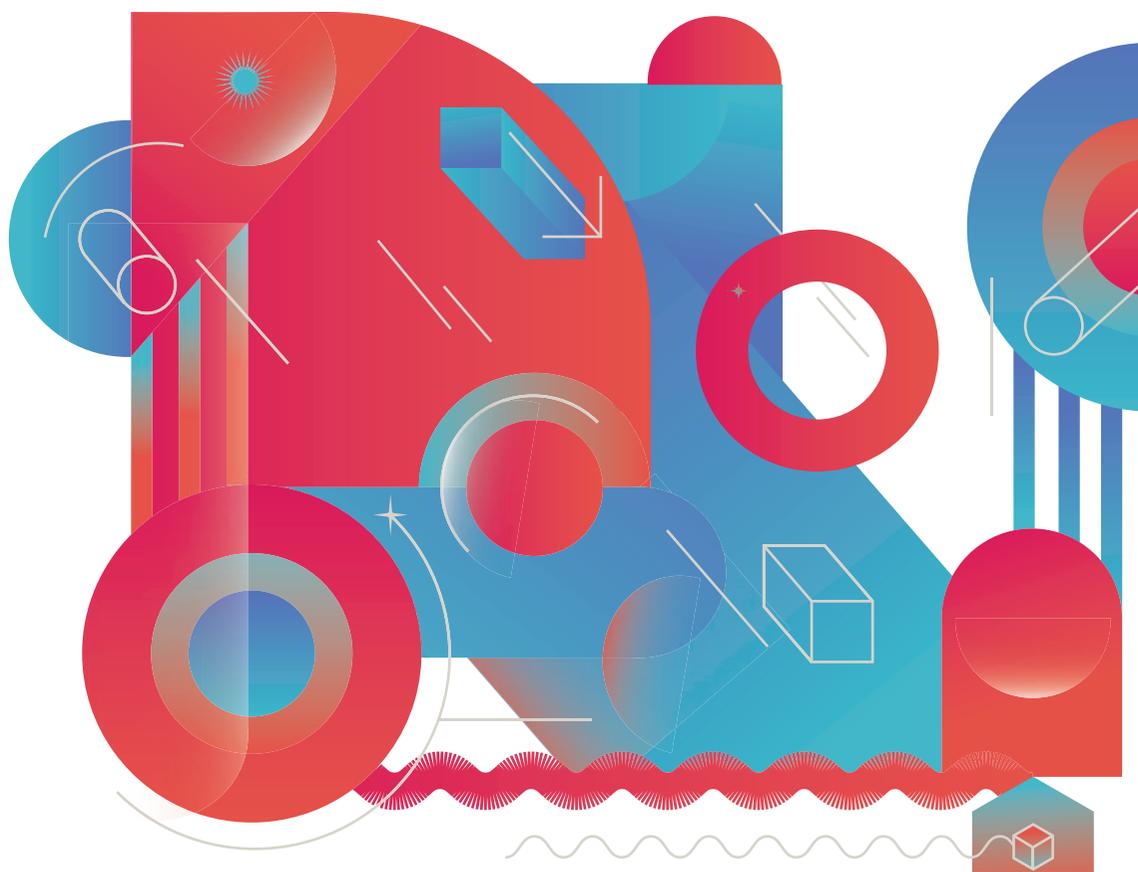


EMBEDDING INTELLIGENCE

Designery reflections on AI-infused products



edited by Davide Spallazzo, Martina Sciannamè



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1. AI-infused products so far. An analysis from a design standpoint

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Since ubiquitous computing was first defined in 1991, computers have been pervading our everyday life. Nowadays, many AI-infused smart assistants are present in the domestic domain, and even robots-like devices, able to simulate human behavior, entered the market.

The contribution aims at analyzing and debating these devices in the design domain, focusing on their characters in terms of appearance, behavior, and interaction abilities.

The formal aspect couldn't be detached from function and the relationship with the context; these devices are designed for home use; therefore, shape, materials and finishing need to be considered. Some devices are mere facilitators for routine activities to be executed with vocal inputs or mediated through apps without exploring all the capabilities they could perform learning through continuous conversations with their owners.

