EXPANDING USER NEED FINDING THROUGH ABDUCTIVE REASONING

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ABSTRACT

Prior research has shown the importance of latent user needs for enabling innovation in early product development phases. The success of a product is largely dependent on to what extent the product satisfies customer needs, and latent user needs play a significant role in impacting the way the product or service unexpectedly delights the user. Complications arise because traditional need finding methods are not able to account for the nuances of latent user needs. A user's need is multidimensional while traditional methods are built on deductive reasoning. The traditional method isolates parts of the user's needs, only pointing to what is deducible within its search space. To address this, we introduce abduction as a way to broaden traditional need finding methods. From a logic based argument it is shown that abduction accounts for the dimensionality of user needs by integrating various traditional need finding theories using design knowledge to isolate the latent need. This theoretical development shows that latent need finding must go beyond a deductive focus, to developing methods that are able to conjecture with the deduced facts in order to abduce the latent user need.

Keywords: Abduction, Latent user needs, Design theory, User centred design, Process modelling

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Cite this article: Bruggeman, R., Ciliotta Chehade, E., Ciuccarelli, P. (2023) 'Expanding User Need Finding through Abductive Reasoning', in *Proceedings of the International Conference on Engineering Design (ICED23),* Bordeaux, France, 24-28 July 2023. DOI:10.1017/pds.2023.175

1 INTRODUCTION

Latent user needs became a central construct to innovation research when conceptually proposed with the theory of attractive quality by Kano et al. (1984; Carlgren, 2013). Slater and Naver (1998) later defined a latent need for methodological purposes as being the need of the user that cannot be articulated, and thus are the inverse of the user's expressed needs. User needs have the potential when fulfilled to create satisfaction, delight, or avoid user dissatisfaction. Users themselves though are often unconscious of these needs as they are difficult to discern, or omit them because they are viewed as prerequisite. Discerning these needs can have a great impact on early stages of product development, therefore going beyond management research, concerning design and engineering (ex. Lin and Seepersad, 2007; Zhou et al., 2015; Hölttä-Otto & Raviselvam, 2016). The motivation to identify latent user needs is the assumption that these identified needs will bring innovative moments and creative opportunities to new and existing products. The success of a product or a service in the first stages of its development is largely dependent on to what extent the product or the service satisfies customer needs (Desmet and Fokkinga, 2020), and latent user needs play a particularly significant role in impacting the way the product or service unexpectedly delights or disgusts the user.

However, with the development of the latent need definition and its elicitation methods by the management discipline, it is not readily apparent that it satisfies design's approach to apprehending user needs for product and service innovation. From a designers' perspective, latency itself is wicked and is not wholly represented by a user not explicitly expressing their need (Carlgren, 2013). Something that is latent is not only unexpressed, but completely unknown until it is revealed. Its potential is much more complex in this sense, being present and capable of emerging or developing but not now visible, obvious, or active (Merriam-Webster, n.d.). To have a need emerge as the one that is latent must involve a level of reasoning on behalf of the designer to conjecture why it is the best way to unexpectedly satisfy the user.

A designer's reasoning will make a mental proposition of a scenario in which an innovative design concept will be successful and then try to generate an explanation as to how this outcome might be plausibly attained (Guenther et al., 2017). Deductive reasoning does not focus on this production of integrated, innovative concepts, but rather the deductibility of truth at a given point of time based on the available facts (Kolko, 2010; Cramer-Petersen et al., 2019). Abductive reasoning on the other hand creates an argument to the best explanation using a hypothesis that makes the most sense given observed phenomenon or data and based on prior experiences. Coined by the American philosopher C.S. Pierce, abductive reasoning is a type of inference that generates novel explanatory hypotheses (Pierce, 1932). Designers have since adopted abduction as the logic that underlies the reasoning that generates novel propositions (Koskela et al., 2018). Designers rely on abductive reasoning as a way of initiating novel ideas by formulating a hypothesis to explain how to achieve a desired, but not yet existent, outcome. "An abduction is the preliminary estimate that introduces plausible hypotheses and informs where to first enquire by choosing the best candidate among a multitude of possible explanations" (Cramer-Petersen et al., 2019).

