

“Voice-First Interfaces in a GUI-First Design World”: Barriers and Opportunities to Supporting VUI Designers On-the-Job

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Voice user interfaces (VUIs) are currently experiencing rapid growth as commercial devices like Google Home, Amazon Echo, and Apple Homepod are adopted by users. However, due to the pace of this growth, the tech industry has had to adapt quickly and vigorously to keep up with demand. Due to this, we currently have limited understanding of the environment of VUI design in industry, including the various multitude of practices and tools that are used. We also have a limited understanding of the barriers VUI designers currently still face. To address such knowledge gaps, we conducted a large-scale online survey to explore the design practices employed by VUI industry designers on-the-job, and the barriers and needs of VUI designers. We found that despite the availability of a wide range of guidelines, textbooks, tools, etc, there are significant gaps in the adoption of these tools within VUI industry design, and that designers rely on their previous experience in developing GUIs when designing VUIs. Based on our survey findings, we provide recommendations for how the HCI community may direct research efforts in developing tools to assist designers in overcoming existing barriers and build usable and adoptable VUIs.

CCS Concepts: • **Human-centered computing** → *Human computer interaction (HCI)*; HCI design and evaluation methods; *Interaction design*; Interaction design process and methods;

Additional Key Words and Phrases: Voice user interfaces, Design, User experience design, Speech interfaces, Design guidelines

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1 INTRODUCTION

Voice user interfaces (VUIs) are becoming more prevalent in people’s daily lives, with an increasing pace of adoption through devices such as phones, smart speakers, cars, and even household appliances. Research has shown that users’ perceptions of VUIs have become more favourable within the past five years, and have noted the growing use cases for using voice as a form of interaction – from allowing for hands-free interaction [11], communicating naturally with technology [8], or even having a robot AI friend [18].

As the pace of this adoption grows, industry designers are often tasked to design voice user interfaces, either by creating a novel interface (e.g., the creation of a new smart speaker) or incorporating

voice interaction into existing applications or services (banking apps, travel booking, etc.). However, industry designers have often been trained primarily in general UI design - which is heavily comprised of GUI design - since most of the training that designers receive (particularly in academic programs) teaches established methods and practices for general UI or GUI design [21, 22, 26]. The problem is that designing GUIs is markedly different than designing for VUIs [37, 44]. Therefore, current design training may not directly transfer over when designing for voice interaction. VUI design training in academia is currently limited, particularly in HCI programs [22]. While courses are beginning to appear in industry that aim to teach VUI design, they are still in their infancy [21]. This leaves many companies to employ their own internal training resources – which may not be sustainable or feasible for smaller companies, independent design shops, or freelance designers. The lack of established tools and resources for VUI designers also adds to the difficulty of designing for VUIs in industry. General UI design uses established and well-known guidelines to ensure UIs are usable, but those do not map directly over to VUI design [26, 37, 44].

Altogether, this makes it difficult for designers that are either transitioning from general UI to VUI design or are entering VUI design in industry for the first time. Research suggests that VUI designers - that have largely been GUI-trained - use their experience from GUI design and training when transitioning to VUI design [26]. However, there is currently a limited understanding of the experiences and practices of current VUI industry designers – in particular, how previous training, experience, and available design tools affect how industry designers conduct VUI design. There is also a limited understanding of the current barriers and needs that industry designers face when ideating, designing, and testing new VUIs.

1.1 Research Questions and Contributions

One of the main purposes of conducting this survey was to gather an understanding of experience and practices in VUI industry. There are little to no studies that aim to create a picture of the experience of VUI designers in industry. We believe that having this picture will allow HCI experts and designers to identify the main barriers to focus on. This leads us to the first research question:

RQ1. What are the current experiences and practices that VUI industry designers employ on the job when ideating, designing, and testing VUIs for usability?

Along with this, we wanted to understand how designers map their experience and practices from general UI to VUI design. Previous papers show that, while GUI heuristics and patterns cannot be

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easily mapped to VUI design [37, 44] existing GUI heuristics may prove to be a good base for developing new VUI-specific heuristics [23, 26, 42]. Some research encourages using heuristics like Nielsen’s as a framework to base new VUI heuristics around [36]. Even further, previous research has suggested that using experience and concepts from GUI heuristics can prove useful in the adoption of new VUI-specific heuristics [26]. This leads to our next question:

RQ2. Do designers use previous experience and design practices from GUI design when they are designing for VUIs?

We anticipate that designers map some their practices and their experience in general UI design to VUI design, as previous research suggests [26]. However, due to the different nature of VUI design compared to GUI design, we also wanted to identify the current barriers and potential needs that VUI industry designers have. Continuing issues with current commercial VUIs [11, 17] suggest this. This leads to our final research question:

RQ3. What are the barriers and needs of current VUI industry designers?

2 LITERATURE REVIEW

This section provides a background of the research currently conducted in the areas of Voice User Interface usability, design, and training, in order to provide context on the problems we explore in this paper.