From the analysis of products available on the market, the chapter emphasizes an incomplete exploration of the topic from a design point of view: a poor translation of functions into tangible shapes and a lack of interaction design basics, such as input and output modalities, feedback systems, and processes discoverability. The discussion frames the results in a broader review highlighting alternative paths for the design of future home virtual assistants.

1.1 AI-infused devices

Artificial Intelligence (AI) is the substance designers will be called on to engage within the subsequent years, according to Paola Antonelli's statement in an interview during the AI-Artificial

Imperfection roundtable held in New York in March 2018 (Antonelli, 2018). This comment by the curator of MoMA's design division may appear provocative, but it establishes a confluence between the areas of AI and design.

For years, AI has been quietly infiltrating systems and devices that we use daily. It has spread in several facets of people's lives, especially in four social domains: Healthcare, Education and Employment, Governance and Social Development, and Media and Entertainment (Burr, Taddeo and Floridi, 2020), and it is destined to become even more pervasive, similarly to electricity (Kelly, 2016). The wide availability of data-enhanced computational capabilities and improved algorithms has led to the diffusion of technologies integrating AI systems and the need for publicly acknowledging it. As a result, some artefacts have been created explicitly for this purpose. Multi-purpose home assistants synthesized the core characteristics of AI in the form of smart speakers that can learn from their owners' continual interactions. Furthermore, cheap domestic robots have reached the market in recent years, paving the way for a frontier closer to the idea generally associated with AI: sentient robots capable of simulating human behavior.

There are currently a few theoretical insights and experiments depicting the convergence of AI and Design. As a result, this contribution aims to further argument about the importance of design in the context defined above, paving the way for future research.

The concept is to frame the transitional period we are experiencing, looking for a path to follow in design research and practice, as the world is gradually moving towards the Ubiquitous Computing that Weiser envisioned in 1991 (Weiser, 1991). Computation is spreading throughout physical space and across multiple devices to build environments that help people in their everyday activities (Kaptelinin and Nardi, 2006). The focus is on virtual assistants, which summarize the first wave of AI's materialization in the domestic setting.

As far as 2020, studies have shown that already 320 million of these devices have been installed, and they are forecast to reach 640 million installed devices by 2024 (Canalys, 2020).

The study here reported analyzes ten devices that integrate AI agents (Table 1 lists the objects of analysis), the only ones on the market with the features indicated below. They are (i) versatile house assis-

tants without a defined goal (e.g., senior help), (ii) especially developed as first-party hardware, (iii) already marketed or coming soon, and (iv) capable of controlling other smart home products. In the case of a product family, the research considers the first one released in its most recent version or its evolution. Some products are still under development, while others have not passed the prototype stage and have never reached the market. However, it is essential to include them in the analysis to provide a comprehensive picture of research on personal home assistants and give a complete description of the devices' functionalities and capabilities.

The study of virtual household assistants begins with a synthetic description of the devices. It continues by examining their interaction aesthetics (Petersen, Hallnäs and Jacob, 2008), which serves as proof of AI embodiment. In terms of preliminary considerations, it includes physical appearance, use, and interactivity; the purpose is not to evaluate the user experience of the analyzed items, but to illustrate state of the art in the field of domestic assistants to stimulate future thought.

As a result, neither UX evaluation procedures (Hassenzahl, 2001) nor usability testing (Brooke, 2013) has been used to evaluate the listed features. Official videos and documentation from the manufacturers were used to assess the products. Given the research's goal and the fact that some of the products are not still on the market, this method was deemed appropriate, ensuring homogeneity of the investigation where first-hand experiences would not be possible.

Table 2 lists the items that were analyzed (in order of the first model's release date) and spans the basic parameters that were used in the analysis: (i) physical appearance, (ii) input and output modalities, (iii) feedback mechanisms, and (iv) function discoverability (Saffer, 2010), with a focus on how proactive such artifacts are.

These factors were chosen to examine and define the selected items fundamentally from the aspect of product/interaction design. A choice motivated by the central hypothesis about domestic virtual assistants; acknowledging the great market success of some of them, this paper aims at showing how immature they are in some respects and encourage designers to take on a leading role in identifying a language and meaning besides a form.

1.2 Domestic smart assistants: a variegate picture

The panorama of domestic devices integrating AI capabilities varies in terms of appearance, dimensions, and functionalities.

