Proceedings of the ASME 2017 International Design Engineering Technical Conferences and Computers and Information in Engineering Conference
IDETC/CIE 2017
August 6-9, 2017, Cleveland, Ohio, USA

DETC2017-67690

SCENARIO-BASED CONJOINT ANALYSIS: MEASURING PREFERENCES FOR USER EXPERIENCES IN EARLY STAGE DESIGN

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ABSTRACT

Conjoint analysis has proven to be a useful method for decomposing and estimating consumer preference for each attribute of a product or service through evaluations of sets of different versions of the product with varying attribute levels. The predictive value of conjoint analysis is confounded, however, by increasing market uncertainties and changes in user expectations. We explore the use of scenario-based conjoint analysis in order to complement qualitative design research methods in the early stages of concept development. The proposed methodology focuses on quantitatively assessing user experiences rather than product features to create experience-driven products, especially in cases in which the technology is advancing beyond consumer familiarity. Rather than replace conventional conjoint analysis for feature selection near the end of the product development cycle, our method broadens the scope of conjoint analysis so that this powerful measurement technique can be applied in the early stage of design to complement qualitative research and drive strategic directions for developing product experiences. We illustrate on a new product development case study of a flexible wearable for parent-child communication and tracking as an example of scenario-based conjoint analysis implementation. The results, limitations, and findings are discussed in more depth followed by future research directions.

Keywords: Scenario-based conjoint analysis, user experience, user preference, design process

1 INTRODUCTION

Conjoint analysis, a statistical technique of measuring preferences by part-worths, has been in use since the early 1970s [1,2] in defining consumer preferences of each attribute of a multi-attribute product [3]. It arose from the observation that conjoint measurement methods could be used in a marketing setting to understand consumer decisions, quantify preferences and part-worths of a product's value, and predict consumer purchase behavior [4]. Conjoint analysis techniques and use cases have continuously evolved since then, but the method has consistently been used primarily to gauge consumer preferences and part-worths of specific features in product iterations - namely, market, incremental, or technical innovations [5,6].

1.1 Use of Conjoint Analysis in Product Design

Early applications of conjoint analysis were to survey consumers utilizing a full profile method, in which the respondent views an entire profile and then sorts and rates each option individually. While thorough and rich in data, this method often causes user fatigue and makes it difficult to provide a proper means for comparison amongst options [7].

In the 1980s, choice-based and hybrid methods were developed, aided by technology and software developments that brought forth more advanced capabilities in modeling and eased the stimulus presentation process, which refers to the number and type of concepts presented and how they are represented for the consumer [4]. Choice-based methods provide profile descriptions for a subset of competitive options with different attributes [7]. Choice-based conjoint analysis gives the respondent alternatives among which they can make a choice; this is more realistic and natural for the respondent, but designing a survey that will provide sufficient information to build a predictive model is more difficult for the researcher [4]. Choice-based conjoint can utilize full profile methods, which involves showing every attribute of each choice provided, or it can use the partial profile method, which presents subsets of total attributes to the user and rotates the attributes throughout the survey [4]. Hybrid conjoint analysis combines the full profile and choice-based methods, and typically involves a self-explication task (in which the consumer scores the options prior to ranking them) before having the respondent evaluate their choices within the subset of full or partial profiles [7].

Stimulus presentation in conjoint analysis continuously develops in conjunction with the various methods, and includes verbal, pictorial, real, and multimedia elements [8]. Traditional methods use verbal and pictorial methods heavily, with increasing use of conjoint analysis on physical products; advanced stimulus modes such as 3D renderings and physical prototypes have been suggested as well.

Conjoint analysis in new product development applications has primarily been used near the end of the design process to hone feature selection. In such cases, conjoint analysis is typically used to evaluate consumer reactions to product variations or an addition to an "existing competitive array" rather than an unexplored concept [7].

However, there are limitations to using current conjoint analysis methods to study radical innovations; for example, factors such as familiarity with the choices provided can influence a consumer's decision-making process [9], especially with new products in which consumers lack understanding of the technology and product specifications. There has been significant research that examines the inconsistencies that arise from different methods of user surveys and the importance of capturing design insights from survey preference analyses. MacDonald et al. [10] show through product design case studies that customer needs should be taken into consideration while building up product attributes. This is emphasized in new designs in which consumer preferences are inconsistent, and it is essential to understand the basis behind the preferences, not only the choices themselves. In addition, choosing an improper stimulus presentation mode (verbal, pictorial, multimedia, or real) to illustrate the features to consumers without prior knowledge of the product can lead to perception differences or general confusion about the feature context [8]. Consumer preferences have been shown to vary, sometimes widely and in a contradictory manner, depending on product representation, so this is a vital factor in the development of new product development (NPD) conjoint methods [11].