2.1 Usability of Voice User Interfaces

Previous research has explored the usability of VUIs, particularly in the last 5-10 years. Infrequent users of personal voice assistants encounter numerous usability challenges [11], including difficulties recalling information [38], system feedback [11, 17], recognition errors [11] and learnability [13, 27, 44]. Many difficulties are a consequence of users’ expectations of VUI interaction versus the reality of using existing commercial VUIs [17]. Nielsen and Shneiderman also commented on the usability issues in speech interfaces. Shneiderman [38] highlighted key issues such as the cognitive effort required for interaction, problems with presenting information through speech, and resolving errors due to speech recognition. Nielsen [29] and colleagues [9] note that the usability of VUIs limits their usefulness, and that visual interfaces surpass voice interfaces in usability for most cases (besides hands-free interaction or for people with physical disabilities). Even with research and technological advances over the past decade, users continue to experience usability issues with VUIs, often leading to a lack of adoption or abandonment [11, 17, 20].

2.2 Resources and Tools for Voice User Interface Design

Many efforts have been made to develop resources for designing Voice User Interfaces. One that has increased over the past 5 years is the develop of design guidelines or heuristics for VUIs. Several sets of VUI heuristics have been developed in previous research [15, 23, 35, 40, 41], and have received varying levels of validation.

Furthermore, books such as “Designing Voice User Interfaces: Principles of Conversational Experiences” [31] by Cathy Pearl have worked to develop a set of industry-adoptable guidelines and practices for Voice User Interfaces, along with guidelines from companies like Amazon [6], Google [5], and Apple [7]. Work on tools for prototyping voice user interfaces and testing said prototypes have been growing both in academic research and in industry. Industry tools such as Google’s Dialogflow [1] and Voiceflow [4] allow designers to easily create conversational flows for a number of different activities in a user-friendly manner. Recently, Porcheron et al. [33] developed a python tool to allow for Wizard of Oz prototype testing with Voice User Interface.

Among the many proposals of tools and resources across both academia and industry, many have little to no validation, and very few have been adopted in industry [25]. Tools are still being developed and are in their infancy. We therefore chose not to ask about specific tools and books developed for VUI design due to the lack of validation of the efficacy of these tools and would require an extensive scoping of all existing tools and books about VUI design, which is outside the scope of this paper. We focus on exploring general principles and prototyping methods in VUI design industry, bringing to light where sources of struggle may be, and where further research needs to be directed. We have chosen only to ask about guidelines for VUIs from the primary companies that develop commercial voice-first devices (Amazon, Google, Apple, IBM, and Microsoft), as these companies claim their guidelines are derived from and implemented within the devices that they develop.

2.3 Voice User Interface Design Training

Currently, there is a limited amount of research that explores how to train designers in VUI design. Research has begun to explore VUI design training in HCI Education [22]. Even so, previous research shows that there is very little discussion and training on VUIs in current HCI curricula [22], making it difficult for designers to transition from the familiar space of designing general UIs to designing VUIs. We can see this in present VUI designs and their serious usability issues [10, 11, 23].

In comparison, much effort has been dedicated to developing better methods for teaching general UI design in post-secondary education – particularly in Human-Computer Interaction [39]. HCI conferences, workshops and symposiums have been held to discuss the methods to better teach HCI methods in their classrooms [2, 3]. Topics range from gaps in current HCI teaching [43] to teaching HCI to non-computing disciplines [19]. Several papers also discuss educators’ practical efforts to develop a curriculum for teaching HCI design methods, from design studio courses [14, 34] to experiential learning [30].

3 METHODS

To answer our research questions, we collected and analyzed data through a large-scale online survey about the practices currently employed by VUI designers in industry, along with the needs and barriers they face when ideating, designing, and testing new VUIs. The purpose of large-scale survey research has been described as “to obtain information describing the characteristics of a large sample

of individuals of interest relatively quickly” [32]. It has furthermore been described as a way to “gather information about people’s habits, interaction with technology, or behaviour” when applied in the HCI space [28]. We aimed with our survey to identify characteristics of VUI industry through their experiences, practices, and perceptions of VUI design. We believe conducting a survey was the most effective way to gather this information to understand these areas.

3.1 Survey Design

We designed a multiple-choice questionnaire, distributed as an online survey hosted on Alchemer. The questionnaire was derived from priorly validated research instruments on digital accessibility awareness and practices, by Lazar et al. [16] and Freire et al. [12], adjusting the application space to “VUI design”, instead of “accessible design”. We opted for this approach on consideration that designing for VUIs may be at the same stage of awareness and practice as designing for accessibility was when Lazar et al. [16] conducted their seminal research on this topic. We ground the VUI-specific questions in papers such as [22, 24, 26, 31], and draw from the authors’ combined 30+ years of research and industry-based VUI design experience.

