

DESIGN CULTURE(S)

Cumulus Conference Proceedings Roma 2021

Volume #2

ARTIFICIAL
LANGUAGES
LIFE
MAKING
NEW
MULTIPLICITY
PROXIMITY
RESILIENCE
REVOLUTION
THINKING

**Design Culture(s)
Cumulus Conference
Proceedings Roma 2021**

Volume #2

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Rome 2021

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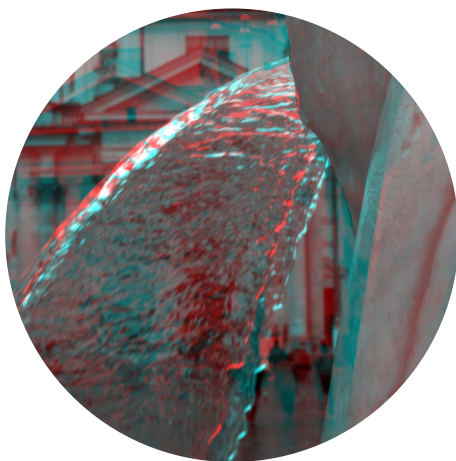
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SIGN
CULT
URE(O F)

ARTIFICIAL

D I G I T A L
T E C H N O L O G Y
R O B O T I C



TRACK CHAIRS

DESIGN CULTURE (OF) ARTIFICIAL
DIGITAL | TECHNOLOGY | ROBOTICS



João de Sá Bonelli,
PUC-Rio Department of Arts & Design, Brasile
“If Design is the Sciences of the Artificial, then how can
Design theories and practices promote a better quality of
life for us, humans?”

Mathias Funk,
Eindhoven University of Technology, Netherlands
“How must design deal with a slow culture shock of the
artificial that smart objects manifest in personal or
professional spaces? Which forms of business or political
machines do we need to reject?”



Patrizia Marti,
University of Siena, Italy
“In the digital age, a new culture of design can flourish to
value the complexity and uniqueness of being human,
bringing aesthetics, creativity, sense making and
value-oriented propositions at the forefront of technolo-
gy development.”

Giuseppe Mincolelli,
University of Ferrara, Italy
“Data are a substantial part of our life, that we do not
perceive and understand by nature. Design is called to
empower humans, bridging this new phisical and cultural
gap between us and our environment.”





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Intelligent Voice Assistants: A Review of User Experience Issues and Design Challenges.

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Abstract | In recent years, voice interfaces have become the primary interaction modality with virtual assistants. While such interfaces have been advertised as a natural way to communicate with virtual agents, research has highlighted a number of issues related to voice-based interactions. Despite the abundance of commercial voice assistants, the groundwork concerning how they should be designed is still missing. Therefore, the need emerges to face the specific challenges of this novel interaction paradigm. As a contribution to the debate, a literature review on domestic voice assistants has been performed. The review follows a framework structured around three lenses: theoretical discourse, user experience, ethical issues and concerns. As a result, six design challenges have been identified. Such challenges represent spaces where design can intervene to improve voice assistants and to mitigate some of the issues stemming from their current design.

KEYWORDS | VOICE-BASED INTERACTION, INTELLIGENT VOICE ASSISTANTS, USER EXPERIENCE, ETHICS, DESIGN CHALLENGES

1. Introduction

Research on Artificial Intelligence traces its roots back to the 1950s. Machines that can interact with humans via “natural language” have a considerable heritage in both fiction (e.g. HAL 9000 from 2001: A Space Odyssey, KITT from the Knight Rider series, and JARVIS from Iron Man comics) and research. However, only in recent years have voice-based user interfaces matured enough to be embedded into many devices we interact with daily, from smartphones to televisions to cars.

More recently, voice has become the primary interface for standalone screenless devices such as Amazon Echo and Google Home. Typically, such devices are described as systems embedding virtual assistants that answer users’ questions, connect to and control multiple applications. These voice-activated devices, also called Intelligent Voice Assistants (IVAs), are making smart homes popular across millions of households in the US, Europe and Asia (Lima et al., 2019).

1.1 Intelligent Voice Assistants

Intelligent Voice Assistants (IVAs) - also referred to as Intelligent Personal Assistant, Virtual Personal Assistants, Personal Digital Assistants, Voice-Enabled Assistants or Voice Activated Personal Assistants - to name a few, support conversational interactions, most often with limited visual feedback. Placed in the home environment, they are designed to be “always-on” and “always listening”, although they engage in interactions only when prompted by users through specific keywords or sentences (e.g. “Hey Google”). From a technical viewpoint, they combine speech recognition, natural language understanding, dialogue management, language generation and speech synthesis to understand and respond to users’ requests. In general, IVAs process a wide variety of verbal instructions to, e.g., run Internet searches, access information and multimedia contents, or compose text messages.