In the following, we briefly describe each device object of analysis in its last release, whether it is available on the market, or its production has been interrupted or never passed the prototyping phase. The objective is to describe the devices to support the qualitative analysis that follows in the next section.

Amazon Echo	Google Nest	Mji Tapia	Asus Zenbo	Jibo
https://amzn.to/3ztwKZ5	https://bit.ly/3PTdIrP	https://mjrobotics.co.jp/en/	https://zenbo.asus.com/	https://jibo.com/
Apple HomePod	Emotech Ollly	InGen Dynamics Aido	Home Connect Mykie	Samsung Galaxy Home
https://apple.co/3cZSDr	https://www.emotech.ai/	https://www.getaido.com/	https://bit.ly/3zutzkd	https://bit.ly/3zQLK4Q

Table 1.1 – List of the analyzed domestic assistants (with links to commercial webpages).

Amazon Echo

The Echo family is undoubtedly the most renowned in the field of domestic smart assistants and anticipated by far the other products. The traditional Echo speaker that entered the market in 2014 it's today substituted by less generic devices focusing on the quality of sound or the presence of a screen. For the sake of the study, we analyze the Amazon Echo Studio that derives directly from the first commercialized.

It is essentially a cylinder covered in grey fabric. A longitudinal cut in the lower part of the body favors the clearness of the sound. The top of the device presents a LED ring for light feedback and four physical buttons for adjusting the volume, turning the microphone off and prompting Alexa.

Google Home/Nest

Google Nest audio is the last release of the 2016 product (Google Home). It appears like a small parallelepiped with major measures in its front view, and a thinner lateral view. Available in light and dark grey, it

is covered with fabric. The physical interface consists of a toggle to turn the microphone off on the back of the device.

Mji Tapia

Tapia is presented as “home communication robot watching over your family”, a personal companion to take care of elderly people or to help children in their learning activities. It appears like a glossy white egg, with a big screen in the upper part to show expressive cartoon-like eyes. It resembles a robot, but does not move any element, except for the eyes on the screen. It has a camera, to fulfil its monitoring aims and users can interact with it through the screen with the eyes.

Asus Zenbo

Zenbo is a robot, that moves autonomously across the house and can follow the users. Presented as a smart little companion, Zenbo was born as a B2C product, but it is now available only in the B2B market. Its latest release is the Zenbo Junior II, a multipurpose robot that can find an application in several fields: education, health, tourism.

It is composed by two white plastic volumes connected by a thin junction that make them resemble a body with neck and head. To increase this perception, the head has a flat surface with a screen, showing cartoon-like eyes and mouth. Colored LED mark the wheels on the lower body. Gridded air intakes on the main body and cuts the sides of the head increase anthropomorphism, resembling a belly or ears. Zenbo can move using the two lateral wheels, and its head can turn on its axis and move up and down. For interacting with Zenbo, user can use their voice or click on the screen (where Zenbo eyes and mouth are).

Jibo

Jibo has been designed to be a friend, a social robot. It is characterized by three-axis motor systems that make its body segments move in a fluid and natural way, increasing its potential in communicating with users.

Its physical appearance is dominated by pure shiny white volumes that rotate one over the other. The top part of the robot is spheric with a flat surface presenting a touch screen.

Everything is designed to make this little device resemble a small robot, including its only cartoon-like eye moving across the screen. The touch screen, beyond voice interface, is the main way of interacting with Jibo, which has also two onboard cameras for panoramic view. The robot is also sensitive to the touch on its head.

Apple Home Pod

Apple is not one of the big players in the field of smart home assistants. Its first device was first marketed in 2018, four years after Amazon.

The original Home Pod is not in the market anymore, and the current product is the Home Pod Mini. It appears like a small sphere in gridded plastic, available in five colors (white, black, blue, orange, yellow). The top of the sphere is cut to host an interactive screen, that shows a Siri-like color animation and hosts two controls to adjust the volume. It does not have a specific companion app, but it is fully integrated in the Apple ecosystem (Apple Home app).

Emotech Olly

Olly was presented at CES in 2017 but it never saw an industrial production. Nevertheless, we consider it relevant to include it in the analysis because (i) it firstly introduced movement without going towards anthropomorphic robots, and (ii) focused on personality.