The main focus of this paper will be to ascertain why a designer's abductive reasoning is needed to elicit latent user needs. Traditional need finding methodologies are tame in scope, not being able to fully capture the multidimensionality of the users needs, to say why a need is latent to a user population. This is because they are constructed using deductive reasoning that can only elicit theories from the available facts. We introduce abductive reasoning as a way to expand traditional latent user need finding methods by showing that latent user needs are wicked by nature and need novel methods that accommodate the multidimensionality of needs. Rather than assuming that the theories that are elicited from traditional need finding are in fact the latent need of the population, abduction validates these assumptions by integrating many need finding methods to find a synthesised latent user need. To prove this, we will first summarise user needs and their characteristics as has been discussed in design literature, followed by a description of need finding methods and their dimensions. We will conclude this section by identifying the logical structure that underpins traditional methods. Second, we will introduce the main constructs of abductive logic as they exist in the traditional latent need finding logic and why it is a necessary expansion for latent need finding methods by arguing for its soundness and completeness. Third, we will discuss the key theoretical and practical contributions, and present opportunities for future research.

https://doi.org/10.1017/pds.2023.175 Published online by Cambridge University Press

2 SUMMARIZATION OF USER NEEDS AND ELICITATION METHODS

2.1 User needs

One of the earliest discussions of user needs to be found in design literature was by Andersen (1983), where he defined a *need* as denoting whatever is required for the health or well-being of a person. In practice the term is often confused with achieving goals, problems or demands. However, in product innovation, needs may be derived from the goals, problems and demands. The need is a present, or anticipated lack of possibilities for a system or person to achieve their goals, solve their problems or meet their demands. This is an important discrepancy that Schaffhausen & Kowalewski (2016) highlight: that *needs are agnostic to solutions*. For example, a user's feedback may have an embedded solution, but this solution might be one of many alternatives to solve the underlying, unmet need. The needs agnostic nature means that when one arises while using a product it is not solution bound, but task related, focusing on a desired outcomes of using the product (Ulwick, 2009). Latent user needs then are those tasks that have the latent potential to arise from the use of the product or service, but are until then unforeseen by the user. The user does not know that those demands exist of the product and are left inactive and unexpressed as a desire by the user.

2.2 User need finding methods

Explicit and latent user needs enhance the ability to innovate, enabling early development phases that identify requirements for features (Patnaik & Becker, 2010). Need finding seeks to understand where the user's problem might arise by developing methods that utilise the user's information and context. Such methods utilise user information in different forms and processes in order to develop a taxonomy of the user's needs. Andersen (1983) suggests that such need finding methods can be classified according to three dimensions of user information retrieval: accessibility of the users information — either existing or newly generated; source of users information — primary users or experts and information agents; and procedure of user information handling — structured or unstructured procedures.

2.2.1 Accessibility of users information

Access to user information represents the ability to understand a larger portion of the user population. By either increasing the quantity or quality of information, the effectiveness of identifying explicit and latent needs in a user population will also increase. This is because a more coherent *user scenario* can be developed, allowing for many things to be covered that would otherwise not be by statistical analyses based on observations and measurements of reality, or by experiments (Hasdoğan, 1996). Variables affecting user needs are much more situation specific and to obtain the appropriate needs of the user, it is necessary to ascertain an image of the user's experience with the product and the frequency with which the user will undertake the task (Harkar & Eason, 1984). The user scenario generates a picture of the tasks in which they want to accomplish and illustrates the context in which this takes place. Large-scale need finding is one such method that aims to help users articulate their needs using specific types of feedback mechanisms, i.e. image or text, and then collecting this data using online applications in order to develop more detailed user scenarios (Schaffhausen & Kowalewski, 2016). In contrast to surveys or other manual collection methods that are often limited to their magnitude of data (Salminen et al., 2021), by increasing the proportion of user insights, the ability to identify the needs of the user population can increase proportionally. This is typically used for crowd-sourcing user scenarios because it is difficult for users to specify what may be unstructured or unpredictable in their needs, making it difficult to get it right in the early specification stage. Access to more user information means generating a more general user scenario from the user population.