Voice interfaces have been advertised as a natural way to interact with virtual assistants. However, several interaction problems with this type of interface have emerged, as discussed in both academic research and public debates, especially online. According to Murad and Munteanu (2019), while affordable commercial voice-based devices abound, the high-level groundwork concerning how they should be designed is still missing. As a result, there is a lack of specific design principles and usability heuristics for IVAs. Therefore, the need emerges to face the specific challenges of this new interaction paradigm, and to adapt existing heuristics and design guidelines to such emerging field.

2. A review of Voice Assistants

As a contribution to the current debate on IVAs, we have performed a literature review on domestic voice-based assistants, using a specific set of keywords to search the ACM Digital Library. As a result, a final selection of 40 papers and journal articles, all published in the last five years, have been analysed. The review was structured around a framework composed of three lenses.

The first lens examines the theoretical discourse around voice assistants: how they are designed and advertised, their potential benefits, what users expect from them. The second lens scrutinises the user experience of voice assistants. Through it, we have collected and organised outcomes from the growing research that analyses the interaction between users and IVAs in practice. The third lens covers emerging issues related to the use of voice assistants: from usability problems, up to social and ethical concerns. From this analysis, six challenges have emerged in relation to the design of such systems. They are discussed in the final section of the paper.

2.1 First Lens: Theoretical Discourse

In this section, we have summarized contributions by three influential groups of stakeholders (Krippendorff, 2005) of voice assistants: companies who design and manufacture them, users who buy them, and researchers who study them - mainly HCI scholars. Each group provides a specific point of view on the (expected) features and (potential) benefits of voice assistants, which also affects the intentions and expectations of the other two groups.

Manufacturers' intentions

IVAs interfaces are modelled after the human-human conversation metaphor (Branham et al., 2019). By analysing users' reviews, Purington et al. (2017) conclude that *personification* of the voice assistant is a marker for satisfaction. Therefore, it is not surprising that companies try to increase the probability that users personify their virtual assistants. In order to achieve this goal, and to make the conversation feel human, IVAs need to showcase unique personalities while interacting with users. To design these systems, designers define a persona (i.e. the personality and profile of the virtual assistant) and then outline their talking style, voice tone, and detailed scripts accordingly. Designers also define the details of a possible interaction, foresee the actions and reactions of the users, and design the reactions of the virtual assistant according to the situation (Lee et al., 2017).

As stated by Branham et al. (2019), who reviewed the design guidelines by five top manufacturers, voice assistants are also designed to carry on personal and efficient conversations. In order to maintain the conversation *personal*, the guidelines suggest the use of contextual data to cooperate with the individual. This includes remembering past conversations, especially if there is "static information and frequent actions" that will likely

recur. For the sake of *efficiency*, voice assistants are designed to keep the conversation short in length and low in complexity, to avoid cognitive overloads on the user's side.

Users' expectations

The ability of IVAs to manage dialogues in a "natural" manner (i.e. fluid, simple, effortless) is at the heart of the promotional discourse surrounding them. Therefore, one of the most spread (and mismatched) users' expectations when buying a voice assistant is that there would be no need for them to learn how to interact with it. Users expect the conversation to unfold naturally, as it happens in a regular human-human conversation. They do not expect the assistant to behave inconsistently, although that is often the case.

As maintained by Kocielnik et al. (2019), users' expectations on AI-powered solutions tend to be inflated; however, there has been little work on designing methods for setting more appropriate expectations. This mismatch between users' expectations and IVAs actual performance carries the risk to decrease users' satisfaction.

Researchers' insights

According to studies performed on IVAs, the possibility to enable hands-free interactions is one of the most important benefits of speech recognition technologies, due to different reasons. Hands-free interactions allow users to use the system even when they have their hands and eyes engaged in a primary activity. Moreover, voice inputs enable users who cannot write to access digital contents and to collect information from the Internet. This could impact large numbers of potential users, such as pre-school children and illiterate people. According to Lima et al. (2019), the rapid diffusion of voice control systems will particularly impact countries where a large part of the population is functionally illiterate.

Finally, some categories of elderly people or people with disabilities, in particular mobility or dexterity impairments, can be empowered by voice-based interactions (although people with speech disorders might be excluded). Despite this potential, as claimed by Branham et al. (2019), voice assistants are currently being designed with white, well-educated, young or middle-aged, able-bodied users in mind.