Olly is doughnut-shaped, with the top surface animated by color LED squares. The main toroidal body can rise from a point on the base and rotate 360° on it. It can be controlled with the voice and through a companion app, but it is highly proactive thanks to contextual awareness.

InGen Dynamics Aido

Aido does not differ from other products like Jibo. Its peculiarity is that the main body may be extended with add-ons that provide the device with mobility, making it close to the Asus Zenbo. From an esthetic point of view, it appears in white shiny plastic. Its head presents a big screen with cartoon-like eyes.

With its one-ball transport systems, it acquires a very distinct anthropomorphic shape, with a long body, neck and head. It does not differ from other similar products except for a video projector.

Like Jibo, it sensitive to the touch not only on the screen, while the main touch screen is the major touchpoint for interaction.

Home Connect Mykie

Mikie is still in its concept phase, and it very likely to stay in that condition. Nevertheless, it is a good example of specialization of a domestic robot. It is developed to serve in the kitchen and its characteristics are designed towards that scope.

It appears in white or black plastic, with troncoconical body and head. The aim is that of creating an anthropomorphic device, and the impression is reinforced by big, stylized eyes. A LED ring at the basis of the body provides feedback on its functioning. Beyond the typical functionalities described for the other devices, Mykie adds a projector to ease following recipes.

Samsung Galaxy Home

Samsung is not a big player in the field of smart assistants. The Galaxy Home announced in 2018 never reached the market. In 2020 Samsung released the Galaxy Home Mini in South Korea, but not as an independent product but rather as a companion to a smartphone. The Galaxy Home Mini follows Amazon and Google with a small dark grey ball in fabric. The top of the sphere is cut, and hosts four buttons to adjust the volume, mute the microphone, and prompt the assistant.

DEVICES		Amazon Echo	Google Home/ Nest	Mji Tapla	Asus Zenbo	Jibo	InCen Dynamics Aido	Apple Home Pod	Emotech Oilly	Samsung Galaxy Home	Home Connect Mykie
Year of production		2014	2016	2016	2017	2017	2017	2018	2018	2020	tba
PHYSICAL APPEARANCE	Simple Shape	●	●	●				●			
	Assembled solids				●	●	●		●	●	●
	Main Color & Material	G, F	G, F	W, P	W, P	W+C, P	W, P	ALL, P	B, P	B, P	W, P
DISCOVERABILITY	Proactive		●	●					●		●
	Non Proactive	●	●		●	●	●	●		●	
INPUT	Voice	●	●	●	●	●	●	●	●	●	●
	App	●		●	●	●	●	●	●	●	●
	Buttons	●	●	●	●	●	●		●		●
	Touch Surface		●					●		●	
	Touch Display			●	●	●	●				●
	Vision (camera)			●	●		●		●		●
OUTPUT	Touch					●	●				
	Other Device Action	●	●	●	●	●	●	●	●	●	●
	Audio	●	●	●	●	●	●	●	●	●	●
	Video			●	●	●	●				●
	Movement			●	●	●	●		●		●
FEEDBACK	Lights	●	●		●	●		●	●	●	●
	Voice	●	●	●	●	●	●	●	●	●	●
	Movement			●		●			●		
	Display			●	●	●	●				●

Colors: B=black; BL=blue; G=gray; O=orange; W=white; Y=yellow. Materials: F=fabric; P=plastic.

Table 1.2 – Comparison of virtual assistants for residential use.

1.3 Analysis of domestic virtual assistants

Physical Attributes

In terms of main colors and materials, domestic virtual assistants have a striking resemblance. They cover the grayscale, with white being the most popular color, maybe influenced by science fiction productions. Black and grey, on the other hand, are derived from classic hi-fi aesthetics, implying their primary purpose as speakers. Plastic is the most common material however fabrics are gaining traction for a better integration into the domestic environment.

