24
23.1	20.8	20.9	21.9	23.1	23.2	23.9	21.9	21.9	19.7	22.1	22.4	20.4	21.9
22.25	19.73	21.25	22.6	21.35	20.53	22.6	21.3	19.6	21.63	20.8	21.9	21.6	21.7
16.6	15	14.9	14.5	17.5	16.7	15.1	15.7	15.4	14.5	15.23	15.7	14.93	15.43
13.9	10.9	11.1	10.5	12.3	11.9	11.65	12	12	11	10.6	11.65	10.77	12.4
19.07	15.9	16.47			17.6	17.25		17.4	17.5	16.8	17.8	17.3	18.9
	48.03	51.4			51.2	56.45	49.5	48.5	48.5	51		50	50.45
18.47	15.8	15.6	17.3	16.2	17.6	18	17.5	17.4	18	16.55	18.15	17	18.2
49.17	41.75	46	48	47.25	48.9	52.77	46	45.1	46.33	45.65	49.45	44.15	49
50.6	46.7	48.67	48.4	50.37	48.13	50.83	49.5	48.6	52.8	49.5	48.6	48.5	47.8
16.4	16.2	16.1	17.15	17.15	15.77	16.1	16.8	16.6	17	16.4	17.03	17.5	15.6
12.98	9.03	10.34	10.68	10.94	11.01	12.87	11.01	10.36	10.14	10.24	12.7	9.75	9.98
47.8	47.4	49	48.6	48.6	47.35	47.45	50.2	50.1	46.5	46.9	48.6	44.5	48.2
9	9	9.2	9.3	9.2	9.4	9.9	9.9	9.5	8	8.7	10.4	9.2	9.6
9.7	9.7	9.7	12.4	12.4	9.7	14.6	12.4	9.7	8.3	9.7	12.4	12.4	9.7
9.5	11.8	10.5	11.8	11.8	8.3	9.5	9.5	8.3	7.2	11.8	8.3	11.8	8.3
2.6	2.2	2.2	2.4	2.4	2.4	2.6	2.6	2.6	2	2.2	2.2	2.2	2.6

Anthro01	Anthro37	Anthro30	Anthro24	Anthro26	Anthro03	Anthro20	Anthro19	Anthro17	Anthro43	Anthro25	Anthro44	Anthro27	Anthro42
F	F	M	M	M	F	M	F	F	M	M	M	F	M
M	W	M	AI	A	W	W	W	W	W	W	A	A	W
35	34	34	34	32	29	28	28	28	25	25	24	24	21
6	10	8.5	9	9.5	6	6.5	7	5	8	9	8	7	6
92.45	97.35	99.5	96.35	92.5	90.4	83.77	85.8	86.9	93.5	89.3	90	87.1	89
71.2	76.2	78.37	75.3	70.3	69.3	63.9	65	66.07	74.5	67.3	73.5	68.1	70
51.87	57.5	57.45	56.4	55.5	54.1	51.8	50.9	50.77	59	52.7	55	52.9	56
33.55	33.43	36.1	32.1	35.65	32.2	31.63	30.5	30.4	40	31.9	38.5	29.9	37
13.7	15.4	15.7	16	14.7	13.7	12.6	12.7	13.5	14.5	14.9	15.2	13.4	13.6
28.6	27.5	27.9	30.1	27.7	26.6	25.77	26.5	25.85	27.5	25.13	26.7	28	24.9
26.2	27.5	29.6	28.2	26.95	25.5	23.4	24.1	23.7	24.9	26	25.9	25.4	24.2
22.9	24.5	25.6	26.05	24.37	22.7	23.07	21.17	23.1	24.8	22.03	23.43	24.77	22.9
18.5	19.8	19.7	19.8	16.85	17.6	15.55	16.4	16.5	18.7	15.9	18.23	17.4	17.13
12.95	13.6	14.17	14.4	13.6	12.2	11.15	12.2	12.8	12.6	12.1	12.53	13.2	12.23
16.7	19.8	19.8			17.37	17.9		18.8	19.6	17.6	18.4	20	18
47.17	57.75	58.1			49.7	57.55	50.9	54.1	59.5	51.55	54.53	58.4	51
16.45	19.9	19.43	18.2	18.8	17.5	16.85	17.1	18.4	19.1	16.95	17.1	18.9	17.27
47.1	56.5	53.07	52.3	54.13	47.9	50.6	48.6	49.37	54.5	47.6	47.65	54.6	47.8
46.6	49.7	53.9	56.33	52.8	48.1	50.8	48.9	50.3	53.4	47.25	49.23	50.8	48.3
15.3	15.8	17.7	19.1	17.1	16.2	16.35	16.2	16.9	17.9	16.07	16.5	16.4	15.6
11.31	15.22	16.29	15.47	14.74	12.16	12.38	11.49	12.34	15.1	12.09	12.07	14.39	11.92
47	49.4	51.8	52.8	50.8	50.7	50.2	47.5	50.3	48.6	50.6	47.4	50.2	48.4
10.8	10.9	11.4	11	10.5	10	9.1	9.4	10.1	10.4	10.4	10.7	10.2	9.9
14.6	14.6	14.6	14.6	14.6	14.6	14.6	14.6	12.4	14.6	14.6	14.6	12.4	14.6
10.5	11.8	11.8	10.5	11.8	11.8	10.5	11.8	9.5	11.8	10.5	11.8	11.8	11.8
2.8	3	3	3	2.8	2.8	2.4	2.4	2.6	2.8	2.6	3.2	2.8	2.6
	3	2.5	3	2.5	2.5	1.5	1.5	2	2	1.5	2	2	2.5

Anthro41	Anthro08	Anthro07	Anthro05
F	F	M	M
A	W	W	W
36	35	35	35
8	8	9.5	8
103.47	96.6	102.25	97.9
81	75.05	79.15	75.4
58.9	55.4	59.85	56.57
36.4	33.4	36.35	35.3
16.4	15.4	16.5	14.3
32.5	29.1	27.47	27.57
30.5	28.33	29.2	27.2
27.4	24.85	27.55	25.45
20.6	19.87	19.7	20.35
14.57	14.6	14.65	13.55
21.5			
64.6			
19.8	17.9	19.4	18.4
61.1	51.37	54.45	50.8
57.9	50.25	55.65	52.8
18.8	16.95	19.4	17.5
18.6	14.23	17.33	14.48
51.8	50.5	52.73	51.7
11.1	11.1	12.1	10.35
14.6	14.6	14.6	14.6
11.8	10.5	10.5	8.3
3.2	2.8	3.2	2.6
3.5	3	4.5	2.5

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