2.2 Second Lens: User Experience

The spread of voice assistants in millions of households raises several questions about the kind of experience users have while interacting with them. What is the nature of people's interactions with these assistants? What kind of relationship do users' have with them? Are users' expectations met, and how?

Through our second lens, we reviewed studies exploring these questions, to gain a better understanding of the actual user experience with voice assistants. We focused our analysis on two main aspects: the personification of these systems and what it entails in terms of user experience; how voice assistants match (or mismatch) users' expectations.

The Personification of Voice Assistants

Voice assistants' ability to talk can lead users to personify them, although studies diverge in their assessment of how pervasive this practice is (Branham et al., 2019).

Lopatovska and Williams (2018) performed a small qualitative study on users' tendency to personify Alexa. Their results show that less than half of participants engaged in personifying behaviours with this IVA, and such behaviours could mainly be explained as "overlearned social mindless responses". In other words, users automatically responded to human-like expressions and language, without engaging in actual, meaningful personification.

The study conducted by Pradhan et al. (2019) on elderly people living alone suggests that someone who is in need of social interactions may be more likely to personify a technology, and, at times, seek social connections through it.

Porcheron et al. (2018) performed a qualitative study on the everyday social practices of households interacting with Amazon Echo. The study sheds light on the complexity of users' relationships with such systems. Indeed, Echo is "recruited" and engaged in the intricate communications and actions, which are at the basis of the family everyday life. In this respect, the researchers observed that the use of Echo is embedded in the social order that the family members produce and live upon.

Users' Expectations Mismatch

Recent studies conducted in household settings have highlighted how IVAs can generate the illusion of natural conversations. In this respect, human-like traits attributed to IVAs play a dual and contradictory role. On the one hand, they engage users in interactions. On the other hand, they cause users to overestimate the assistants' intelligence, creating false expectations about their performance (Cambre, Kulkarni, 2019). In this regard, the most common technical challenge for voice assistants is speech recognition. In a study performed by Cowan et al. (2017) on a group of 20 Siri infrequent users, several problems with users' accents and language comprehension emerged. Participants in the study provided many examples of how Siri did not accurately understand what they said.

Velkovska and Zouinar (2019) highlight issues connected to the use of indexical terms by users when interacting with their voice assistant. Indexical terms refer to contextual elements (such as "here" or "it") that voice assistants are often incapable of understanding. In the same vein, Lee et al. (2017) mention that voice assistants receive not only simple commands from the user, but also several emotional inputs including rough and aggressive tones. Voice assistants' inability to understand the context and the user's emotional state is considered one of the biggest challenges for these systems, because it can undermine the quality of the user experience.

Participants also mentioned several strategies they used to prevent speech recognition mistakes, such as avoiding idiomatic expressions and speaking very slowly.

Branham et al. (2019) affirm that voice assistants, which are optimised to comprehend young adult and middle-aged voices, can have interaction problems with non-standard users' categories (e.g. elderly people and children). Moreover, for users with cognitive impairments, the average duration of the conversation is problematic: researchers who studied populations with speech impairments, e.g. Alzheimer's disease, and intellectual disabilities, have shown that the current timeout period of IVAs is insufficient for these users to utter their voice command. Users with visual impairments also found the timeout frustrating, but for a different reason: it limits their ability to input longer and more complex voice commands, which they are more used to adopt in human-human interactions.

2.3 Third Lens: Ethical Issues and Concerns

The spread of IVAs raises a variety of social and ethical concerns. In this section, we elaborate upon these aspects.

Reinforcement of Gender and Cultural Biases

The sound of voice conveys a diversity of cues that humans are naturally predisposed to recognize. They include the speaker's gender, age, and personality (Cambre and Kulkarni, 2019). The use of female voices in IVAs raises controversy over gender discrimination and stereotype reinforcement. As maintained by Søndergaard and Hansen (2018), voice assistants give shape to the dominant narrative of "female servants and secretaries that are part of our collective imaginings" (p. 878). In addition to using words that can be ascribed to women, Alexa also reproduces expressions that can be associated with people with a low social status (Habler et al., 2019). When voice assistants are designed with gender stereotypes in mind, such stereotypes will be reflected in the assistant's "personality". As a result, pre-existing biases and stereotypes of people interacting with the assistant will be reinforced and amplified.

IVAs can also carry cultural biases. Lima et al. (2019) conducted an experiment aimed at understanding whether the user's gender and accent influence the quality of the interaction with the system. Results suggest that accent and mispronunciation due to regional and socio-economic differences significantly affect the quality of speech recognition.