The most important element is the shape. The review focuses on two main formal paths: on the one hand, there are smart objects that follow simple and primary regular shapes; on the other hand, assembled bodies are built using geometric addition of solids (Van Onck, 1994), with five cases looking for a characterization as a human/animal-like shape with recognizable head and body. The separation of formal outputs also emphasizes a different functional goal, demonstrating that the planned activities are related to the final shape: smart speakers are the first manifestation of AI, and thus a natural outcome for a speaking technology. For example, the Home Pod is solely focused on audio quality and appears to be nothing more than a speaker. Devices that try to develop a social connection, on the other hand, take on a more anthropomorphic shape. Aido, for example, is regarded as a butler, and its height and shape contribute to this perception. As a result, functions have a significant impact on the object's overall, formal configuration, as well as its dimensions. Speaker-shaped assistants are only decorative, whereas those with social capabilities grow to the size of tiny household appliances or grow larger, in the event of a more realistic human simulation. The ability to move may also add to the embodiment of function: Olly does not have a simple or human shape, but its movements foster a sense of social connection.

Discoverability and Behavior

A typical feature of AI assistants is that they are built on machine learning and then evolve according to their owners' preferences. The major objective of home virtual assistants, once again, determines

their behavior, emphasizing the distinction between smart speakers and domestic robots.

Most of the assistants, including smart speakers (Amazon Echo, Google Home, Apple HomePod, Samsung Galaxy Home) and, surprisingly, some robot-like assistants (Zenbo, Jibo, and Aido), are non-proactive, answering when prompted.

Three assistants, on the other hand, are proactive and offer information, activities, or content to their users based on their habits, moods, or anticipated needs. They integrate a camera (or more) to improve their proactivity by relating on more data to support their suggestions: they not only analyze noises or routines, but they also read body language and can grasp what their users are doing. Furthermore, they can recognize and reacting to their users as they pass by. Olly represents the highpoint of empathetic engagement and proactivity, developing and manifesting its own personality in response to that of its interlocutor. Non-proactive objects have a limited discoverability, and most of their functions are unknown to the user. Alexa is an example of this: it contains thousands of skills, the majority of which were created by third-party developers, but they are rarely known or used (White, 2018).

Interaction

According to Saffer's Systems Design (Saffer, 2010), the inquiry of interactivity has been limited to input, output, and feedback modalities. The main inputs and outputs are vocal, highlighting one of AI's most significant contributions to more human contact. Indeed, Natural Language Processing (NLP) has progressed to the point where it can now understand and respond to human queries. This provides the foundation for the rise of digital assistants, which are the most visible manifestation of this technological achievement. A through-app interaction is another characteristic that all the devices share as an input: its functionality spans from basic setup to complete functions (especially for all the smart speakers).

Furthermore, they are provided with buttons for specialized functions, such as a mute-microphone button and volume up/down buttons or a touch surface. Robot-like assistants, on the other hand, just require the starting one because they have a touch display as a face. Proactive devices use their cameras to interpret body language and gestures as

inputs. Finally, being snuggled causes some of them (particularly Jibo and Aido) to emotionally respond to tactile inputs.

As an output, all the assistants support interaction with other home appliances and the providing of audio content such as online searches, music, podcasts. Video contents could be supplied from devices with a display or a projector (Aido and Mykie), which can be a reproduction of online sources or an enriched characterization of what they are saying or doing. Movement can be a response to a request – such as dancing (Jibo) or moving across rooms (Aido and Zenbo) – or just a reinforcement of communication – such as moving up and down while counting push-ups (Olly).

The feedback mechanism, however, is more important in an interpersonal-simulated connection. Referring the analysis to a framework for studying human-product interaction (Wensveen, Djajadiningrat and Overbeeke, 2004), AI-infused assistants provide almost no inherent feedback because physical actions are only required in a limited way; thus, only functional feedbacks (corresponding to the described outputs) and augmented feedbacks characterize current domestic assistants. Lights, spoken utterances, movements, and displays indicate the object's internal status while the function is processing. Almost all the objects, notably the speaker-based assistants, employ lighting systems to indicate their present condition, and their choreographies are like those found on other devices (for example, it is the case of Google Home bouncing dots). Except for Galaxy Home, all the brands have chosen colorful lights, which are most expressive in Olly's custom-built circular LED display: it really emphasizes the effort of creating a patent communication system using lights.