2.2.2 Source of users information

Identifying a type of user or users, alters the way needs can be elicited from the general population. Explicit user needs are those that will occur more commonly within a user population, and thus users will oftentimes make this more explicit. Latent user needs are unknown to the general user population, and so identifying types of users that put unique demands on their product increases the likelihood of identifying unique needs that might be relevant to the general population. To increase the designers ability to account for these unforeseen needs, identifying a lead user as an information agent benefits the search, as these users generally face some strong needs before the mass customers encounter them (von Hippel, 1986). The lead user will try to solve their problems in advance, revealing dimensions of

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the product that would otherwise be unforeseen by the general user. Andersen (1983) refers to this lapse in time between when a user's needs are expressed as being either an *existing need* or *future need*. The existing need concerns improper or missing need satisfaction by the existing products, which are exposed by the general user and are generally more easily revealed. Future needs concern those which can not easily be determined and evolve over time due to a users' change in environment or demands. The ability to go beyond the immediate demands of the product and expose future needs underlies the lead user hypothesis, although, whether these will be future needs of the general user requires further analysis.

2.2.3 Procedure of user information handling

The procedure of handling information refers to the techniques in which this information is assessed. Such techniques include *manual methods*: surveys, focus groups, interviews; or *automated methods*: sentiment analysis, text analytics/mining/analysis, or the use of deep learning (Salminen et al., 2021). For example, manual methods such as surveys, use different probability sampling methods which involve researchers inviting users to respond to open or close-ended questions and then performing some form of data analysis on the results. Sentiment analysis identifies user attitudes towards products by assessing who the user is, what product they are talking about, and whether their comments are negative or positive in order to assess the products performance. The underlying goal of these information handling methods is to reveal the *emotional* and *rational* needs of the user (Andersen, 1983). Rational needs concern the product's function, performance and operation, and are often connected to the physical aspects of the product. Emotional user needs concern novelty, styling, appearance, status, personal value and others connected to the product's perceived psychological performance, and are taken into account when evaluating the ultimate need satisfaction and product value for the user.

2.3 The deductive reasoning approach

The three dimensions of need finding methods indicate that they will elicit a certain attribute of a user's need. For example, by working with a certain procedure to handle the user's information, the researcher is more likely to elicit emotional needs over rational needs, or vice versa; or by working with lead users one is likely to reveal need time information. Given the nature of latent needs, integrating the three dimensions of need finding methods in a constructive way is necessary to reveal the nuances that each need attribute presents about a user in order to explicate a more nuanced demand. Traditional latent need finding methods put emphasis on one of the three dimensions, thus relegating them to focusing on one of the connected user need attributes. For example, Tuarob & Tucker (2015) developed a set of algorithms to mine social media networks to reveal product features by their association with a lead user, while others focused on identifying emotional markers as non verbal indicators of latency (Zhou et al., 2013). Methods like these and others (Griffin & Hauser, 1993; Rasoulifar et al., 2015) are reductive and pigeonhole the results of need finding to a singular search space, not revealing the general latent need, but rather a latent need attribute. Traditional latent need finding can be thought of as *deductive* because the need is being deduced from a finite set of observations made about the user (Takeda et al., 2001). Logically, this takes the form,

$$A \cup F \vdash Th \quad (1)$$

Where A is the axiom (in this case the users use of a product), F is a set of facts about the products (i.e. lead user information), $\vdash$ is the inference rule used to prove a theory Th about the needs of the general user population of the product. Syllogistically we have

Given	
A	Users spend time getting their shoes on.
And	
$F(x)$	Lead users slip their shoes on to save time.
We can infer that	
$Th(x)$	Common users have a need to slip their shoes on to save time.

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The deductive argument logically guarantees the truth of its conclusion, therefore leaving it self contained (Kolko, 2010). The deductive logic of traditional need finding is self justified as the premises guarantee the truth of the conclusion. The argumentation does not take into account the other user's need attributes, such as emotional and rational needs, and the user's scenario, but isolates a single one. This tame approach is a formulation that can be stated, containing all the information that researcher needs for understanding the users needs (Farrell & Hooker, 2013). This means that if researchers or developers would like to identify latent needs for product development, they would have to choose one method and have faith that it resolves a user population's latent need, as traditionally there is no clear multidimensional method that accounts for all of a user's need dimensions.

