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Understanding customers across national cultures: the influence of national cultural differences on designers' empathic accuracy

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ABSTRACT

For engineering design to be successful, it is essential to understand customer experience and identify customer needs. However, it is challenging to understand customers, especially those from different national cultures. The empathy literature suggests that having similar experiences to another person can help understand them better. This study adopts an empathy measure from psychology for use in a project where designers attempt to understand customers' driving experiences in different countries and identify their needs for detecting road hazards. We quantify designers' empathic accuracy and the correctness of their rating of customers' emotional tone. The results show that national cultural differences significantly affect the accuracy of designers' empathic understanding but do not impact their understanding of customers' emotional tone.

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Empathy; national cultural differences; customer needs; understanding customers; engineering design

Introduction

Understanding customers is essential. In engineering, we often develop technologies that have not previously existed. It is challenging to understand customer needs for novel technology since customers have not experienced it. For example, consider the case of the novel detection technology we are developing for personal motor vehicles for customers all over the world. Today, drivers often rely on their driving experience and rear-view mirrors to drive safely and to avoid obstacles. However, what if there were a new technology that could predict and report unexpected dangers on the road more accurately? What are the drivers' needs? Do we understand these needs correctly? What are the differences between the needs of drivers from different countries? To answer these questions, designers should investigate target customers and understand their needs in various situations.

However, customers cannot express their expectations and needs, since they have not used the specific technology yet. To solve this problem, designers should understand customers from the customer point of view. Empathy is a way to build connections with customers and enhance the accuracy of understanding by metaphorically stepping into the customers' shoes. In psychology, empathy is 'the capacity to understand or feel what another person is experiencing from within their frame of reference' (Bellet and Maloney

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1991, 1831). In the field of design, McDonagh and Thomas (2010) believe 'empathy is the critical component that deepens the designer's understanding of users who may be very different from the designer' (183). Koskinen (2003) proposed that letting designers experience customers' lives would help them acquire rich customer knowledge. Therefore, empathizing with customers is considered a way to achieve more accurate customer understanding.

If empathy helps designers understand customers, can it help designers better understand customers from different cultures? More specifically, can it be applied to the development of the road hazard detection device to better understand customer needs in their cultural contexts? Different cultural backgrounds lead to different customer habits, beliefs, and social contexts. Lachner et al. (2015) believe that considering cultural differences in design helps designers to 'create [a] culturally targeted, hence better product' (p.68). Moreover, Clemmensen, Ranjan, and Bødker (2018) find that culture-related knowledge shapes the reasoning patterns of design thinking. These elements tell us that cultural differences have an impact on design. However, how cultural differences influence customer understanding and what aspects of that understanding are impacted remain unclear.

This is the core research gap our paper addresses. More specifically, this study adopts an empathy measure from psychology to gauge how accurately designers can understand customers from different cultures. In this study, we specifically consider national cultural difference as one aspect of cultural difference. We hypothesize that national cultural differences will increase the difficulty of customer understanding, including understand customers' cognitive mental content and emotional tone.

Research background

Understanding Customer Needs

Successful product design depends on the degree to which designers understand their target customers. The Kano model shows that customers' satisfaction with a product is correlated with the extent to which customer requirements are fulfilled (Kano et al. 1984), or, in other words, 'the higher [the] level of the fulfillment, the higher the customer's satisfaction' (Sauerwein, et al.,1996, 314). Moreover, in product design and development, a further reason for focusing on user needs over solutions is that needs tend to be less transient than solutions (Patnaik and Becker 1999). The most direct way to establish connections with customers and understand their needs is to interview them. However, Otto and Wood (2001) claim that customers are likely to discuss the failings of the current product rather than their expectations. This reflects the way customers usually express their explicit needs regarding an existing product. Nevertheless, designers must also consider customers' observable needs, tacit needs, and latent needs (Sanders 2002). To better develop novel technology and new products, designers should appreciate customers' hopes and wishes, which often reflect their latent needs (Sanders 2002). Such needs might be related to the operation or usage situation of the product (Otto and Wood 2001). A contextual interview combined with scenarios is a way to discover latent customer needs because it does not limit customers and designers to existing products but stimulates them to identify a product's future development. Scenarios are a narrative tool that provides 'descriptions of a set of users, a work context, and a set of tasks that users perform or want to perform' (Nardi 1992, 13). The application of scenarios in design 'provides several coherent futures selected from an infinite number of possibilities' (Cooper and Evans 2006, 71). A further method for better understanding customer needs involves establishing a physical connection through experiencing a functional prototype, product, or usage situation (Campbell et al. 2007; Johnson et al. 2014; Raviselvam, Hölttä-Otto, and Wood 2016). Other need-finding methods, such as questionnaires and focus groups, are also widely used (Otto and Wood 2001). However, these methods are not the main focus of our study, so they will not be discussed in more detail.

Empathy in Engineering Design

Within product design and development, empathic design is one approach to incorporating customer needs into the design process. Empathy is a way to experience customers' situations and bridge the understanding gap between the designer and the customer (van Rijn et al. 2011). It encourages designers to challenge their preconceptions and immerse themselves in customers' experiences. The process of empathizing in design includes the four phases of discovery, immersion, connection, and detachment (Kouprie and Visser 2009). The main empathic design methods are: 1) ethnographic methods, such as in-depth observation and interview, 2) empathic modelling, for example, 'experiencing with your own body the physical situation' (Thomas and McDonagh 2013, 4) and 3) empathic priming, which helps the designer gain inspiration by focusing on the verbal or visual attributes of customers (So and Joo 2017).

In-depth observations and interviews are the most direct way to connect with customers, but they require both time and money. Empathic modelling, such as wearing an aging suit or eye covers, provides a way for designers to simulate customers' particular circumstances. Similar applications of empathic modelling are found in design studies for atypical customers, such as those with visual impairments or dementia (McDonagh and Thomas 2010; Cardoso and Clarkson 2012; Raviselvam, Hölttä-Otto, and Wood 2016). In addition, empathic priming is also essential in this area. This concept is adopted from psychology, indicating a psychological phenomenon where an individual's exposure to a stimulus affects their response to subsequent stimuli (Weingarten et al. 2016). So and Joo (2017) demonstrate that personas, as a part of empathic priming, help designers create an association between customers' daily problems and designers' self-experienced situations, thus facilitating idea generation. von Unold et al. (2018) developed a peopleless persona on the basis of contextual empathic design to help designers understand users and intergrate knowledge of the users into design.