The questionnaire consisted of 54 questions, grouped into seven sections:

- A General Demographics: nine questions about participants’ gender, age, education level, work experience, etc.
- B General UI Design Experience: five questions about participants’ general design experience and interfaces they are currently or have previously designed.
- C Voice User Interface Design Experience: seven questions which asked pa experience with VUIs in particular.
- D General UI Design Practices: eleven questions (one open-ended) which asked about the ideating, prototyping, and usability practices used in general UI design, along with their familiarity and usage and design tools/resources.
- E VUI Design Practices: eleven questions, a duplicate of Section D except for asking practices and tools used for VUI design
- F Perceptions and Views of General UI Design: n: seven questions asking how general usability is perceived in their companies and what influences usability. It also asks about the challenges, barriers, and needs (tools-wise) of designers in general UI design.
- G Perceptions and Views of VUI Design: seven questions, a duplicate of Section F except for VUI design

The full survey is included in the supplementary materials. As most (excluding demographics) were multiple-response questions, response percentages do not add to 100. Only three open ended questions were included in the survey – one verifying human responses, and two optional questions on why general or VUI usability was not considered by participants, which were rarely filled in.

3.2 Recruitment

Participants were recruited through snowball sampling through the author’s professional network within industry, as well as through advertising the survey by making posts on online designer discussion

boards or groups on platforms like Reddit and Facebook. Participants were asked to complete a short online enrollment form identifying their interest, with a CAPTCHA to help prevent bot responses, and screening questions (not included in the analysis) asking respondents to describe their experience in UX design. Each response was verified by one of the authors for duplicate or invalid responses (e.g., copied from Googleable job design descriptions) before the survey link was emailed to them. Survey data was anonymized by participant ID, and not associated to initial enrollment or compensation forms.

3.3 Survey Analysis

Responses were collated and reviewed to ensure completion and consistency and to identify duplicates or outliers. Responses to open-ended questions were reviewed for quality by checking if the answers provided were relevant to the questions asked, in order to avoid fraudulent responses [1].

Data was then processed and coded through SPSS. Descriptive statistics were employed to analyze the quantitative data provided through the multiple-choice questions. Frequency analysis was performed on all non-open-ended questions, and percentage was reported - with both relative percentage and percentage of cases (responses) being reported for multiple-response questions. We discuss the **percentage of responses** where relevant, rather than the relative percentage (adding up to 100%), as it best illustrates the percentage of times a particular response was chosen and assists our analysis where we aim to identify the most common practices and barriers experienced in VUI design (participants could choose several options).

Spearman’s correlation (with two-tailed significance testing) was also calculated across responses from equivalent questions from the “General User Interface Design” sections and the “Voice User Interface Design” sections, to explore correlations that exist across the two different design spaces. For example, correlation would be calculated across responses to “What do you do when you are first starting the development of a new interface?” and “What do you do when you are first starting the development of a new voice interface?”. Spearman’s correlation was used due to the non-parametric nature of the multiple-choice questions in the survey (categorical values with non-normal distribution). These correlations are primarily used to analyze how designers potentially map their experience and practices from UI design over to VUI design, and whether particular barriers are unique to VUI design or are also present in UI design.

3.4 Participants

105 participants completed the survey. Participants were required to have experience in UX design – this was based on a self-reported open-ended question at the beginning of the survey which asked participants to briefly describe the past one or two design projects they had taken part in. Participants were compensated with an Amazon gift card (\$15) on completion of the survey, that was delivered to them through email.

Participants consisted of both VUI-specific designers and general UI designers, in order to compare the practices, experiences,

Table 1. Demographics Table of Participants (n=105)

Variables	Responses	n	Rel. %
Gender	Female	48	45.7
	Male	54	51.4
	Non-Binary/Genderqueer	1	0.9
	Choose Not To Answer	2	2
Geographic Location	Canada	26	24.7
	USA	56	53.3
	United Kingdom	11	10.4
	Spain	1	0.9
	Italy	1	0.9
	Germany	8	7
	France	1	0.9
	Australia	2	1.9
Occupation	Academia	15	14.3
	Industry Researcher	2	1.9
	UX/UI Designer	59	56.2
	Usability Professional	1	1.0
	Student	12	11.4
	Other	15	14.3
Education	No occupation	1	1.0
	High School Diploma	7	6.7
	College Diploma	11	10.5
	Bachelor's Degree	50	47.6
	Master's Degree	26	24.8
	Doctor of Philosophy	6	5.7
Other	5	4.8	

and challenges of both VUI-specific and general design. While we consider a VUI designer someone who has been involved in any phase of the design & creation process (e.g. ideation, prototyping, research, evaluation), we did not place artificial constraints on this definition given the broad range of designation in industry. Instead, we allowed for respondents' self-identification through the survey. We also understand that many VUI designers may have been primarily GUI-trained, who transitioned to VUI design or continued in both spaces, due to increasing market demand for VUIs. Therefore, we wanted to explore how established UI practices may have/have not transferred over to VUI design.