Consequences on Human-Human Interactions

Can the interactions that users have with digital artifacts affect the way users interact with other human beings? This social issue is raised by Habler et al. (2019), who investigates the effects of gendered voices and language on the perception of voice assistants like Siri, Alexa, Cortana, and Google Assistant. Results show that virtual assistants with low status language were associated with higher performance and received higher ratings by participants, as such IVAs apparently better conveyed the metaphor of obliging assistants.

Lovato and Piper (2015) raised the issue of how question-asking behaviour in children can be influenced by the use of this technology. If children begin to see IVAs as potential sources of answers to their questions, how would that affect the relationship between children and

their parents? Moreover, the authors argue that there is the risk that children “establish a master-servant relationship with robots that could bring about negative developmental outcome”, based on the results of previous studies on children-robots interactions.

Privacy

The rapid spread of virtual assistants raises social and ethical concerns also in terms of privacy and security. Firstly, IVAs are designed to be “always-on” and “always-listening”, posing serious privacy concerns. Moreover, Mitev et al. (2019) report on recent multiple attacks - consisting of unauthorized commands - against devices that utilise voice-based UIs. To check the level of security of Alexa, the scholars designed and implemented an attack to Echo’s smart lock and home security system. Their experiment demonstrates that it is possible to bypass the security features of the system by implementing malicious “skills” (i.e. software extensions that can be developed by third parties to, e.g., control household appliances or call delivery services).

Technology Anthropomorphism

Serious ethical concerns arise when technology imitates human-human conversation – the human voice in particular – to such an extent that users are driven to wonder whether they are interacting with a real person or a machine. In this regard, Google recently introduced a speech synthesis engine and dialogue system able to book appointments over the phone in place of the user. The system was so human like that Google had to add a feature to let the person at the other end know they were talking to an artificial system (Aylett et al., 2019).

At a social level, anthropomorphism of technology can have both a positive and negative impact. Positive aspects include therapeutic benefits for certain user groups. Negative consequences refer to reduced human-human interactions and the danger of manipulation. For instance, users who tend to personify their voice assistants might be more likely to share personal information with them (Pradhan et al., 2019).

3. Six Design Challenges

Based on the features of IVAs and the issues emerged in our literature review, a number of design challenges have been identified. Hereafter, we illustrate six of them, which, based on our analysis, are the most significant ones. In our view, these six challenges represent spaces where design can intervene to improve IVAs and to mitigate some of the issues connected to their use.

1st Challenge: Questioning the Human-Human Conversation Metaphor

As identified in our second lens, voice assistants’ responses do not necessarily follow the human input in a coherent way, making the interaction substantially different from the human-human one. This mismatch between users’ expectations and system performance

may affect people's experience and their level of satisfaction (Cowan et al., 2017). This is the reason why Porcheron et al. (2018) reject the idea, popularized by the dominant promotional discourse, that voice assistants are "conversational" in nature and that the interaction with them is a "true" conversation.

Drawing on prior work about the needs of people with visual impairments, also Branham et al. (2019) critically assess the taken-for-granted human-human conversation metaphor, arguing that it restricts usage from a variety of user categories, including people suffering from blindness. The researchers solicit more inclusive interaction models, especially with respect to elements such as conversation length, complexity, and speed. According to them, not only people with visual impairments, but also other groups of users with disabilities would benefit from IVAs that adopt such an inclusive approach.

It follows that developers should consider carefully whether humanness is the right metaphor to adopt when designing a voice assistant.

2nd Challenge: Designing for Situated Interaction

The interaction between the user and the voice assistant unfolds in a specific context of use, which implies a specific set of cultural values. This cultural milieu influences the user experience and therefore needs to be considered when designing voice assistants.

According to the analysis performed by Velkovska and Zouinar (2018), the inability of IVAs to be context-aware is one of the main usability issues currently faced by developers. To improve conversational technologies, two areas of interventions are addressed. The first consists in allowing users to understand the source of the problem both when the system gives a wrong answer and when the system is unable to respond. The second consists in helping users formulate their commands effectively.

Linguistic factors also play an important role in the user's perception and expectations. For example, research has shown that people prefer devices that use an informal language, and that preferences on gender and personality vary depending on geographical regions and languages (Cambre and Kulkarni, 2019). It is in these elements that the complexity of designing voices for smart devices across cultural contexts lies.

"For example, the word for "dishwasher" is masculine in Spanish, yet feminine in German. Would these linguistic cues make it more likely for a Spanish speaker to expect a male voice from a smart dishwasher, and more likely for a German speaker to expect a female voice from the same smart dishwasher?" (Cambre and Kulkarni 2019, p.10).