1.2 Market Trends Driven by User Experience

Innovative products benefit from extensive consumer research. Established conjoint analysis methods haven't methodically addressed the needs of the product planning or strategy phase in NPD applications, which exposes a compelling need for a new method to fill this gap. New NPD processes, such as design roadmapping (a method of combining human-centered design research and technological analysis into a shared layout for design and development teams), are shifting the focus from objective to subjective attributes during the early stages of conceptual design before and while making a physical prototype of a concept [12,13]. Similarly, our proposed method of conjoint analysis strives to assess user experiences rather than product features in order to reflect the priority of understanding user needs for creating experience-driven products, especially in cases in which the technology has advanced beyond consumer familiarity. Interviews and observations are commonly used to identify core user needs (explicit and latent) for developing product concepts. When used to supplement or as a follow-up to interviews, conjoint analysis can mitigate problems associated with variability in phrasing questions and interpreting results of interviews [14]. Conjoint analysis quantifies these subjective opinions from users in a standardized way. It can be especially beneficial for gathering information for hypothetical products that are unfamiliar to respondents, such as when a physical prototype is not readily available for consumers to experience [15]. Using conjoint analysis as a way of gauging preferences can also reveal preference inconsistencies, which may initially seem undesirable, but can actually be utilized to gain a deeper understanding of the customer's choices and evaluations regarding the product [16]. By combining qualitative and quantitative design methods, the designer can extract valuable information about both the customer's motivations in making product purchasing decisions and how the customer internally relates product experience attributes with their resulting preferences [16].

2 RESEARCH DESIGN

Through a case study, this paper examines a product development situation where scenario-driven conjoint analysis was implemented in the early stages of a design in order to complement qualitative research and identify fruitful project directions. In the given case study, a scenario-based and choice-based approach was used for the experiment design.

2.1 Choice-based Conjoint (CBC)

Choice-based conjoint (CBC) methods [17] are used for their simplicity and closeness to the actual shopping situation. While early conjoint analysis methods require users to rank all of the different possible profiles that have been assigned, the choice-based conjoint provides a set of 3-5 full or partial profiles from which the reader simply picks the one that they most prefer [18], and this process is repeated several times. Figure 1 illustrates the difference between conventional conjoint analysis and the choice-based model.

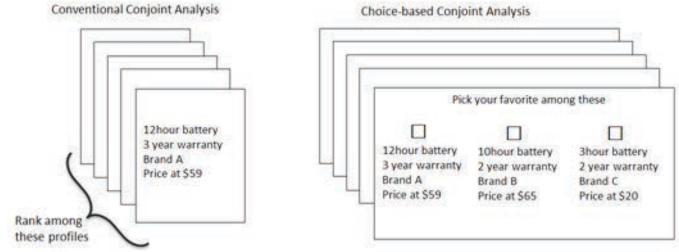

FIG. 1: GRAPHICAL COMPARISON BETWEEN CONVENTIONAL CONJOINT ANALYSIS AND CHOICE-BASED CONJOINT ANALYSIS [18]

The ease of the comparison task for the user is important, because according to Johnson and Orme [19], if a survey or question is too long or difficult, the value of the respondent's answers correspondingly fall as respondents get bored or fatigued. The choice-based option hence can lead to more accuracy due to its simplicity and lower cognitive burden on respondents. With CBC, the profiles are divided into smaller sets for comparison and the user only needs to compare between 3-5 profiles at a time, whereas traditional conjoint analysis requires users to remember and rank 12-20 existing profiles at once.

2.2 Scenario-based Conjoint Analysis Design

User scenario-based design is an aspect of human-centered design that involves creating a story and context for a product experience. It has been widely used in the human-computer interaction, system design, and design research fields [20-22]. It has become popular in interaction design because it expedites communication about potential designs that require feedback from stakeholders [23]. Experiences can be described in the context of a user scenario [24] and such scenarios can be used as design and prototyping inspirations and to evaluate specifications. They complement early prototypes to extract user requirements along with a preliminary design [25]. Conjoint analysis has been included in the early opportunity identification stages of new product development on occasion [15,16], but scenario-based conjoint is not currently widely used in this context.