3.4.1 Demographics and Design Experience. We present participants' demographics in Table 1, and design experience in Table 2. Ages of respondents ranged between 19 and 54, and the mean age was 31.44. 51.4% (n=54) of participants had stated that they had previously worked on designing a voice application or interface.

3.4.2 VUI Usage. We illustrate the familiarity and usage of VUIs by participants in Table 3, and the types of interfaces currently and previously designed in Table 4.

4 RESULTS: VUI DESIGNERS' PRACTICES AND BARRIERS

We synthesize here the survey findings, to answer RQ1 and RQ3. We report both the descriptive statistics and frequency analysis of survey responses. As mentioned in Section 3.3, we discuss percentage of responses vs. relative percentage, due to questions being primarily multiple-choice. We group the findings along the two aspects of VUI design we aimed to explore – practices employed in VUI design (and how they may map from GUI design), and barriers and needs in VUI design.

4.1 Practices Employed by VUI Designers in Industry

First, we provide a synthesis of the current practices employed by VUI industry designers – particularly in terms of the ideation, prototyping, and usability testing phases of VUI design, along with the resources used during all these phases of design. In this section, we first report percentage of responses for the entire population set (both VUI and general UI designers) for questions about general UI design (n=105). We then control for and report percentage of responses for the subset of designers who have conducted VUI design (n=54), when for questions about VUI design.

4.1.1 Design Ideation and Development of Voice User Interfaces. When asked what designers did when developing a new UI, the top responses were referring to existing UIs (78.8%), referring to online resources (76%), and speaking to colleagues (59.6%). In comparison, when those who had conducted VUI design were asked when they did when developing a new VUI, the top responses were the same: referring to existing VUIs (71.1%), referring to online resources (71.1%), and speaking to colleagues (66.7%). 35% reported haven't been involved in the beginning of a new VUI, while no one reported to not have been involved with the beginning of development for a general UI.

When asked how designers ensure general UI usability, the top responses were interviews (78.8%) and user tests (71.2%) – however, questionnaire/surveys (63.5%), use cases (62.5%), and usability tests (67.3%) were close behind. In comparison, when designers who had conducted VUI design were asked how they ensure VUI usability, the top responses remained the same, but at a lower frequency: interviews (56.9%), questionnaires/surveys (47.1%) and user tests (51%). 13.7% of respondents who conduct VUI design selected they do not use any research methods in initial VUI design, in comparison to the 2.9% of all participants who selected that they do not use any for initial UI design. This suggests that designers are more likely to conduct usability research during the ideation phase for general UIs vs. for VUIs.

When asked how usability is perceived in one's company or practice, on a 5-point Likert scale from "Not Important" to "Highly Important", 78.1% of all participants selected general UI usability being perceived as "Fairly important" or higher by their company. In comparison, 52.9% of respondents who conduct VUI design selected VUI usability being perceived as "Fairly Important" or higher by their company. This suggests that usability is more highly valued by companies for general UI design than it is for VUI design.

Table 2. Design Experience (n=105)

Variables	Responses	n	Rel. %	% of responses
Type of design training	HCI/Human Factors	105	43.2	100.0
	Computer Science	38	15.6	36.2
	Psychology, Behavioural Science, or Cognitive Science	20	8.2	19.0
	Science and Engineering	16	6.6	5.2
	Media or Communication	33	13.6	31.4
	Other	20	8.2	19.0
	No design training	11	4.5	10.5
Medium of design training	Academia	77	32.1	73.3
	Professional Industry training	38	15.8	36.2
	Self-trained (textbooks/online resources)	58	24.2	55.2
	Learn through experience	58	24.2	55.2
	Other	6	2.5	5.7
	Not applicable	3	1.3	2.9
Method of VUI design training	Undergraduate courses	10	7.6	9.6
	Graduate Courses	13	9.8	12.5
	Online Courses	19	14.4	18.3
	Training in the workplace	29	22.0	27.9
	Other	9	6.8	8.7
	None	52	39.4	50.0

Table 3. VUI Usage (n=105)

Variables	Responses	n	Rel. %	% of responses
VUI application familiarity	Smart speakers	91	22.3	87.5
	Intelligent Personal Assistants in phones	98	24.0	94.2
	Automotive voice interfaces	58	14.2	55.8
	Voice-controlled appliances/internet-of-things	46	11.3	44.2
	Speech-to-text applications	68	16.7	65.4
	Voice accessibility control	41	10.0	39.4
	Other	5	1.2	4.8
	None	1	0.2	1.0
VUIs used in daily life	Amazon Alexa/Echo	42	23.9	40.0
	Google Assistant/Home	50	28.4	47.6
	Siri/Apple Homepod	47	26.7	44.8
	Microsoft Cortana	8	4.5	7.6
	Samsung Bixby	6	3.4	5.7
	Other	4	2.3	3.8
	None	19	10.8	18.1
Amount of VUI usage	Never	39	37.1	37.1
	1-2 times a day	27	25.7	25.7
	3-5 times a day	10	9.5	9.5
	6-10 times a day	9	8.6	8.6
	+10 times a day	20	19.0	19.0

4.1.2 *Tools and Resources Used for Voice User Interface Design.* When asked what resources designers refer to when developing general UIs, the top responses were personal professional experience (80%) and standards/norms (81.9%). In comparison, when participants who had conducted VUI design were asked what resources

they refer to when developing VUIs, the top responses were the same, but at a lower rate: personal professional experience (59.3%) and general standards/norms (59.3%). This may suggest that designers feel more confident in their personal experience and established standards for general UI design than for VUI design.