3 THE ABDUCTIVE REASONING APPROACH

Given the limits that a deductive logic has for latent need finding methods, we propose an abductive reasoning as a way to incorporate the dimensions of traditional methods with the many attributes of user needs. March (1976) regarded abduction as the reasoning of design since co-opting it from Pierce (1932). In March's original prescription, he proposed that an abductive design reasoning is concerned with realising a particular outcome, whereas in the deductive sciences, the goal is to establish general laws. The pattern of abduction proposed by March states that from certain characteristics that are sought, and on the basis of previous knowledge and models of possibilities that are held by the designer, a proposal can be put forward. The formal structure of Pierce/March abduction can be proposed as follows (Tomiyama et al., 2003),

$$A \cup Th(k) \models F(k) \tag{3}$$

The abductive logic states that if you are given an axiom A and observe some Th that aligns with a designers previous knowledge k, they are able to model some novel $F(k)$. The axiom remains the same as it was stated above in the deductive process, but now, rather then combining it with some premise $F(x)$ to deduce the latent need $Th(x)$ of the general user by syntactic consequence, the designer fits the facts with their own knowledge to model the new fact $F(k)$ by semantic consequence $\models$. As Tomiyama et al. (2003, p.3) highlight, to perform this type of abduction, "we must be given a knowledge base that contains k and k should satisfy $Th(x)$." Unlike the deductive structure of traditional latent need elicitation method that had a self contained search space of $\{F(x) \rightarrow Th(x)\}$, latent user needs finding through abduction becomes a search for a problem by the designer, utilising the different traditional elicitation method constructions of $Th(x)$. The abductive logic utilised by the designer navigates the axiom (i.e. users' use of the product) by combining it with different attributes of the need to transform the problem as an initial intent, into a functional requirement for the product (Lu & Liu, 2012). Rather than a closed form operation, latent need finding through an abductive reasoning is about synthesising multiple theories (Takeda et al., 2001; Tomiyama et al., 2003; Lu & Liu, 2012). An axiom allows theories to be formulated deductively, the designer can then combine those theories with their knowledge of the axiom to conjecture about the need, but if the need is judged impossible to find within those boundaries by the designer, the designer can then introduce another set of facts deduced by other traditional methods to form a new set of theories, and integrate those with another set of theories to identify the latent user needs (eq. 6, 7; Figure. 1). For example, rather than only utilising a lead user fact, we can complement it by integrating sentiment analysis facts.

Once a set of theories $Th(x)$ are deduced by an axiom and facts, the designer introduces the theory into abduction by distinguishing between their knowledge $k(x)$ and the established facts $F(x)$ that were used when designating the original $Th(x)$, now treated as the axioms to deduce a knowledge induced theory (eq. 4).

$$k(x) \cup F(x) \vdash Th(k(x)) \tag{4}$$

The theory is unified with the original axiom to abduce a unique set of facts $F(k(x))$.

$$A \cup Th(k(x)) \models F(k(x)) \tag{5}$$

If $F(k(x))$ is deemed inadequate in eliciting the latent need by the designer, they can integrate $F(k(x))$ with a new set of deduced theories $Th(y)$ to conjecture a new fact.

$$(k(y) \cup F(y)) \cup F(k(x)) \vdash Th(k(x,y)) \tag{6}$$

$$A \cup Th(k(x,y)) \models F(k(x,y)) \tag{7}$$

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A syllogistic example of an abductive reasoning using a deduced user need fact to identify a more specific need of the user,

Given

A	Users spend time getting their shoes on.
And	
$k(x) \cup F(x)$	Laces take long to tye ∪ Lead users slip their shoes on
$\vdash Th(k(x))$	⊦ Laces are a burden.
We can infer that	
$F(k(x))$	The lacing system is a burden on time for users and needs to be less burdensome.