3 CASE STUDY IMPLEMENTATION

In Spring 2016, a team of Master of Engineering (M.Eng) graduate students at UC Berkeley researched consumer needs and product opportunities in the wearables field for their capstone project in collaboration with a consumer electronics company. The team identified the market need for a child-tracking wearable and designed a modular child-tracking wearable device. The product aimed to relieve parents of the worry of losing their children during outdoor activities. In designing the product, the design team found that users had difficulty imagining how they would interact with wearable products they had not experienced before. The team found that users often could not fully distinguish between potential technological components - for example, Bluetooth 2.0 vs. GPS-based location tracking – and had a tendency to fixate on technologies and concepts they were already familiar with. This prompted the design team to adopt a scenario-based approach to determine the experience users preferred. The scenario-based conjoint analysis study was conducted after an initial phase of interviews, observations and concept generation in order to narrow down the product experience concepts developed.

3.1 Project Development Process

The project development process for the wearable device involved two phases: preliminary user research to understand the market need and to formulate product concepts (3.2) and user conjoint surveys to further drive product strategy (3.3). The team conducted interviews and observations during the first phase, through which they identified the need for child location tracking and parent-child communication problems. During this phase they also extracted a list of experiences that a product addressing such needs could potentially provide.

During the second phase the team conducted a conjoint survey, in which the users were asked to choose between product scenarios developed from the list of potential product experiences identified from the first phase. The part-worth utility of each experience was computed from the comparison choices to determine the final experience that the product should provide. The team used the results from this test to drive product strategies to complement and expand on their qualitative findings.

3.2 1st Phase: Preliminary Design Research

From general observation and interviews, the team identified a recurring user need, which was the difficulty of location tracking children outdoors. The development team carried out in-depth interviews and observations to better understand the context of connectivity concerns between the two user segments (parent and child).

The team found two core experiences that absolutely needed to be present in the product. First, all parents wanted to experience some form of a warning if their child started wandering out of their line of sight. Second, all parents wanted a means of tracking and locating their child back once they have lost sight.

On top of these two core capabilities, the team also identified four additional user experiences that would potentially enrich the product experience and alleviate parents' worries:

1. Having an emergency situation only communication method between parent and child,
2. Informing the child when the parent is searching for them
3. Facilitating a casual communication method between the parent and child, and
4. Giving the parent a non-intrusive background signal as long as the child is within range so the parents can be aware of the child's whereabouts without looking.

Table 1 lists the core and potential additional experiences and their attributes for the product.

3.3 2nd Phase: Conjoint Analysis Surveys to Drive Product Strategy

The aim of the scenario-based conjoint (CBC) analysis was to determine experiences that particularly resonated with parents, quantitatively understand the utility worth of each experience, and develop a product strategy that would provide the set of experiences with the highest utility value combination. Parents were briefly informed about the general concept in an online survey, and then were asked to choose between sets of situational scenarios of using the product.

TABLE 1: CORE AND POTENTIAL ADDITIONAL EXPERIENCES

	Experience
Core Experiences	Alert parent when the child is wandering out of visual range, or line of sight
	Track and locate the child when lost
Potential Additional Experiences	Allow direct communication when needed
	Signal the child when the parent is looking for them
	Allow parent-child communication
	Have periodic and non-intrusive reminders for the parents so the parent can know the child is safe and within range without having to directly monitor

The individual part-worth utility value of every possible user experience was calculated based on the scenarios they preferred in each comparison. A total of twenty responses were collected for this research of which fifteen were analyzed (n = 15). Five of the responses were incomplete and had to be removed from the sample.

3.3.1 Conjoint Analysis Implementation

To minimize repetition, the conjoint survey and models were divided into two tests as shown in Table 2. The conjoint analysis was conducted in the form of text-based online surveys.