Table 4. Types of Interfaces Designed (n=105)

Variables	Responses	Previously Designed	Rel. %	% of Responses	Currently Designed	Rel. %	% of Responses
Types of interfaces designed at company/independent practice	Web-based applications	87	21.4	83.7	85	22.4	82.5
	Business applications	46	11.3	44.2	43	11.3	41.7
	Forms and documents	56	13.8	53.8	36	9.5	35.0
	Big complex systems	19	4.7	18.3	36	6.8	25.2
	Mobile ICT	33	8.1	31.7	34	8.9	33.0
	Kiosk displays	21	5.2	20.2	15	3.9	14.6
	Consumer software	44	10.8	42.3	35	9.2	34.0
	Video game software	19	4.7	18.3	14	3.7	13.6
	Physical products w/ digital capabilities	21	5.2	20.2	18	4.7	17.5
	Voice user interfaces	32	7.9	30.8	35	9.2	34.0
	Chatbots	22	5.4	21.2	29	7.6	28.2
Other	7	1.7	6.7	10	2.6	9.7	
Types of VUI interfaces currently designed at company/independent	Voice dictation/speech-to-text/voice keyboard	16	11.9	15.5	19	13.8	18.1
	Incorporating voice interaction into existing virtual application (website, phone app, etc.)	34	25.2	33.0	38	27.5	36.2
	Incorporating voice interaction into existing physical application (microwave, thermostat, etc)	15	11.1	14.6	15	10.9	14.3
	Voice in automobiles	6	4.4	5.8	8	5.8	7.6
	Other	15	11.1	14.6	12	8.7	11.4
None	49	36.3	47.6	46	33.3	43.8	

In terms of established written guidelines and patterns, 68.8% of all respondents selected “heuristics and guidelines” as a tool used for general UI design, compared to the 44.4% of respondents who conduct VUI design selected it as a tool used for VUI design. Similarly, 76.2% of all respondents selected “design patterns” as a method used for general UI design, compared to the 40.7% of respondents who conduct VUI design that selected it for VUI design. When evaluating the usability of interfaces, 59.6% of all respondents selected that they check compliance with design guidelines for general UI design, compared to the 32.1% of respondents who conduct VUI design who stated that they check compliance with design guidelines for VUI design. Across the board, the percentage of responses noting the usage of general UI design guidelines is higher than the percentage of responses for VUI guidelines. This may suggest a level of confidence in the development and validation of design guidelines and patterns for general UI design vs. for VUI design.

When asked about industry-established guideline familiarity and awareness, 24.3% claim to not use industry-established guidelines (such as those from Nielsen, Norman, and Shneiderman) while designing general UIs in practice, with 15.4% that stated that they were not aware of such design guidelines. In comparison, 26.9% of respondents who conduct VUI design stated they do not use industry-established VUI design guidelines (such as those from companies like Google, Siri, Amazon, etc) in practice, with 18.5% that stated they were not aware of such guidelines. The difference between those who do not use industry-established guidelines and those who aren’t aware of them are similar across the two design spaces. This suggests that those familiar with industry-established

guidelines will tend to use them, for both general UI design and VUI design

4.1.3 Prototyping and Evaluation of Voice User Interfaces. When asked about the most commonly used evaluation techniques for general UIs, the top responses were conducting usability tests with experienced UI users (65.4%) and with novice UI users (79.8%). In comparison, when respondents who conduct VUI design were asked about the most commonly used evaluation techniques for VUIs, the top responses remained the same, but at a lower rate: conducting usability tests with experienced VUI users (56.6%) and with novice VUI users (75.5%). However, 13.2% of respondents who conduct VUI design responded that they do not evaluate their VUIs for usability, while only 2.9% of all respondents stated they do not evaluate their GUIs for usability.

When asked what prototyping methods were used for general UI design, the top responses were mock-ups (76%), sketches (68.3%), and wireframes (75%). In comparison, when respondents who have conducted VUI design were asked what prototyping methods were used for VUI design, the top responses remained the same: mock-ups (59.2%), sketches (38.8%), and wireframes (44.9%), but yet again at a lower rate. This suggests a general trend towards not prototyping VUIs as frequently or as conventionally as general UIs.