However, there are some limitations to applying empathic methods in product design. For example, Heylighen and Dong (2019) state that empathy is compromised when there are large differences between designers and customers, and they believe the limitations of simulating customers' experience stem from the 'incompleteness of empathy' (114). They also remind us to 'respect the interpersonal differences among people' and remain aware of 'the eventual limits of knowing the experiences of others' (119). Moreover, Kullman (2016) argues that imitating customers' daily life could not reflect the whole picture of customer experience. Instead, he believes in-depth observation and interaction with real users could identify user needs more efficiently. McDonagh and Thomas (2010) combine ethnographic tools and empathic modelling in product design, and they believe this can help 'provide designers with more relevant data' (185). Nevertheless, how accurately a designer can empathize with a customer remains unclear. Chang-Arana, Piispanen, et al.

(2020) introduce a psychological measurement to engineering design research, providing a quantitative way to measure designers' empathic understanding in design tasks. This is an initial step to understand how accurately a designer can empathize with a customer. We adopt the same measure in this paper.

Forms of Empathy in Psychology

In psychology, where empathy is well-studied, psychologists suggest two types of empathy: affective and cognitive. Specifically, the affective empathy comes from a person's instinct, and represents how a person reacts to emotional changes and shares feelings of others. The cognitive empathy is top-down controlled, and represents how a person infers another person's thoughts or feelings. Heyes (2018) described the types of empathy as emotional contagion and empathic understanding. Emotional contagion comes from an innate instinct that represents a state in which emotions are also affected when people and some animals experience emotional changes (de Waal and Preston 2017). Empathic understanding is the 'behaviour resulting from controlled processing', and it 'develops later, and, insofar as the controlled processing involves mindreading' (Heyes 2018, 499). Cognitive empathy and affective empathy do not exist independently. Instead, they usually occur together. Reniers et al. (2011) state that 'general consensus requires empathy to encompass a comprehension of other people's experience (cognitive empathy) as well as the ability to vicariously experience the emotional experience of others (affective empathy)' (85). While affective empathy may be relevant or even a precursor of true understanding, cognitive empathy is often the goal in empathic design. In other words, the goal in engineering design is to form an empathic understanding of users. Thus, in engineering design, empathy refers to how designers actively take the users' places, immerse themselves in the user experience and understand users in general (Kouprie and Visser 2009). Affective empathy might be in play during the immersion, but the final user understanding falls under cognitive empathy, and this is the focus of our study.

Measuring Empathy

Many methods can be used to measure empathy. Neumann et al. (2015) aggregate empathy measures into three types: self-reported, behavioural, and neuroscientific measures. Since this paper is focused on the measure from psychology, we do not discuss neuroscientific measures here. Self-reported measures, such as the Interpersonal Reactivity Index (Chlopan et al. 1985), the Empathy Quotient (Baron-Cohen and Wheelwright 2004; Allison et al. 2011) and the Feeling and Thinking Scale (Garton and Gringart 2005), inviting participants self-rate a series of questions to evaluate their empathic ability. The main difference between self-report measures and behavioural measures is that self-report measures are sensitive to biases, while behavioral measures comprise subjects' performance in experiments and are focused on measuring a person's empathic concern, empathic accuracy or affective empathy. For example, Ickes (1993) proposed a method called Empathy Accuracy Rating (EA). It is a performance-based behavioural measure to quantify cognitive empathy in a specific context in real time between two persons. It demonstrates similarities and differences between a person's own mental states and another person's inferences of them, and an emotional tone rating of the mental states (Ickes, Gesn, and Graham 2000). A person's empathic accuracy is determined by the degree of similarity between the remembered and inferred mental contents of two interacting individuals, while the concept of emotional tone provides a basic reflection of the person's positive, negative or neutral feelings.

The Influence of Cultural Differences on Empathic Understanding

Sociologists define culture as 'the integrated and maintained system of socially acquired values, beliefs, and rules of conduct that impact on the range of accepted behaviours distinguishable from one societal group to another' (Apgar 2018, 78). It is related to how people interact with the internal and external environment and how they understand the world and other people. Individuals come from the same nation or ethnicity usually share similar values, beliefs, behaviours and norms (Berrell 2021). Evidence from the fields of psychology and design show that cultural differences influence how a person understands another person. In the field of psychology, Soto and Levenson (2009) find that individuals have significantly 'greater physiological linkage' when they are trying to understand a subject with the same ethnicity (882). Atkins, Uskul, and Cooper (2016) state that cultural differences influence affective and cognitive empathy, including a person's response to another person's pain, empathic concern, and empathic accuracy. Casselss et al. (2010) find that cultural differences influence on individuals' empathic responding. In design, McDonagh-Philp and Denton (1999) suggest that everyone has a horizon of empathy, which defines 'the individual's range of understanding of user experiences in different contexts' (21). Many factors constitute this horizon, such as cultural background, educational level, social environment, empathic motivation, and perspective taking. Clemmensen, Ranjan, and Bødker (2018) argue that 'culture shapes design thinking', while to frame design questions in a 'culturally underspecified context', designers need to make their knowledge more accessible in cross-cultural design (129). Moreover, a significant difference in designers' empathic accuracy between understanding mobile payment users from the same and different national cultures has been found (Li and Hölttä-Otto 2020). Therefore, we believe cultural differences influence designers' empathic understanding of customers.

Design case and research questions

The primary aim of this paper is to study how national cultural differences influence designers' empathic accuracy of understanding customers in engineering design. The design challenge is a road obstacle detection device and the target customers are drivers.

RQ1: Do national cultural differences affect designers' empathic accuracy of understanding customers?

RQ2: How do national cultural differences affect designers empathic understanding?

Methodology

Empathic Accuracy

In this study, we selected a method, namely Empathic Accuracy (EA), created by Ickes (1993) to measure designers' empathic understanding of customers. This performance-based method gives us a quantitative means to understand the accuracy of empathic understanding between individuals and has been used in design (Chang-Arana, Piispanen, et al. 2020). Specifically, it measures designers' understanding accuracy of customers' thoughts, feelings and emotional tone. We select EA for three reasons: 1) customer interview is widely used in needfinding. The EA method includes a face-to-face interaction with customers and thus EA provides a way to see how a designer understands a customer in a typical inter view; 2) EA is a behavioural measure, which reflects how accurately a designer understands the customer's thoughts or feelings in real time; and 3) this method also includes an emotional tone rating, which addresses the designers' empathic ability to recognise customers' emotional changes through the context. Since the thoughts, feelings and emotional tone refer to how designers understand and infer customers' mental state (i.e. cognitive empathy), and do not require an ability to share or have an emotional stimulation (i.e. affective empathy) (Kerr-Gaffney, Harrison, and Tchanturia 2019), this paradigm relates closely to cognitive empathy but involves emotional tone as a part of cognitive empathy.