TABLE 2: TESTED USER EXPERIENCES AND ATTRIBUTES USED FOR TEST 1 AND TEST 2

	Experience	*Potential Experience Attribute levels*
Test 1: **Core Experiences**	Active alert when child wanders out of range	Alert with a beeping sound when child wanders off Vibrate when child wanders off Flash light and warning message on the mobile phone when child wanders off
	Child Tracking	Show child's location on map on phone Direct to child's location with compass on phone
Test 2: Potential Additional Experiences	Emergency Communication	Be able to voice call the child (parent to child) No calling option enabled
	Child Alert	Notify the child through vibration No child alerting enabled
	Casual Communication	Be able to send and receive emojis No casual communication enabled
	Passive Reminder	Signal with small beep or vibrate every 10 minutes while child is in range No passive reminder enabled

The first portion – Test 1 (Core Experiences) – tested the user's perceived preferences on the execution of the two necessary experiences: 1) tracking the child, and 2) alerting parents when child wanders off. The results of this test would not define whether each of the two experiences would be included - as they are both necessary for the product - but rather how they would achieve the functional purpose. There were 6 sets of comparisons with 2 scenario cards each. A sample comparison is shown in Figure 2.

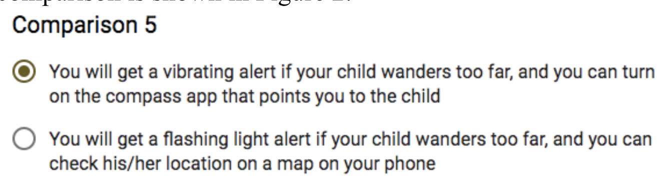

FIG. 2: SAMPLE COMPARISON FOR TEST 1

The second portion – Test 2 (Potential Additional Experiences) – tested potential experiences that could be further added to the product on top of the core experiences in Test 1. These were 1) give parents a method to make an emergency call to the child, 2) have a method for the parent to alert the child when the parent is looking for them, 3) allow casual communication between the parent and child anytime through emojis, and 4) give parents a passive reminder when the child is nearby, allowing parents to take their attention off the child and still know where they are. The result of this test would be combined with qualitative research to determine if each additional experience would be incorporated into the product. There were eight sets of comparisons with three scenarios each. A sample comparison is shown in Figure 3.

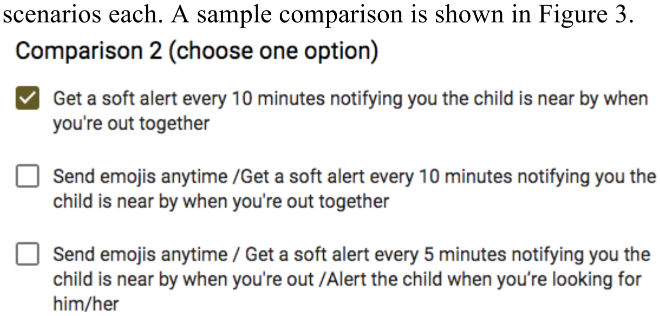

FIG. 3: SAMPLE COMPARISON FOR TEST 2

Because Test 2 comprised of more experience levels and attributes, the research team employed a full profile choice-based conjoint method for Test 1, but a partial profile choice-based conjoint method for Test 2 to limit the number of choices and reduce each respondents' cognitive burden [7]. Hence, Test 1 had six comparisons with a mix of the three levels of two attributes, and Test 2 had only eight comparisons instead of 24 profiles.

While a full profile conjoint displays every single attribute of the product, partial profile conjoint tests consist of only a subset of attributes [18]. The partial profile method relies on the fact that overlaps between two profiles [a, a, b, c] and [a, a, c, b] convey the same information. In a survey, asking about either one of the two profiles would yield customer preference pertaining to the [a, a, b/c, b/c] portion. The partial profile method reduces the number of profiles by eliminating those with partially redundant information and orthogonally selecting only the necessary profiles. Details regarding the design of the experiments, including attribute, levels, and profiles, can be found in Appendix A.

In addition, as a scenario-based approach, the conjoint choices were comprised of cards describing experience scenarios rather than a list of attributes. That is to say, profiles that would have looked like Table 3 in a conventional conjoint analysis were turned into scenario profile cards as shown in Table 4.