When asked what evaluation techniques were used for testing intermediate UI prototypes, the top responses were think-alouds (71.8%), cognitive walkthroughs (54.4%) and A/B testing (51.5%). In comparison, when respondents who conduct VUI design were asked what evaluation methods were used for testing intermediate VUI prototypes, the top responses remained the same: think aloud

(55.1%), cognitive walkthroughs (32.7%), and A/B testing (53.1%). While the same types of methods are used across general UI and VUI design, they are used at a much lower rate for VUI design (besides A/B testing). Along with that, no particular evaluation method stands out for VUI design as it does for GUI design. This suggests that the tools currently used for VUI design prototyping and evaluation may not be adequate, and we have yet to develop specific ones for VUI design.

4.2 Barriers and Needs of VUI Industry Designers

Second, we describe the barriers and needs of VUI industry designers as reported through the survey. In this section, we report on the percentages of all respondents (VUI and non-VUI designers) when discussing both general UI and VUI design. As many non-VUI designers are quite aware of VUIs and may even have colleagues who conduct VUI design, it is important to capture their perception on barriers to VUI design, as well as tools and resources required for VUIs, and whether they would be prepared if they were to transition to this field.

4.2.1 Challenges and Barriers to Voice User Interface Design. The largest challenge in VUI design found by respondents was speech recognition accuracy (69.5%) and making interaction natural/conversational (64.8%). Creating appropriate voice commands (55.2%), helping users recognize and correct errors (50.5%) and security and privacy (54.3%) were close behind. According to participants, the largest barriers to designing VUIs are budget restrictions (50.5%) and project scope (54.6%). Other logistical barriers with high response rates are time restrictions (44.3%) and technical constraints (43.3%).

We were most interested in the design and knowledge barriers that VUI industry designers currently experience. 40.4% of respondents who conduct VUI design selected “lack of design knowledge between colleagues”, and 42.3% selected “lack of tools/resources information” each as barriers to VUI design. While a similar percentage of all respondents noted “lack of design knowledge between colleagues” as a barrier to GUI design (42.3%), only 27.9% percent of all respondents selected “lack of tools/resources/information available” as a barrier to GUI design. This may suggest two things: 1) The general lack of VUI design guidelines, or knowledge of existing ones, causes it to be a much larger barrier than for general UI design; or 2) While designers may be familiar with VUI design guidelines, a lack of confidence in their validity may lead to a lower rate of usage, and therefore be identified as a larger barrier.

4.2.2 Tools and Resources Needed for Voice User Interface Design.

As mentioned earlier, 40.2% of respondents who conduct VUI design selected “lack of tools/resources/information” as a barrier for VUI design, while 33% of respondents selected that a lack of familiarity with tools and guidelines was a barrier for VUI design. The highest requested tool for VUI design by respondents was prototyping tools (70%), with design guidelines (59%) close behind. Respondents noted the need for design training, both academic (56%) and industry (57%) training. In comparison, while only 38.5% of all participants noted a need for more general UI design guidelines, prototyping tools (49%) and academic (45.2%) and industry (53.8%) design training were also requested. This suggests that design training is highly valued in

both general UI design and VUI design. 13.5% noted that they do not need new tools or resources for general UI design, while only 6% noted the same for VUI design. These results may suggest that a lack of tools, resources, and training for VUI design may be contributing to existing usability issues in commercial VUIs.

5 RESULTS: COMPARING VUI DESIGNERS’ TO GENERAL UI DESIGNERS’ PRACTICES AND BARRIERS

Here, we performed correlation analysis and report significant correlations found from conducting Spearman’s correlation across responses from equivalent questions in the survey across the “General User Interface design” sections and “Voice User Interface design” questions (as described in Section 3.1).

The purpose of performing this analysis was to answer *RQ2: Do designers use previous experience and design practices from GUI design when they are designing for VUIs?* Performing correlation analysis across responses for equivalent questions for general UI and VUI design can provide insight on whether designers perform similar practices from GUI to VUI design, and whether any experience from general UI design is mapped over to VUI design. This analysis also helps answer *RQ3: What are the barriers and needs of current VUI industry designers?*, as it helps to provide us insight on whether the same barriers are seen across general UI and VUI design.

5.1 Practices Employed by VUI Designers in Industry

Spearman’s correlation found significant correlations between respondents who refer to textual resources when designing a new UI and those who do when designing a new VUI ($r_s = 0.388, p < .001$). There was also a significant correlation between those who refer to academic research papers when designing a new UI vs those who do when designing a new VUI ($r_s = 0.418, p < .001$). These mean that general UI designers who use textual resources or academic papers for designing UIs are also likely to use them for VUIs. Less significant correlations were found between those who refer to online resources when designing a new general UI vs those who do when designing a new VUI ($r_s = 0.240, p < .05$), and those who look at reference industry UIs vs. those who look at reference industry VUIs ($r_s = 0.218, p < .05$).