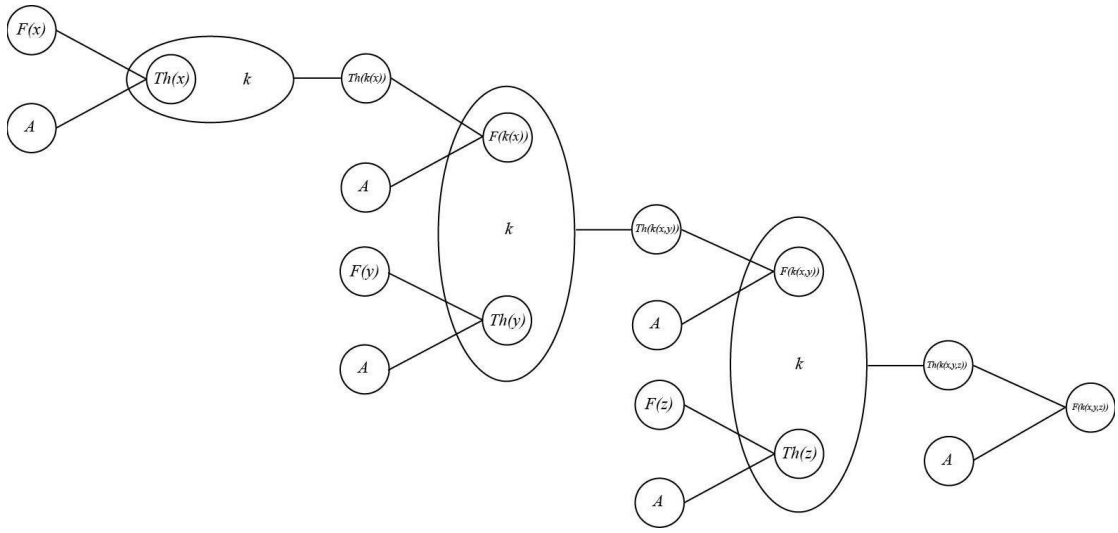

Figure 1. Univariate deduction of Th(x), Th(y) and Th(z) is transposed into a multivariate abductive space by design knowledge.

3.1 The soundness of abductive reasoning for need finding

Abductive reasoning expands traditional latent need finding methodologies by introducing a way to conjecture with more than one theory. As von Hippel (1986) points out, the lead user is a source of information, and further analysis is needed to synthesise the information to the general user, rather than "assume such data is straightforwardly transferable." The abductive ability to model semantically with the information produced syntactically by traditional methods introduces a soundness to traditional need finding methods. This is because the traditional methods that rely on a deductive logic assert the existence of a theory given the facts F and A. The abductive logic then asserts that design knowledge k holds when modelling with A on the condition of being conjoined with the deduced theory. We argue that the abductive reasoning is sound because we can conclude that

$$A \models Th(k) \text{ when } A \vdash Th \tag{9}$$

Deducing information about the user's needs allows designers to anticipate what the user is likely to need by serving as facts to construct a user model. Carlgren (2013) says that designers first understand latent needs in terms of focusing on the end user and context; for example, the ability to empathise with users and accommodate their views, as well as focusing on the situation of the user. The role of combining this information is where abduction becomes salient as a form of reasoning, since it is more closely related to such cognitive tasks as perception, guessing and insights (Paavola & Hakkarainen, 2005; Koskela et al., 2018). The designer's ability to 'see' goes beyond visually registering information, to also constructing its meaning. Rather than focus on a single fact as a syntactic consequence, the abductive model requires that knowledge unify facts in a meaningful way through an integrated and synthesised solution. When the designer does not think that a deduced fact outright

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satisfies the need, latent or not, of the user, they can have recourse to derive a new outcome, by utilising another set of theories that deal with another dimension of the users need. This highlights the wicked nature of the latent user need as not arising automatically and inevitably from the interaction with the deduced theories, but rather from the designer anticipating the user's needs by modelling future themes, ideas, and early signs of a product in its future context by having a sensitivity to trends, as well as hidden and emerging phenomena using their design knowledge (Farell & Hooker, 2013). They are not reliant on one method to satisfy the multiple attributes of the user needs, but must ascribe multiple need finding methods where necessary to attain a sound outcome. The semantically sound latent need is thus developed through the integration and synthesis of design knowledge using traditional latent need finding methods.