TABLE 3: SAMPLE OF NON-SCENARIO-BASED ATTRIBUTE LIST PROFILE FOR TEST 1

Observation	*Location Tracking*	*Active Alert*
Profile 1	Display on map	Sound alert
Profile 2	Display on map	Vibration alert
Profile 3	Display on map	Flashing light
Profile 4	Direction with compass	Sound alert
Profile 5	Direction with compass	Vibration alert
Profile 6	Direction with compass	Flashing light

TABLE 4: SCENARIO-BASED PROFILES USED FOR TEST 1

Profiles	*Location Tracking Scenario*
Profile 1	At a park or a playground, you will get a sound alert if your child wanders too far, and you can check their location on a map on your phone.
Profile 2	At a park or a playground, you will get a vibration alert if your child wanders too far, and you can check their location on a map on your phone.
Profile 3	At a park or a playground, you will get a flashing light alert if your child wanders too far, and you can check their location on a map on your phone.
Profile 4	At a park or a playground, you will get a sound alert if your child wanders too far, and you can turn on the compass app that points you to the child.
Profile 5	At a park or a playground, you will get a vibration alert if your child wanders too far, and you can turn on the compass app that points you to the child.
Profile 6	At a park or a playground, you will get a flashing light alert if your child wanders too far, and you can turn on the compass app that points you to the child.

4 RESULTS

4.1 Utility Values

Utility values are calculated using multinomial logistic regression in which the utility variable is a beta coefficient.

$$C_{ij} = \sum_{k=1}^{K} \sum_{m=1}^{M_k} \beta_{ikm} x_{jkm} + e_{ij}$$

i = respondent (i = 1…15)
j = profile
M_k = number of levels within attribute k
K = number of attributes
C_{ij} = choice decision on profile j by respondent i
β_{ikm} = part-worth associated with mth level of kth attribute
x_{jkm} = binary variable 1 if mth level of kth attribute is included in jth profile, 0 otherwise
e_{ij} = error terms

Utility values quantify how much a given attribute level contributes to the profile being chosen. A positive value suggests that the given attribute level influenced the respondent to choose the attribute, while a negative value suggests the given attribute level motivated the respondent to pick something else. The absolute value shows the "strength" of this attribute level in influencing consumer product decision.

However, it is important to note that the sum of utilities per attribute is set to zero in order to reflect the zero-sum nature of attribute levels – the selection of one level and inflicting a positive beta causes the deselection of other levels in that attribute and inflicts a negative beta on all other levels. Hence one must note that a negative utility does not suggest a "bad" choice which repels buyers, but rather that other positive utility choices are simply preferred over the negative utility choice within that level given all else equal.

4.2 Test 1 (Core Experiences) Results

In the category of alerts for parents when the child wanders off, sound and vibration alerts were deemed most useful, and received utility values of 0.735 and 0.658 respectively. Parents generally thought that flashing light alert was an inconvenient method, as seen by its negative utility value. In the category of location tracking, parents preferred directions via a map application on the phone over directions through a compass application. Resulting values are shown in Table 5.

TABLE 5: CHOICE-BASED CONJOINT RESULTS FOR TEST 1 (CORE EXPERIENCES) n = 15

Attribute	*Level*	*Utility Value*	*Standard Deviation*
Alert parent	Direct with compass	-0.901	0.347
	Display on map	0.901	0.347
Location tracking	Flashing light	-1.392	0.335
	Sound alert	0.735	0.261
	Vibration alert	0.658	0.220
			R^2 value (McFadden) = 0.310

4.3 Test 2 (Potential Additional Experiences) Results

Parents saw the most value in being able to send an alert to their child while looking for them (utility value = 0.383). Casual communication via emojis (utility value = 0.092) made little difference in the parents' decision. Parents saw even less value in having voice calls available during emergency situations (utility value = 0.044 with standard deviation = 0.141). The passive alert experience was quite strongly not preferred, and thus this experience was eliminated from the product. Resulting values are shown in Table 6.

TABLE 6: CHOICE-BASED CONJIONT RESULTS FOR TEST 2 (POTENTIAL ADDITIONAL EXPERIENCES) n = 15

Attribute	*Level*	*Utility Values*	*Standard Deviation*
Casual emoji	No	-0.092	0.102
	Yes	0.092	0.102
Passive alert	10 min	-0.312	0.204
	5min	-0.119	0.164
	No	0.431	0.198
Emergency communication	No	-0.044	0.141
	Yes	0.044	0.141
Alert to child	No	-0.383	0.103
	Yes	0.383	0.103
			R^2 value (McFadden) = 0.072

4.4 Final Product Decision Based on Results

Using the conjoint analysis and other interview results, the team finalized the design concept to include two of the additional experiences (alert child when parent is looking for them and facilitate casual communication through emojis) along with the core experiences in the final design as shown in Table 7.