Across the board, significant correlations were also found between using the same types of methods for ensuring UI usability vs. ensuring VUI usability. Overall, these correlations suggest that practices and methods that are used in UI design are also likely to be used in VUI design – perhaps suggesting that designers actively attempt to map the current practices they use from general UI to VUI design. Spearman’s correlation analysis also showed significant correlations between general UI and VUI designers with guideline usage ($r_s = 0.351, p < .01$), using personal professional experience ($r_s = 0.328, p < .01$), and using established personas ($r_s = 0.403, p < .01$) and scenarios ($r_s = 0.293, p < .01$). There was also significant correlation between those who were aware of general UI guidelines and those who were aware of VUI guidelines ($r_s = 0.245, p < .05$). As in the last section, this further suggests that tools and resources that are used in UI design are also likely to be used in VUI design, even if at a lower rate. The lower rate may be due to a lack of confidence in the validity of tools, as previously mentioned.

Furthermore, across the board, Spearman’s correlation calculation showed that there was a positive correlation ($p < 0.01$) between one practice used for general UI design and the same practice being used for VUI design. Significant correlations also appeared ($r_s > 0.4$, $p < 0.01$) between prototyping techniques being used for both VUI and general UI design, as well as between prototype evaluation techniques being used for both VUI and general UI design ($r_s > 0.3$, $p < 0.01$). This which suggests that designers use the same methods for VUI prototypes that they use for general UI prototypes as well.

5.2 Barriers and Needs of VUI Industry Designers

There were significant positive correlations ($r_s > 0.3$, $p < 0.01$) between those who found different company logistical constraints (budget restrictions, time restrictions, project scope, lack of client/managerial support, and technical constraints) as barriers for general UIs and as similar barriers for VUIs – with most of the significant correlations being with the same type of constraint across both design spaces. While this may not be something that the HCI community can help solve through research, it is important to note, as it may help companies fuel more resources into their VUI design teams.

As well, across the board, Spearman’s correlation found significant positive correlations between a tool that designers wish they had for general UIs vs. for VUIs ($r_s > 0.3$, $p < 0.01$). Strong significant correlations were found between those who wanted academic and industry training for general UIs, vs. those who wanted the same for VUIs, and for prototyping tools among the two design spaces. This heavily supports the argument that designers currently map the practices and resources they use in UI design over to VUI design.

6 DISCUSSION AND TAKEAWAYS - ANSWERING THE RESEARCH QUESTIONS

Grounded in the analysis of data from our survey responses, we return to answer the research questions we formulated at the beginning of this paper (Section 1.1).

RQ1. What are the current practices that VUI industry designers employ on the job when ideating, designing, and testing VUIs for usability?

We found many similarities between the practices used in VUI design and those used in general UI design. Previous experience seems to be relied on more than other practices when designing for VUIs, particularly in the ideation and development phase. We see this through participants referring to existing VUIs (71.1%) and their fellow colleague’s experience (66.7%) most when in the VUI ideation phase. This is also shown when respondents noted using professional experience (59.3%) as a design resource more than validated tools such as heuristics and guidelines (44.4%). Interestingly, the difference between those who use professional experience vs heuristics and guidelines is much wider for general UI designers than for VUI designers – this may speak to the lack of personal experience that designers have in VUI design. This coincides with designers referring to VUIs that already exist as inspiration, or experience from their own colleagues. However, this also may be problematic,

as a “lack of design knowledge between colleagues” was also noted as a large VUI design barrier – so referring to colleague experience may not be a helpful resource, even though designers may be opted to turn to it when lacking their own VUI design experience. In turn, established tools such as design guidelines or heuristics may be more useful for VUI design at the current time, due to the lack of personal experience on proper VUI design practices.

Validated tools and resources seem to be used less often in VUI design than in general UI design. As noted in Section 4.1, across the board, tools and resources used for ideation, prototyping, and evaluation were used at a lower rate for VUI design than for general UI design. It’s not clear from the survey responses the reason for this, but research shows that VUI design is still relatively new in industry, and tools and resources are either underdeveloped or not heavily known. As mentioned earlier, previous design experience is not always helpful, as general UI and GUI design is very different than VUI design. As well, while research methods such as questionnaires/surveys, interviews, and user tests are shown to be commonly used in VUI design, they are used at a much lower rate than they are for general UIs, as noted in Section 4.1.1. The 13.7% of respondents who conduct VUI design who do not using research methods for VUI design may be due to the lack of development and validation of practices for VUI design [26].