Experimental Site & Demography

This experiment was conducted at the Vehicle Laboratory, where a detection device technology was under development (Komulainen 2019). Thus, this study also contributed to the design of a road hazard detection device. The customers in this paper are frequent drivers, having driving licenses is a mandatory requirement of recruiting participants. Participants are 13 designers (eight females, 61.5%) of varying design experience (from 10 months to 22 years) and two drivers (two males). Average age of them is 37.6 (maximum 44 and minimum 24). The 13 designers include five Finnish, four Chinese, a Portuguese, a Mexican, a Bulgarian, and a Canadian, while the two users comprise a Chinese and a Finnish. Designers were divided into three groups by their nationalities, namely the Finnish Designer Group (FDG), the Chinese Designer Group (CDG), and the Other Designer Group (ODG). The average design experience of designers in three groups are 9.2, 6.25, and 5.75 years, respectively. Because all the designers were recruited in Finland, the designers in the CDG and ODG were born and raised in their own countries while working or studying in Finland. In addition, there are four raters (two females and two males) rating the designers' empathic accuracy. None of them are native English speakers, but their working and studying language is English. All of them are experienced researchers and fluent English speakers.

Experimental Procedure

The experiment (Figure 1) was divided into two parts: Customer's Participation and Designer's Participation. The Customer's Participation comprised a 20-30-minute semi-structured interview and a video review with each customer. The first author of this paper was the main interviewer, while the second author helped recording the interviews and organised the video review. Customers were first invited to a face-to-face interview in a car borrowed from the Vehicle Laboratory (Figure 2). The interview aimed at understanding the customers' driving experience during some extreme scenarios, such as driving in the darkness, heavy rain, and crowded intersections. The scenarios were selected as potentially relevant scenarios for the technology under development. After completing the

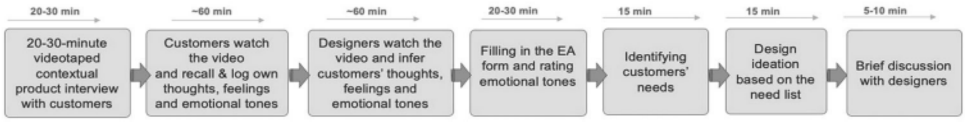

Figure 1. The whole process and time span of the experiment.

Figure 2. Customer interview in the Vehicle Laboratory.

interview, customers immediately went to another room to re-watch the recorded interview; paused the video when they recalled any thoughts or feelings during the interview; then wrote down their recalled thoughts and/or feelings at that moment and also completed the customer's entry form (Table 1). The form is combined with the paused time, the user's thoughts and feelings, and emotional tone rating (+ means that the customer had a positive emotion at the moment; 0 means neutral; – means negative).

The Designer's Participation was organised as a separate session. Each designer was invited to watch the customer interviews individually. The interview video was paused at every point where the customer had paused it. The designer was asked to infer the customer's feelings or thoughts, and rate the emotional tone. After that, the designer was asked to identify as many of the customer's needs as they could and to provide some design ideas. Both tasks were to be completed within 15 min. We also recorded whether the designer had visited the customer's country, since it may help designers better understand driving situation in the user's country. Finally, all designers had a 5-10-minute discussion with the first author. The topics of the discussion included designers' experience of the

Table 1. Example of customer's entry form.

TIME	THOUGHT OR FEELING	+, 0, -
07:15	*I was: thinking this column is blocking my view so often.*	+ 0 ⊖
08:03	*I was: thinking you might ask that.*	⊕ 0 -
08:41	*I was: feeling luckily the rain is not usually that heavy.*	+ ⓪ -

Table 2. An example of similarity rating

CUSTOMER'S ENTRY	DESIGNER'S INFERENCES	SIMILARITY SCORE
'I feel like I am repeating my answer again.'	He was: thinking how there really is a time when you do not see the road and cannot control it.	0
'I think I've seen this electronic component before.'	He was: feeling curious about something he sees in the car, otherwise felt ok being done with interview	1
'Good point. Finding parking spots is always a problem for me'	He was: thinking how finding parking is also a problem and how this device could help.	2

experiment, whether they have visited the customer's country, and any questions they have of the customer, the experiment, or the road hazard detection device.

Evaluation

Four raters participated in the empathic accuracy evaluation step. They rated the similarity between the customer entries and designer inferences (Ickes 1993). Following Ickes' protocol (2000), the similarity between customer entries and designer inferences was evaluated using a three-point Likert scale from 0 to 2. A 0 was given if the texts were 'essentially different content'; 1 if 'somehow similar, but not the same content'; 2 if 'essentially the same content' (Table 2). All customer and designer demographic information was hidden, and their answers were randomly arranged when evaluated. In addition, we compared the difference between users' original emotional tone and designers' assessment of the tone. The results are reported in Table 4.

To further explain how national cultural differences affected designers' understanding accuracy, we firstly assigned designers into two types of groups: 1) Same Cultural Group (SCG) if the designer and the customer were from the same country and Different Cultural Group (DCG); and 2) Visited Group if the designer had visited the customer's country and Non-visited Group. The cultural groups and visited groups were considered as independent variables. We only used the DCG group data in the visited / non-visited analysis. Table 3.

We are also interested in whether there is a difference in how well the designer understands the customer overall and how well they understand issues more directly linked to the design brief in question. In authors' previous study, a significant difference of designers' empathic accuracy between design-related and non-design-related inferences was found (Chang-Arana et al. 2020). The result tells that designers can achieve better empathic accuracy when understanding design-related entries. To understand whether design-relevance

Table 3. Examples of design-related ratings of users' entries.

Customer's entry	Relevance score	Rationale
'This is an easy question.'	1	Not related to design brief, but instead focused on the interview situation or language.
'Thinking good moments when driving with friends.'	2	Related to user's life and broader context, but no direct connection to design brief.
'I keep thinking is there any other information I need. I think I will use the GPS, and following its instructions. In China, the GPS is usually correct.'	3	Loose connection to design brief. Something that a designer might want to ask more about.
'I am interested to hear what technology is used to make it see other cars.'	4	Clearly but indirectly related to the design brief, product, or accessory. Potentially specifying a need.
'I do not think I really need a separate device to tell me this information because I drive often. I believe I can drive safely based on my driving experience'	5	Direct mention of product or accessory specified in the design brief.