The results of the conjoint drove the product to include alerts with sound and vibration for when the child starts wandering off, the locational display of the child on a map, and a vibration alert that communicates to the child either to return to the parent or to stay calm and remain at their location.

The team then synthesized the results of interviews, observations, conjoint analyses and follow-up prototype testing to complete the conceptual design strategy. While it was true that the compass mode function did not produce positive utility according to the conjoint, the researchers observed that participants found the function useful upon actual use during product testing. Hence, the option of switching to compass mode was added to the product.

Although the emoji communication option was only weakly favored in the conjoint analysis with parents, when the parent-child pair was interviewed together, they tended to favor complementing emergency situations with emotional assurance and guidance. Hence taking in the child's perspective – that of one of the actual users that was not reflected in the conjoint – this function was also included in the final model despite the weak conjoint results.

TABLE 7: FINAL PRODUCT CONCEPT SELECTION

	Experience	*Experience Attributes*
Core Experiences	Active alert	Alert parent when the child is wandering out of visual range using a sound and vibration
	Child tracking	Track and display the location of the child onto a map, with option to add compass mode
Potential Additional Experiences	Alert child	A vibration alert to let the child know to return or to stay put because the parent is coming
	Casual communication	Allow parent-child communication through emojis

After the product experiences were finalized based on the combined conjoint and interview results, the team selected the technology and product exterior design to best incorporate the above experiences. The technological component, component performance levels, and form factors were determined afterwards to streamline user experience. For example, the wearable device included mini-screens with duplicated function as push buttons and was designed to be worn at the front part of the body so that the child could view and control emojis. It was also designed for close proximity to the skin on softer parts of the body so vibrational alerts could be felt by the child (Figure 4).

The use of conjoint in this case study is distinguished in that it assumes that people are not cognizant of the exact specifications they look for in a product but they better understand the situational experiences they would prefer.

FIG. 4: FINAL WEARABLE DEVICE MODULE PROTOTYPE WITH CIRCULAR SCREEN, ROTATION DIAL, AND PUSH BUTTON

The conjoint performed in this case study attained a broader scope by being deployed at the early stage of design in conjunction with qualitative methods to drive product strategy, rather than just to hone features near the end of the product development process.

5. CONCLUSIONS

From the case study of the development of a new wearable product, we observed that the scope of the conjoint analysis could be broadened to include user experience scenarios at the initial stage of product development to aid in strategic decisions. We posit that scenario-based conjoint could be implemented alongside user interviews or other qualitative methods to help product developers build the product with the highest value to the user.

The early-stage scenario-based conjoint brings perspective by quantifying consumer preferences in terms of desired experiences. This quantitative output provides product developers insights for prioritizing each experience attribute.

However, that is not to say that the quantitative result from the conjoint should be the final deciding factor in product strategies. As seen in the case study, decisions on some of the attributes with less significant utilities can be overturned or refined through further interviews and prototype testing. Hence, it is highly suggested that this new form of conjoint be used in conjunction with other existing qualitative user research techniques.

6 LIMITATIONS

In this research, the team only used online text surveys. While one or two pictures were included, verbal, pictorial, real, and other types of multimedia elements were highly limited, which might have resulted in different user preferences for the same experiences [8,9,11]. The experience attributes described on the scenario cards were also bordering on features – the team could have created a higher-level experience survey to better drive the product strategy rather than technological implementation. This is an opportunity for improvement in future scenario-based conjoint analysis work.

Another limitation that was not addressed in the given case study was the presence of multiple users experiencing different aspects of the product. There were two categories of users of the given product – a parent and a child. The team did not incorporate conjoint responses from one these parties - the child. While children were the actual wearers and direct users of the wearable device, the conjoint analysis was only conducted on the parents as customers. Surveying children in a consistent manner, especially with repetitive comparisons, is a highly difficult task and tends to yield unreliable data. However, the team synthesized the conjoint analysis with other qualitative design research methods, such as observations and interviews with the children (e.g., the children favored the emoji option in interviews). In the future, we will explore methods for using conjoint analysis with all facets of user groups.