In particular, we were interested on how design guidelines are used by VUI industry designers. We found that design guidelines were used much more heavily in general UI design (68.6%) than they are in VUI design (44.4%), as noted in Section 4.1.2. Only 32.1% of VUI design participants noted checking compliance according to VUI design guidelines, compared to the 59.6% who do for GUIs. This makes sense, there is little research working on validating design guidelines and heuristics for VUIs [15, 20, 23, 24, 41]. As mentioned earlier, there may be a lack of confidence in the validity of design guidelines currently developed for VUIs. This is in addition to previous research finding that GUI guidelines can’t be mapped directly to VUI design [24, 37, 44]. However, there is a significant correlation between those who use GUI guidelines and those who also use VUI guidelines – this may mean that *designers are willing to use existing design guidelines as a design resource but have a barrier to doing so due to the uniqueness of voice as an interaction technique*. This suggests that more work needs to be done to develop and validate design heuristics for VUIs and get them into the hands of industry designers, so that these established practices may be conducted in VUI design. This leads to our first takeaway:

Takeaway 1: VUI designers want to use guidelines – but may not find the available ones adequate, making guideline development an immediate necessity

RQ2. Do designers use previous experience and design practices from GUI design when they are designing for VUIs?

Our survey results show that, yes, much of the practices that respondents noted using for GUI design are the ones that are also used when conducting VUI design. We found significant correlations across the board for many the practices used for GUI design and the same ones

used for VUI design, such as methods for ensuring usability, prototyping methods, and usability testing methods. This matches our initial expectations, in that general UI designers use their previous experience when employing new practices for VUI design. However, even so, we found that existing practices are still used much less often for VUI design than they are for general UI design, as noted in Section 4.1. This may also coincide with respondents noting that usability is perceived by companies as more important in GUI design than it is for VUI design, along with the 34.7% of participants who do test their VUI prototypes for usability. Our findings show a clear focus on ensuring usability for GUIs vs. ensuring usability for VUIs. This may be, again, due to the lack of validated practices for VUI design, since it is clear that designers do try to map practices they use for general UI design to VUI design – just at a much lower frequency.

Takeaway 2: Current industry designers rely on their existing GUI experience when designing for VUIs, and we should leverage this experience when in transitioning them from GUI to VUI design, to improve adoptability.

RQ3. What are the barriers and needs of current VUI industry designers?

Much of the barriers noted by respondents were often logistical barriers imposed by their workplace, such as time constraints, budget constraints, project scope, and technical constraints, as noted in Section 4.2.1. These are not barriers that the HCI community can directly address now and will vary from company to company. However, it was noted that a lack of design knowledge and lack of tools/resources/information were in fact large barriers to designing VUIs. This likely coincides with why designers noted using existing examples of VUIs or their own personal knowledge for VUI design vs. other types of resources. Due to the nature of VUI design research at the moment, it makes sense that this is an existing barrier, and supports the immediate need to develop and validate tools such as design guidelines, evaluation tools, prototyping methods, etc.

As far as current needs for VUI design, most noted were prototyping tools, and academic and industry training, as shown in Section 4.2.2. Interestingly, these were noted as being equal or even more important than design guidelines. Previous research has shown that there is a lack of training for designers [21, 22] – though the amount of industry courses that are available for VUI designers to take is growing [20], as is evidenced by “training in the workplace” and “online courses” being the largest sources of professional VUI design training according to our survey. *This suggests that there should be much more focus for developing a training curriculum for VUI designers.* Given that each one of our participants has had professional academic training in Human-Computer Interaction, this suggests that developing a curriculum for VUI design in academic HCI programs may be a great way to give designers VUI design training that may take into industry, as this is a primary way to transfer knowledge of guidelines and tools to new designers.

Takeaway 3: VUI industry designers want industry and academic training for VUI Design, and this should be a focus for

the immediate future.

There was a high response rate of “lack of established prototyping tools” as a barrier to VUI design, which was a finding that we did not initially anticipate. Designers said that they currently employ wireframes, sketches, and mockups for both GUIs and VUIs, so (digital) tools that allow them to do this efficiently for voice would be very useful. More interesting is that there are several prototyping tools that are well-known and largely advertised as useful for industry VUI designers, such as Dialogflow [1] and Voiceflow [4], among others. This may suggest two things: either 1) *existing VUI prototyping tools are still relatively unknown to current industry designers, or 2) they do not satisfy the prototyping requirements that VUI designers have.*

Takeaway 4: VUI industry designers want better digital prototyping tools, and current ones are not being adopted, necessitating immediate development and adoption efforts for VUI prototyping tools.

7 CONCLUSION

In this paper, we conducted a large-scale online survey with 105 designers, exploring the design practices of current VUI industry designers, and how existing experience, practices, and tools used in GUI design are mapped or carried over to VUI design. Our study also explored the barriers and needs of current VUI industry designers. We found that VUI designers do use their previous experience in GUI design and employ it when working on VUI design, however several barriers are experienced while doing so. Our survey results showed a large gap in the adoption of existing guidelines, tools, and patterns in current VUI design industry, and that designers rely on their previous experience in developing GUIs when designing VUIs. We believe immediate future research should be focused on guideline and prototyping development and adoption, and introducing academic and industry training curriculums, in order to better support designers in the transition to voice interaction design.

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