3.2 The completeness of abductive reasoning for need finding

The completeness of this argument is built on the condition that design knowledge is what unifies the multidimensionality of need finding methods with the multiple attributes of user needs. Logically, the argument is that $Th(x)$ represents elicited user need through some need finding method, but it is not valid until conjoined with some design knowledge k. We argue that the abductive reasoning is complete because we can conclude that

$$A \vdash Th \text{ when } A \models Th(k) \tag{9}$$

The knowledge present in abduction is capable of going beyond established boundaries and toward a responsive reformulation and reconfiguration according to the demands of the designer and user. A designers knowledge presents the ability to acquire, reorganise, confirm, resolve, revise, synthesise, analyse, compose, decompose, and recompose the model of the problem according to situation, their level of expertise, and content they are presented with (Koskela et al., 2018; Thoring et al., 2022). Going beyond the visible textual needs and addressing the underlying drivers of user behaviour means the development of user models that abstract the latent user need taxonomies (Salminen et al., 2021). Rather than relying on the deduced taxonomic facts that are restricted to the accessibility of user information, the user information source, or the way the user information is handled, the designer must validate this with their preliminary knowledge of the user's emotional and rational needs, the users needs in time, and the users scenario, in order to validate the fact (Figure 2).

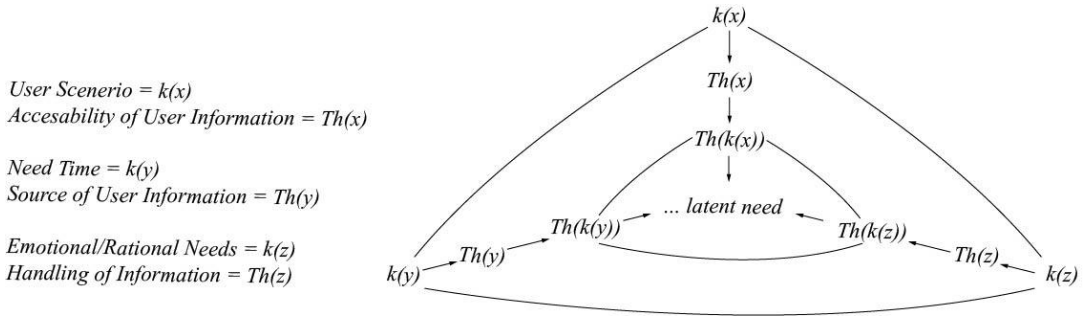

Figure 2. The preliminary user model established by design knowledge unfolds over time as new Th are introduced to reveal latent need.

The validation is not done once, using one method, but rather recursively, validating multiple theories using the designers knowledge model of the user until a synthesised picture of the users' needs is developed and a latent need is isolated. Emphasising one method will negate critical user information that can go into identifying a general latent user need. Of course, revealing the facts to inundate the designers knowledge model of users needs is reliant on the methods used, and so this representation building and mapping of the user needs is interleaved, unfolding dynamically over time. This means that the designer must first develop a preliminary user model based on design knowledge k to then initiate and validate the theories Th they are presented with. By utilising a design knowledge model of user needs, the designer will rework the user model to conjecture why a latent need is the most likely to emerge, and which methods are most likely to attain this goal, validating deduced theories and their applicability. The methods themselves do not allow for this multi-dimensional conclusion but are reliant on the motivation presented by the designer's knowledge to achieve this end.

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4 DISCUSSION

Abductive reasoning for latent need finding accommodates the nuances of latent needs by expanding the tame traditional elicitation methodology. By looking into the logical structure of the arguments that traditional need finding makes, it can be seen that the arguments are deductive and unable to go beyond the confines of their search space. An abductive model introduces the ability to integrate all these theories using a designer's knowledge to have a more complete picture of a user's needs. Abductive reasoning introduces why a certain identified need is the best way to unexpectedly delight the user, by enhancing the ability to compare, contrast, and integrate many needs of many different types using a designer's knowledge about the user until a synthesised conjecture is ascertained. This means that in order to elicit latent needs future efforts need to focus on developing the reasoning models necessary to handle the synthesising of facts, rather than the fact producing methods alone.