Table 4. Summary of Hierarchical Regression Analysis for Variables predicting Empathic Accuracy.

Variable	b	β	t	R	R^2	ΔR^2
Step 1				.453	.206	.206
National Cultural Differences	−8.949	-.453	−2.492*			
Step 2				.616	.380	.174
National Cultural Differences	−5.818	-.295	−1.678			
Visiting Experience	−10.643	-.447	−2.543**			

Note. $N = 26$; $*p < .05$, $**p < .01$, $***p < .001$

of users' mental content influenced empathic understanding, we categorized the customers' mental content into design-related and non-design-related entries in this study. Defining design-related users' mental content was not a simple choice. Fully understanding the diversity of the users' mental content could be helpful in design. Thus, we used a five-point Likert scale to assess how design-related a thought or a feeling was (1 = irrelevant; 2 = likely to be irrelevant; 3 = more or less relevant; 4 = likely to be relevant; 5 = highly relevant). The ratings were further anchored with a rationale describing the relevance (Table 3). Entries were defined as design-related if they were rated with 4 or 5. Here, the relevance is considered as an independent variable.

Results

Overall, each designer inferred 50 entries from two customers (31 entries from the Finnish customer, and 19 entries from the Chinese customer). Each rater rated the similarity of 650 pairs between customers' entries and designers' inferences. The result of the rating is reliable (Cronbach's Alpha = 0.78). The average score of each designer's empathic accuracy and correct rate of inferring customers' emotional tone are demonstrated as percentages (Figure 3 & Figure 4). Designers 1–5 are from Finland, designers 6–9 are from China, and designers 10–13 are from other western countries. Here, most designers achieved higher empathic accuracy scores when empathizing with the customer from the same country compared to empathising with a user from a different country. The difference was not observed in rating customers' emotional tone. Table 5.

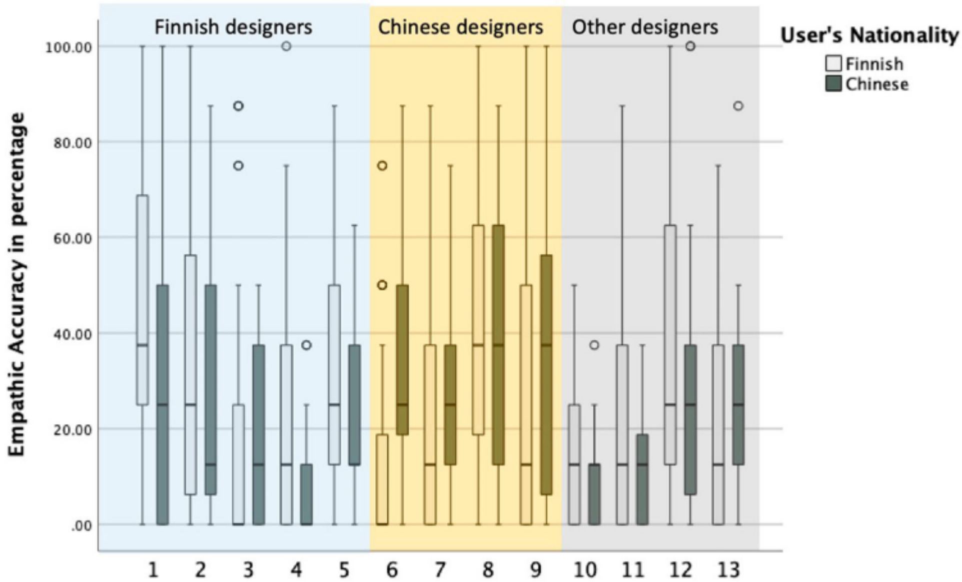

Figure 3. A boxplot of designers' empathic accuracy of understanding Finnish and Chinese users.

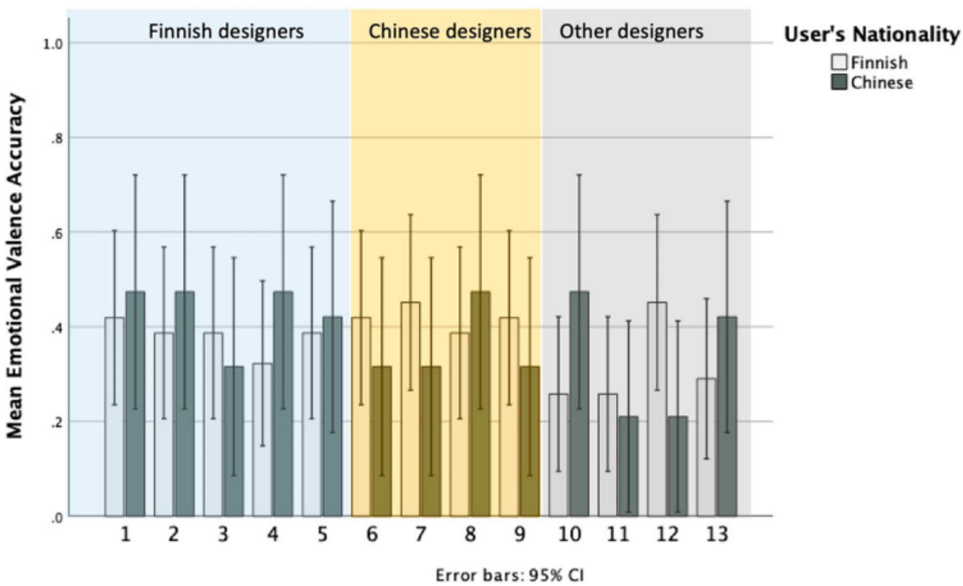

Figure 4. A bar chart of designers' emotional tone accuracy of understanding different users.

Empathic accuracy and emotional tone accuracy

The K-S test result suggested that data of empathic accuracy came from a normally distributed population (D [26] = .09, p = .20). Since we had two non-independent variables, national culture and visiting experience of a designer, we selected a hierarchical linear model for our analysis. Therefore, variances according to designers' visiting experience was

Table 5. Summary of Hierarchical Regression Analysis for Variables predicting Emotional Tone Accuracy.