Another common form of feedback provided by digital assistants is voice: whether in a strict or more private manner, with a robotic or person-like tone, these devices let their users know if and what they have understood before providing the desired content. This type of feedback is particularly useful when interacting with anthropomorphic helpers since it offers the appearance of having a real discussion with someone rather than just talking to a machine.

These are fantastic opportunities for feedback for devices with a display and the ability to move: natural and fluid movements can follow the action or stress the robot's awareness of being addressed to its user – for example, tilting its head towards the one who is speaking.

Instead, displays are employed to display the bot's abstracted eyes, which animate in response to the user's inputs. Those feedbacks are the most successful at creating a natural relationship since the machine looks to be more alive and expresses its own individuality.

Feedforward (Wensveen, Djajadiningrat and Overbeeke, 2004) is a feature that is closely related to feedback and has a significant impact on engagement. In the case of virtual assistants, users (and maybe also the designers and/or programmers) have no idea about what will happen once a request is made. In many circumstances, they can only guess or anticipate a particular outcome, although they can be sure about the more common interactions (through app or buttons) or the basic and routine commands that they had executed various times. Otherwise, the interaction's output is unpredictable and – more importantly – not immediate, two factors that may detract from the interaction's perceived quality.

1.4 Reflections on AI-infused Assistants' Embodiment

The evaluation of the formal outcomes is inextricably linked to the object's main functions. As previously said, the shape of the devices is determined by their function and the relationship they have with their context. The concept of home has been inadequately considered when developing the appearance of those goods, except from its incorporation in the names of some products. All of them are technologies that may be freely placed in any location but have yet to establish a link with our domestic reality, a situation that may lead to people perceiving them as strangers in their homes. Perhaps a closer relationship would make it easier for users to comprehend the benefits of the assistant. Meanwhile, they are understood in terms of their resemblance to other, well-known objects or the abstract expectations fostered by our culture's theories. The fact that the most prevalent use of speaker-shaped intelligent assistants is to play music (Sciuto *et al.*, 2018) is not by happenstance, despite the development of NLP features is opening up new possibilities. On the other hand, devices with a humanoid figure are commonly defined as companions or home managers.

Then, when it comes to their functionalities, it appears that customers prefer a few well-known commands that effectively turn

intelligent assistants into regular executors, especially considering smart speakers. As a result, in most cases they rarely use their various skills, as explained by (Kinsella, 2018) and validated by (Sciuto *et al.*, 2018) through quantitative and qualitative analysis of Alexa usage. The study by (White, 2018) emphasizes that discoverability in smart speakers is a significant issue for designers, and it suggests alternative solutions, such as context awareness and proactivity, to address the issue. This lack of discoverability and affordance (Norman, 1988; Gibson, 2014) could be owing to a lack of skill embodiment into tangible things, which is typically associated with a rejection of sensory curiosity and pleasure (Jordan, 2000; Marti, 2010). In fact, consumers are precluded from perceiving the acts' fundamental effect when they do them. The framework designed by (Wensveen, Djajadiningrat and Overbeeke, 2004), might be used to pursue a more intuitive interaction. The authors propose reinstating natural couplings between actions and reactions based on six different parameters in order to improve its quality. At the present, the most promising and simple-to-integrate solutions are connected to interaction expression: the output modality might be a reflection of the conditions under which the request is made, such as the user's mood or the time of day (Pavlicsak, 2018). Only three of the evaluated devices (Olly, Mykie, and Tapia) now have these features, but they might add real value to the assistants' general interaction and usability, as well as inform their shape.

One theory is that a humanized appearance and behavior can make an AI-infused device appear to be a true domestic assistant. Its likely relationship with a human person creates the conditions for a more natural contact, making it easy to envision that the object has a wide range of skills and will play a proactive part in our daily lives. Yet, as humans, we have a tendency to anthropomorphize everything (Pavlicsak, 2018), and functions – made clear through proactivity –, shape, and movements seems to facilitate users in terms of discoverability and hence, engagement. Furthermore, the behavior of the devices provides them with well-defined identities.

In light of this reasoning, another issue to consider is that some anthropomorphic assistants have a characteristic known as mutuality of effects systems (Marti, 2010), which means they are sensitive to perceptual crossing. It is not just the user's responsibility to see the object of interaction; it is also the user's responsibility to sense the individual

who will trigger it, preparing and announcing this awareness. Even without the use of an interface, the interaction becomes expressive, embodied, and responsive in this way.