The theoretical contribution to latent need finding is the expanding of the traditional methodology, introducing a new, and just as important step in identifying latent user needs. The abductive model shows that a univariate method to latent need finding is not enough to account for the multiple dimensions of a user's needs. Rather than learning perceptual categories (or having machines learn perceptual categories) designers are able to learn factual concepts and make conjectures on them. It is not enough to assume that all effort should be put into looking at lead users, sentiment data, or the like, separately, but that an equal amount of effort should be put into the way the facts can be transformed by designers to synthesise and identify meaningful latent user needs. When a traditional latent need finding method does not yield a satisfactory result, the abductive model allows the designer to integrate another theory they think would fit. This allows for the construction of semantic consequences using all the dimensions of the user's needs to build a more holistic picture, going beyond the traditional syntactically consequential methods. We suggest think aloud protocols as a way to assess how a designer's abductive reasoning models and integrates the multiple dimensions of the user to go beyond a unidimensional representation, to arrive at the latent user need.

Practically, abductive reasoning emphasises the necessity to shift industrial operations lenses from focusing solely on how to elicit latent needs, to how they can be reasoned about and made active. The abductive reasoning shows that traditional methods are singular in scope and do not offer a comprehensive view of the user, limiting the likelihood of eliciting latent user needs. Rather, by adopting an abductive logic and developing skill sets to reason about the users need information at hand, industrial operations can acquire more for less. Instead of allocating effort towards data collection alone, learning how to properly synthesise current data can yield just as valuable results. For example, rather than eliciting lead user studies on the one hand and sentiment analysis on the other — which are essentially explicit needs and disparate — designs abductive reasoning is essential to elicit the deeper, more elusive latent need. This is vital in scenarios of increasing complexity where direct relationships are harder to determine. Abductive reasoning enables the ability to synthesise the need across multiple dimensions of information, rather than being over reliant on a single dimension. It can also be surmised that integrating designers into engineering and business oriented teams that are dealing with user research can increase the return of latent user needs in practical settings. Design knowledge is needed to orient the user's need information in a meaningful way that explicates the product attributes most necessary to design or redesign in the early stages of product development. Integrating teams of designers with engineers, marketing specialists, and other professionals should increase the likelihood that an innovative concept could be elicited from user need information.

4.1 Future directions

The expansion of latent user need elicitation shows that efforts should be put into developing systems that can reason beyond the information they are initially given. This means learning how to computationally model a user's need dimensions and developing algorithms that can conjecture using different design knowledge. Reasoning has been used scarcely for latent need finding by automated systems (Zhou et al., 2015). As need finding grows on online platforms a greater effort should be put into developing systems that have the ability to abductively reason like that of a designer in order to conjecture complex concepts. It is necessary to be able to go under the surface of the text to identify rich, meaningful user insights. Automated systems must not propagate the traditional latent need finding methods as this isolates a specific outcome. Developing systems that elicit needs according to the traditional deductive methods will limit search spaces and reduce the ability to elicit latent user

https://doi.org/10.1017/pds.2023.175 Published online by Cambridge University Press

needs. Future work will involve modelling the designer's knowledge computationally, to develop models that are able to abduce the latent need.

5 CONCLUSION

Traditionally, latent user needs had been viewed as a thing that could be elicited using a tame straightforward method as they were just not made explicit; the methods used were often singular in scope and neglected the complexity and multi-dimensionality of the users needs. The abductive model expands these perceptions, by identifying latent needs as wicked and introducing the ability to integrate these previous theories using design knowledge. Rather than a deductive method that aims to identify a need that will unexpectedly delight the general user, the abductive model integrates many theories and their outcomes to validate prior assumptions about what the latent user need would be. This means that opposed to developing one's product or service off of a single theory, design knowledge is needed to identify a more meaningful product innovation for the user. This is an important theoretical development that shifts latent user need finding from being factually deduced, which is against the nature of latent user needs, to being abductively conjectured, activating the latent user need.

ACKNOWLEDGMENTS

This material is based upon work supported by the National Science Foundation under the Engineering Design and System Engineering (EDSE) Grant No. 2050052. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation. Thank you to Mohsen Moghaddam, Tucker Marion and Lu Wang.

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