The authors conclude that there is no globally optimal voice for a certain device that obtains users' liking across different cultures.

3rd Challenge: Aligning Users' Expectations and System Behaviours

It is well recognized that the user experience of a system cannot be evaluated considering only performance or usability (Gürkök et al., 2011). Indeed, such evaluation is highly influenced by prior user expectations as well as by the specific context of use. The findings of a study performed by Kocielnik et al. (2019) show that shaping users' expectations correctly can be an effective way to improve user's acceptance of AI-based solutions.

The alignment of users' expectations with the actual system behaviour is the focus of a study by Azmandian et al. (2019). Based on their results, the authors acknowledge that designing the behaviour of virtual assistants is a challenging problem: the alignment of end users' expectations with an agent's actual behaviour is indeed influenced by many factors. What makes it harder for designers to address the issue is that, in any specific interaction, there may be more than one correct answer regarding how an agent should behave. Indeed, even if designers purposefully create personas to attain a desired user experience, the same persona will be perceived differently by different users. This is the concept of second-order understanding, well-illustrated by Krippendorff in his semantic turn (2005). Therefore, designers should include the perspectives of end users in the persona-creation stage, gathering viewpoints related to what different user groups or individuals might expect from their voice assistants (Pradhan et al., 2019).

4th Challenge: Is Voice just Voice?

Cambre and Kulkarni (2019) investigate how users would react if the IVAs' voice were gender neutral. Some researchers have already proposed gender-neutral voices for voice interfaces. We might also question the choice of replicating a human voice in virtual assistants, instead of having a deliberately robotic type of voice. Non-human voices may indeed mitigate some of the issues related to the mismatch of users' expectations and to the reinforcement of cultural biases and gender stereotypes.

According to Kim et al. (2018) the single-medium, voice-based communication limits expressiveness and richness of information. In their view, IVAs designers should explore multimodal interaction modalities. They propose, for instance, adopting tactile forms of interaction to enrich people's experiences with IVAs.

5th Challenge: Designing for Embodied Interactions

To date, designers and researchers have largely focused on the conversational aspects of voice assistants. What has been neglected is the form and embodiment of this technology, as well as how that makes a difference in the user experience. Cambre and Kulkarni (2019) believe that, besides the specific context of use and the characteristics of the voice interface, the user experience is also "shaped" by the physical dimension of the devices. Therefore, form, aesthetics, and physical features do influence the resulting experience of users.

According to them, adopting a human-robot interaction (HRI) perspective would offer a more holistic approach, since HRI merges embodiment and voice in its research.

6th Challenge: Taking a Political Stance

As maintained by Søndergaard and Hansen (2018), voice assistants are neither innocent nor neutral: regardless the actual awareness of their developers, they are political entities that raise ethical and philosophical issues. Such issues should be addressed and acknowledged by all the stakeholders we analysed in our first lens (manufacturers, users, and researchers) but above all by researchers and designers.

Aylett et al. (2019) claim that the mere analysis of the systems in place – as most researchers have been doing – is not going to innovate IVAs. Researchers and designers should take an active role in questioning the status quo, also by developing provocative and critical artefacts that challenge the dominant perspective on the design of IVAs. A recent example in this direction is VORO, a couple of “data hungry pets” that perform their role as smart assistants correctly only if the user gives them attention and constantly feeds them with the data they crave. According to its designer Findlay Macdonald, VORO is meant to challenge *“the current paradigm of the lack of control that we, as users of smart home products, have over our data.”* (<https://www.finmacstudios.com/voro>)

In a similar vein, instead of reproducing traditional gender roles, IVAs could be designed to question them and to leave them open. If the design community does not take up these challenges, large corporations will continue to set the rules, pursuing their commercial objectives. As a result, any possible alternative scenarios - built upon a different conception of humanness, culture, and interaction modalities - will have no chances to come into being.

4. Conclusions

We performed a literature review aimed at providing a structured overview of scholars' contributions in the field of IVAs, organized around a three-lens framework. We also outlined six design challenges, which represent a call for the design community at large to take action, both by developing consistent design guidelines, and by envisioning and prototyping novel and critical alternatives for IVAs.

As Søndergaard and Hansen (2018) point out, technological futures are built on and (re)produce collective imaginaries that intersect technology with social, cultural, and political matters of gender, race, and class. Such technological futures, therefore, are not pre-determined, although not entirely open either. Indeed, it is the designer's task to challenge the dominant narratives in order to propose different, and still acceptable, futures.

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