Variable	b	β	t	R	R^2	ΔR^2
Step 1				.044	.002	.002
National Cultural Differences	.767	.044	.217			
Step 2				.046	.002	.000
National Cultural Differences	.681	.039	.176			
Visiting Experience	.295	.014	.063			

Note. $N = 26$; $*p < .05$, $**p < .01$, $***p < .001$

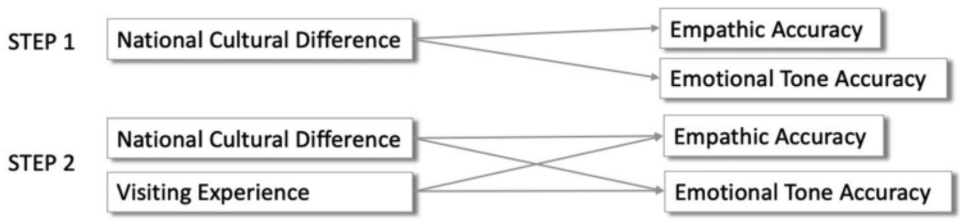

Figure 5. A hierarchical linear model of predicting variances of empathic accuracy and emotional tone under independent variables of national cultural differences and visiting experience.

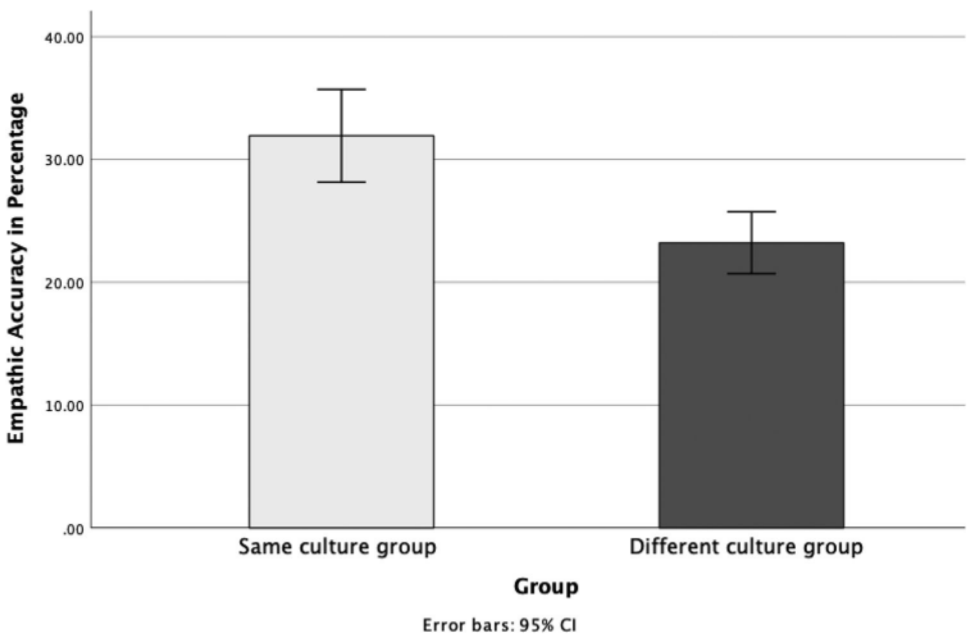

Figure 6. Comparison of designers' empathic accuracy in two cultural groups.

nested within the variance by the national cultural difference. A two-stage hierarchical multiple regression was conducted with empathic accuracy and emotional tone as dependent variables here (Figures 5 and 6).

From the result of statistical analysis, the National Cultural Differences contributed significantly to the regression model of predicting variance of designers' empathic accuracy, $F\,(1, 24) = 6.21$, $p = .020$, and accounted for 20.6% of the variation in Empathic Accuracy.

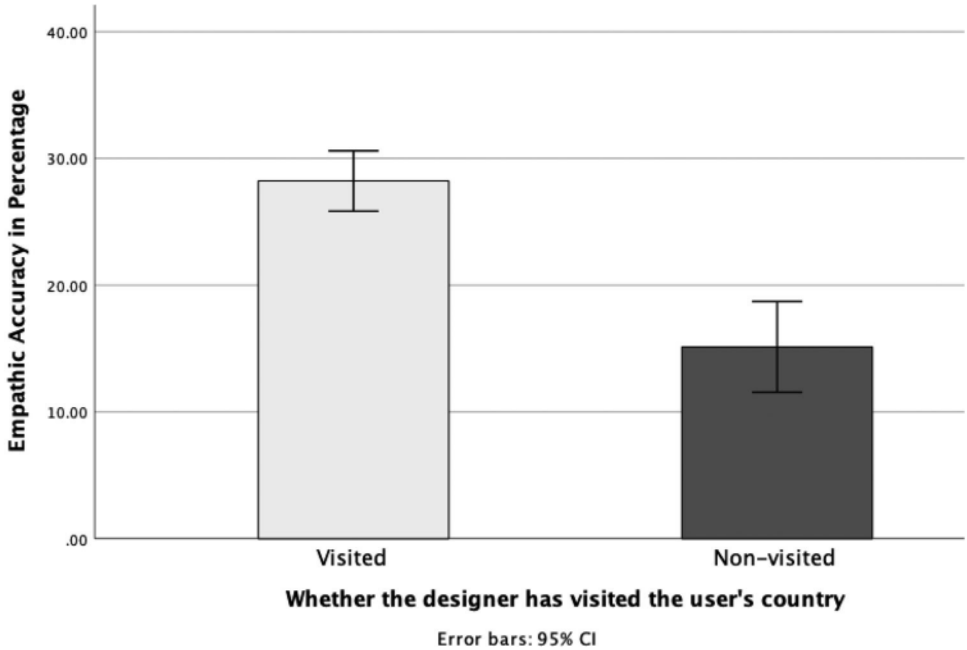

Figure 7. Comparison of designers' empathic accuracy under different visiting experiences.

Combining with Visiting Experience explained additional 17.4% of the variation in Empathic Accuracy, $F\ (2, 23) = 7.047, p = .004$, and the change in R^2 was significant, $p = .018$. Figure 7 and Figure 8 visualise the difference in empathic accuracy under the influences of National Cultural Differences and Visiting Experience. However, National Cultural Differences did not contribute significantly to the regression model of predicting variance of designers' emotional tone accuracy, $F\ (1, 24) = .047, p = .830$. When combining with Visiting Experience, $F\ (2, 23) = .025, p = .976$, there was no significant change of R^2, $p = .950$.

Design-Related and Non-Design-Related Empathic Accuracy

The second and fourth authors rated 50 customers' entries independently, and the inter-reliability of the rating scheme was checked (Cohen's weighted Kappa = 0.68). After the relevance rating, we found six design-related and 25 non-design-related entries from the Finnish customer, while the Chinese customer had five design-related and 14 non-design-related entries. In total, 13 designers inferred 143 design-related and 507 non-design-related inferences. The data was normally distributed. The empathic accuracy of 143 design-related inferences was higher than 507 non-design-related inferences, while the difference was significant ($p = .000$) (Table 6 & Figure 8).