Coupled with qualitative ethnographic research, the team followed most of the conjoint analysis results when developing their final product recommendation, but also encountered exceptions where the qualitative results conflicted with the quantitative results. Upon prototype testing, some parents discovered the compass mode option was quite useful (despite its low utility value), allowing them to react faster. Hence, the compass function remained in the app as a mode parents could switch to. This highlights that qualitative research is still necessary.

Another limitation in this study was the small sample size and high standard deviation in the conjoint results relative to the utility values. The small sample size of 15 participants in the research experiment was partially the cause for such high variance. Clearly, the results would have been strengthened with a larger sample size. When combined with qualitative research, the results did provide complementary validation for early design strategies, but will need to be validated through future testing.

7 FUTURE RESEARCH

Technology is advancing so quickly that it is difficult to rely on users to correctly select the technological components and levels that they wish to see in a product - especially in cases of new products that they have not experienced. We argue that designers should focus on the customer experiences together with the “invisible parts of products such as interfaces and interactions [which] are getting more important” [26] during customer research. The motivation for using experience scenarios rather than specification lists is based on the assumption that with unfamiliar products, users have difficulty correctly identifying particular features that they would find useful from a list of product attributes. The team believed that writing out scenarios would put the product in context and render usage situations more relatable for the respondent.

Overall, this scenario approach is more fitting in streamlining the user experience and employing human-centric design in the new product development process. This mainly differed from established conjoint analysis methods in that it was used to 1) determine user experience rather than plain product features, and in conjunction with other qualitative methods, 2) drive core product strategy, such as product functions, technologies, resulting aesthetics, and performances by determining the experiences a product needs to provide.

Our current research project is a work in progress. We will continue to examine the use of scenario-based conjoint at slightly later early stages where higher-fidelity prototypes are involved. We will continue to work on conducting successive scenario-based conjoint analysis surveys with the prototypes in person, possibly with pictorial and/or multimedia elements so that we may compare the results of text-based and multimedia-based stimulus presentation methods. In this process, we will move away from functional descriptions and introduce broader and better developed ‘scenarios’ into the experiments and measure its impact.

ACKNOWLEDGEMENT

The authors would like to express our gratitude to the research subjects who participated in interviews and online conjoint-analysis survey. We also thank our corporate sponsor, along with the Fung Institute for Engineering Leadership for coordinating the Master of Engineering Leadership program.

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APPENDIX A

DESIGN OF EXPERIMENTS FOR CONJOINT ANALYSIS TEST 1 & 2

Test 1: Full Factorial Design for Core Functions

Test 1 Attributes and Levels

Short Name	Long Name	No. of Categories	Category 1	Category 2	Category 3
M1	Location Tracking	2	Display on map	Direct with compass	
M2	Active Alert	3	Sound alert	Vibration alert	Flashing light

Test 1 Generated Profiles (Non-scenario Version)

Observation	Location Tracking	Active Alert
Profile 1	Display on map	Sound alert
Profile 2	Display on map	Vibration alert
Profile 3	Display on map	Flashing light
Profile 4	Direct with compass	Sound alert
Profile 5	Direct with compass	Vibration alert
Profile 6	Direct with compass	Flashing light

* Users were given scenarios that were written based off of these generated profiles

Test 2: Partial Factorial Design for Additional Functions

Test 2 Attributes and Levels

Short Name	Long Name	No. of Categories	Category 1	Category 2	Category 3
A1	Casual Emoji	2	Yes	No	N/A
A2	Passive Alert	3	Beep / vibrate every 5 minutes	Beep / vibrate every 10 minutes	No
A3	Emergency Communication	2	Yes	No	N/A
A4	Alert the child	2	Yes	No	N/A

Test 2 Generated Profiles (Non-scenario Version)

Observation	Casual Emoji	Passive Alert	Emergency Communication	Alert Child
Profile 1	Yes	10mins	Yes	Yes
Profile 2	No	10mins	Yes	Yes
Profile 3	Yes	10mins	No	No
Profile 4	No	10mins	No	No
Profile 5	Yes	5mins	No	Yes
Profile 6	No	No	No	Yes
Profile 7	Yes	No	Yes	No
Profile 8	No	5mins	Yes	No

* Users were given scenarios that were written based off of these generated profiles