To understand whether national cultural differences and visiting experience influenced design-related and non-design-related empathic accuracy, we first divided each designer's overall empathic accuracy into design-related and non-design-related empathic accuracy (Figure 9). A two-stage hierarchical multiple regression was conducted with design-related and non-design-related empathic accuracy as dependent variables here (Figure 10). Tables 7 and 8.

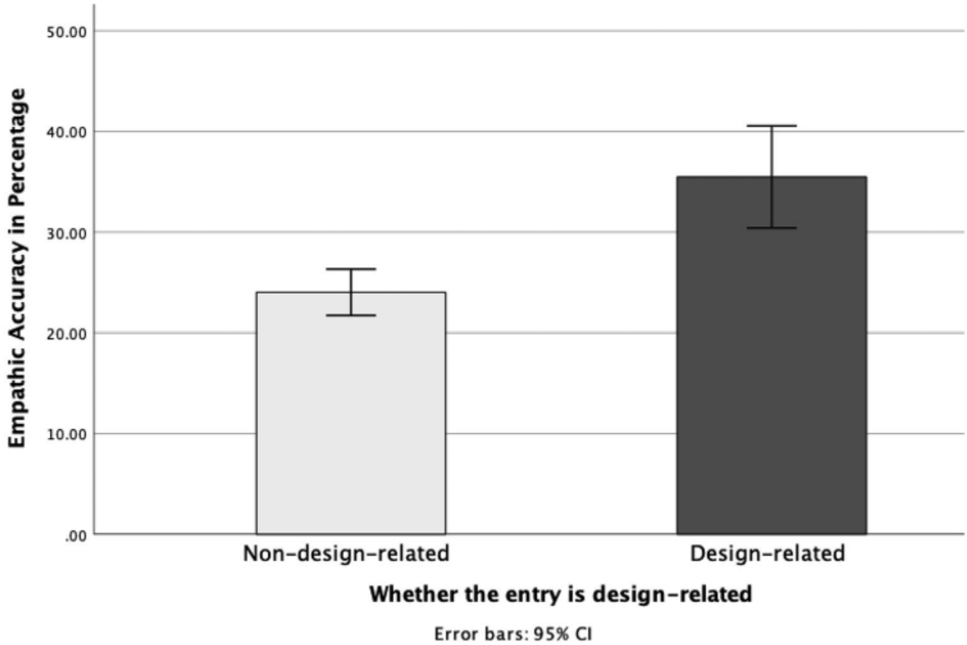

Figure 8. Comparison of designers' empathic accuracy under the independent variable of whether the customer's entry is design-related.

Table 6. Comparison of designers' empathic accuracy of inferring design-related and non-design-related entries.

Customer's entries	*N*	*M*	*SD*	Sig. (2-tailed)
Design-related	143	35.48	29.19	.000
Non-design-related	507	24.10	26.76	

From the result of statistical analysis at Step one, the National Cultural Differences contributed significantly to the regression model of predicting variance of both design-related and non-design-related empathic accuracy, $F_{design-related}$ (1, 24) = 4.867, $p = .037$, and $F_{non-design-related}$ (1, 24) = 5.822, $p = .024$. The National Cultural Differences accounted for 16.9% of the variation in Design-related Empathic Accuracy and 19.5% of the variation in Non-design-related Empathic Accuracy. Combining with Visiting Experience explained additional 18.1% of the variation in Design-related Empathic Accuracy, F (2, 23) = 6.181, $p = .007$, and the change in R^2 was significant, $p = .019$. The combination of independent variable also explained additional 11.8% of the variation in Non-design-related Empathic Accuracy, F (2, 23) = 5.246, $p = .013$, and the change in R^2 was significant, $p = .059$. Figure 11 and Figure 12 visualised the differences of design-related and non-design-related empathic accuracy under influences of the National Cultural Differences and Visiting Experience.

Examples of different and similar opinions from designers and customers

In addition to the quantitative scores, we listened to the recorded brief discussions we had with designers after their experiment participation. The quotes (Table 9) qualitatively

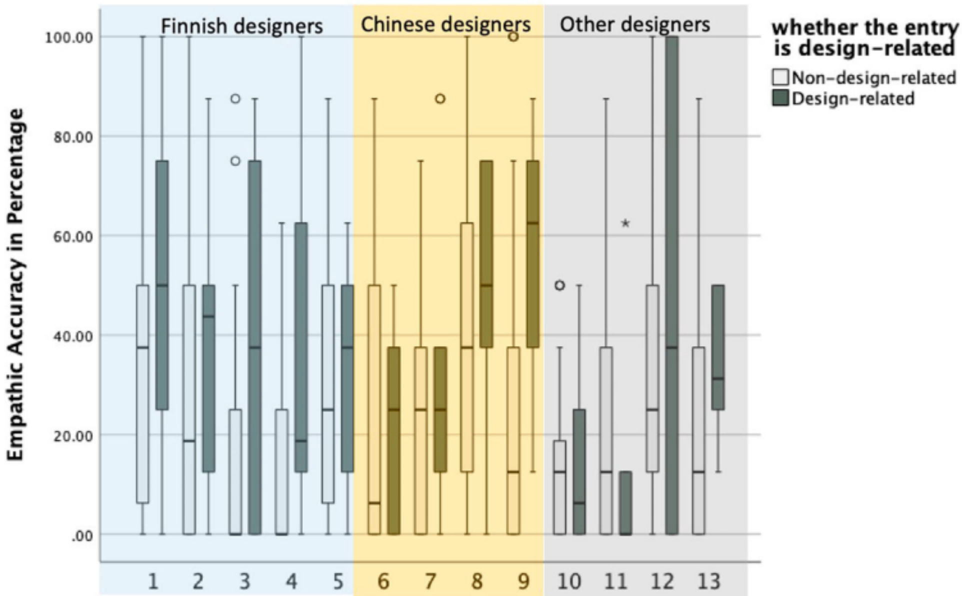

Figure 9. A boxplot of designers' design-related and non-design-related empathic accuracy.

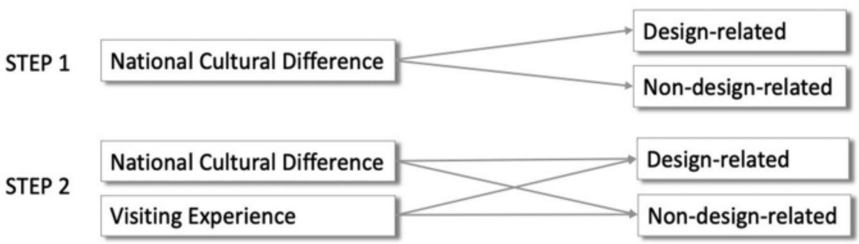

Figure 10. A hierarchical linear model of predicting variances of design-related and non-design-related empathic accuracy under independent variables of national cultural differences and visiting experience.

Table 7. Summary of Hierarchical Regression Analysis for Variables predicting Design-related Empathic Accuracy.

Variable	*b*	*β*	*t*	*R*	R^2	ΔR^2
Step 1				.411	.169	.169
National Cultural Differences	−16.258	-.411	−2.206*			
Step 2				.591	.350	.181
National Cultural Differences	−9.861	-.249	−1.385			
Visiting Experience	−21.750	-.455	−2.530**			

Note. $N = 26$; $*p < .05$, $**p < .01$, $***p < .001$

reflected how customers and designers thought when they talked about the same topic. This provided further insight into how designers understood customers, be it accurately or inaccurately.

Table 8. Summary of Hierarchical Regression Analysis for Variables predicting Non-design-related Empathic Accuracy.

Variable	*b*	*β*	*t*	*R*	R^2	ΔR^2
Step 1				.442	.195	.195
National Cultural Differences	−8.287	-.442	−2.413*			
Step 2				.560	.313	.118
National Cultural Differences	−5.839	-.311	−1.684			
Visiting Experience	−8.321	-.368	−1.989*			

Note. $N = 26$; $*p < .05$, $**p < .01$, $***p < .001$

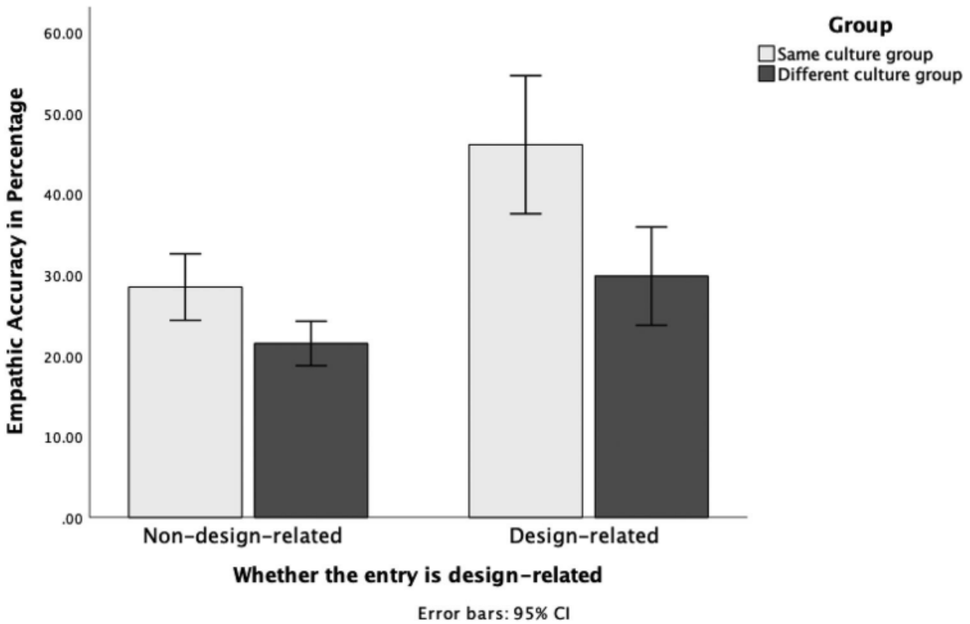

Figure 11. Comparison of designers' design-related and non-design-related empathic accuracy under the influence of national cultural differences.

Discussion

This study suggests that the national cultural differences affect the accuracy of designers' empathic understanding in the early phases of engineering design. By investigating designers' inferences of customers' thoughts and feelings at specific time points in semi-structured interviews, we find that the inferences are more accurate for customers who are from the same culture as the designer. Our results indicate that familiarity with the customer's context in terms of sharing a cultural background, or even through a short-period visiting, increases the accuracy of empathic understanding. Van der Linden, Dong, and Heylighen (2019) have theorised the benefits of user research, and it is heavily recommended by design practitioners (Mattelmäki, Vaajakallio, and Koskinen 2014; Smeenk, Tomico Plasencia, and van Turnhout 2016), but this study is among the first to quantitatively measure the influence of national cultural differences on empathic understanding. Even a short and potentially generic immersion (e.g. a working trip in the user's home country) has a large and statistically significant effect on empathic understanding accuracy. For example, under

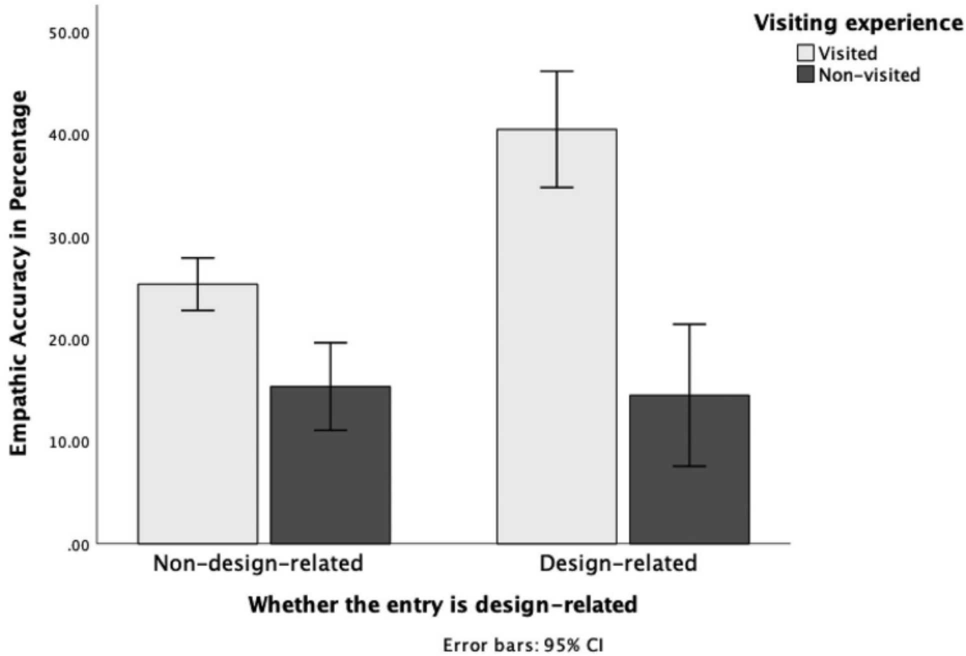

Figure 12. Comparison of designers' design-related and non-design-related empathic accuracy under the influence of visiting experience.

the entry of *Potential Dangers Caused by Animals when Driving in Dark Rural Areas* (Table 8), all the designers who had visited China achieved empathic accuracy scores from 25% to 100%, while the designers who had never visited China received scores from 0% to 25% for a single inference. The examples in Table 8 provide qualitative insight into this difference. The designers who had visited China demonstrated a better understanding of Chinese road conditions and customer needs. This phenomenon reminds us that understanding customers in their own situations is important. The differences in different customers' living situations increases the difficulty of understanding customers in a cross-cultural design context.

Moreover, we find that the customers' thoughts or feelings during the interview are not always about their own needs or the product. Most of their mental contents focus on their personal life, feelings about the interview, or something irrelevant to the product. These differences persist in different types of user thoughts and feelings, namely those directly related to the design brief and those not directly related. An increase in empathic accuracy is found in both SCG and DCG when designers inferred design-related entries. It is reassuring that while the overall empathic accuracy was quite low, it was higher for the design-related thoughts and feelings. This phenomenon is independent of how accurately individual designers understood the users overall. For example, when discussing the *Reliability of the Road Hazard Detection Device* and the *Curiosity towards technology* (Table 8), both which are design-related entries, most designers show accurate empathic understanding. However, when the design-related entry is closely related to cultural elements, the designers who are from the customer's country demonstrated more accurate understanding, such

Table 9. Examples of opinions from designers and customers under the same topic

Topic	Speaker	Quote
Potential Dangers Caused by Animals when Driving in Dark Rural Areas	Chinese customer	*'To be honest, I do not feel animals are dangerous for me in this situation.'*
	Finnish customer	*'In a few seconds, you are not so sure if there is any animal come to the road.'* And *'I have concerns about this situation (if animals come).'*
	Finnish designer who has visited China	*'I don't think he (the Chinese driver) is worried about animals. If you have visited China, you will find it is rare to have animals on the motorway.'* And *'They are thinking differently. The Chinese user is thinking of some small animals, like dog; but the Finnish user is obviously thinking of wild animals, such as moose or deer. Wild animals are more dangerous for drivers since they will cause critical accidents, but it is rare to have them in Chinese rural area.'*
	Finnish designer who has not visited China	*'Yeah, animals are dangerous. It is a problem for most drivers.'*
Reliability of the Road Hazard Detection Device	Finnish customer	*'I am not sure whether the device is reliable.'*
	Finnish designer	*'He is doubting the reliability of the device.'*
	Chinese designer	*'He cannot believe this hazard detection device is reliable.'*
	Other designer	*'(amused)He does not trust it.'*
Curiosity towards technology	Finnish customer	*'I'm interested to hear what technology is used to make it see other cars.'*
	Finnish designer	*'He was feeling curious about how the actual device works.'*
	Chinese designer	*'He was feeling puzzled about the device and how does it work.'*
	Other designer	*'He was interested in getting to know more about the device.'*
Necessity of Technology	Chinese customer	*'I do not think I really need a separate device to tell me this information because I drive often. I believe I can drive safely based on my driving experience.'*
	Finnish designer	*'He was thinking about the situation, imagining when he would use the product.'*
	Chinese designer	*'He was doubting further application of it and feel confident about his driving skills.'* And *'I don't know how to explain but I can feel he is very confident in his driving experience. My dad and friends who used to talk like that don't trust technology but themselves.'*
	Other designer	*'He was thinking that the interviewer interrupted his flow of thinking .'*

as in the example of *Necessity of Technology* (Table 8). Under this topic, a Chinese designer who accurately infer the customer's mental contents has been asked how she achieved such high accuracy, and she struggled in explaining her thought inferring process. She said that there was no explicit facial expression or body language from the customer that would have been responsible for neither her inferring of a disliking feeling toward the technology nor making her feel confident about the customer's driving experience. The only reason to her inference was that her friends and families, who are from the same national culture as the customer, used to express similar feelings in a similar way. Overall, this case provides further insight into how national cultural differences can influence the ways in which designers understand customers.

Furthermore, neither national cultural differences nor visiting experience influences designers' accuracy of inferring customers' emotional tones. Even between the top and bottom performers in overall empathic accuracy, the accuracy of inferring customers' emotional tones remains similar. Although understanding both emotional tones and mental contents is conceptually a part of cognitive empathy, our results indicate that accurately inferring customers' emotional tones does not translate into the accuracy of inferring customers' mental contents. When we empathize with someone, it is natural to guess the person's feelings. However, the role of the emotional tone rating in the cognitive empathy measure remains unclear. It will be interesting to discover the connection between emotional tone and empathic accuracy in future research.

Limitations

As mentioned in the results section, the sample size of this study is small. We are still looking for more participants to increase the diversity of both the designer and user samples. Moreover, all the designers in the CDG and ODG were working in Finland at the time of their participation. This might influence their empathic understanding of Finnish users since they are familiar with Finnish culture. This study didn't investigate connections of empathic accuracy and design outcomes. Future studies are needed to explore the relationship between designers' empathic accuracy and their performance in needs identification and ideation.

Conclusion

In this study, we measured designers' empathic accuracy and accuracy of inferring customers' emotional tones under the influence of cultural differences and design-relevance. The main results are:

- National cultural differences and visiting experiences influence designers' empathic accuracy significantly.
- Designers' understanding is more accurate when the customer's mental contents are design-related.
- Neither cultural differences nor visiting experiences influence designers' accuracy of inferring customers' emotional tones.

Overall, these results quantitatively indicate that observer-target similarity influences how well a designer can initially understand a customer. Although statistical results show that national cultural differences and visiting experience only predict approximately 31% to 38% of empathic accuracy, the significant differences highlight the essential role of national cultural differences in empathizing with customers. This partly confirms the theory developed by Heylighen and Dong (2019), who suggest that embodiment, in another word, the designer either having had or being able to imagine similar experiences as the user, is crucial in designer-user understanding. According to our results, even when the design context, such as everyday driving, is familiar to both the designer and the user, cultural differences can make embodiment difficult. In future work, it would be interesting to study how different types of observer-target dissimilarity influence empathic accuracy. Similar results, namely contextual knowledge improving empathic accuracy, have been obtained in various social psychological studies, where differences in interpersonal understanding have been compared between friends and strangers.

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