Deeper linkages between shape, capabilities, and behaviors should be built based on a more reciprocal interaction between items and people, with the goal of figuring out what it is all about.

Faced with the complexity of these technologies and their significance in everyday life, designers must also consider the materialization of a large number of abilities, particularly if the only means of interface is dialogue. In fact, most of the examined assistants include a companion app that can be accessed via smartphone and allows for product customizing as well as traditional skill browsing. However, it opposes one of the principles of natural interaction: removing interfaces to make the artifact's mechanism directly available to system users (Dourish, 2001).

Devices that integrate a tablet as a head, which may be actively utilized for input and output, allow for a similar, if perhaps less obvious, engagement. A debatable solution that necessitates an obviously inadequate examination into the meaning of interaction.

Similarly, using voice as the primary concrete expression of domestic assistant intelligence does not automatically make them true conversational agents, nor does it make it easier to utilize their potential. Every maker has chosen to implement additional input mechanisms ranging from simple buttons to cameras and elaborate nested menus to be viewed through bespoke apps, demonstrating this condition. To put it another way, conversational agents are commonly conceived of as the tip of an iceberg that will make interaction more human and friendly, yet they still lack a clear definition.

1.5 Virtual Assistant Design Scenarios in the Future

As indicated in the introduction, the initial wave of AI materialization in the home sphere is still deeply immature in terms of function, language, and meaning (Kolko, 2011).

Designers are tasked with balancing form with ever-increasing functionality, finding a balance between conveying and obfuscating them. The current situation continues to reflect the contradiction that pervades

AI debate. On the one hand, smart speakers turn AI into aesthetically pleasing devices that we can utilize in our homes. Objects of various shapes, on the other hand, strive to be viewed as valuable humanoids who can assist in everyday living. A paradox that pervades all of the study's components – in terms of physical appearance, conduct, and interaction – and shows a still immature design reflection and the need to develop a unique language.

Despite the fact that the argumentation only addresses a few early factors and presents limits that are best addressed later, certain preliminary considerations may arise. The perception is that the sector is still going through the intoxicated period that comes with the debut of any new technology (Antonelli, 2018). Domestic assistants appear to be stuck in the toy phase, unable to make actual contact with reality (Levinson, 1977), and design should play a key part in directing a human-centered shift to meaningful products. As a result of current perspectives, AI discourse is being integrated into the discipline of Interaction Design. They all share the goal of enabling more natural contact, rather than relying on display-mediated interfaces.

Then, when it comes to converting AI into a real and domestic form, shape cannot be isolated from function and meaning from a human-centered and holistic perspective. According to what has been seen, AI-infused objects could simplify their functional structure so that interactions are more rapid and meaningful in terms of experience and utility. In this regard, there are three possible outcomes: (i) virtual assistants could evolve into self-standing objects, perhaps with more specific and limited functions that better translate into a clearly recognizable form; (ii) they could evolve into more accurate humanized robots, taking the role of actual people at the service of others; or (iii) they could be completely dematerialized and spread across other existing appliances and devices throughout the physical environment, with a sensibility for their location and proximity; or (iv) they could be completely dematerialized and spread across other existing This, in turn, may lead to more questions about the embodiment, its scale (product or environment), and how the enhanced functionality will be expressed.

Clearly, the study presents several limitations. It considers only a narrow number of products, even if they are representative of all those that responded to the selection criteria. A larger study may cover the

whole spectrum of goods from the companies evaluated here, as well as third-party products that integrates AI agents. Furthermore, this initial argumentation begins with the fundamental characteristics of a product, but it may expand to include other design issues such as UX, or interdisciplinary reflections such as social/psychological implications, such as the emotional response they may foster through interaction, as well as experimental studies.

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Artificial intelligence is more-or-less covertly entering our lives and houses, embedded into products and services that are acquiring novel roles and agency on users.

Products such as virtual assistants represent the first wave of materialization of artificial intelligence in the domestic realm and beyond. They are new interlocutors in an emerging redefined relationship between humans and computers. They are agents, with miscommunicated or unclear properties, performing actions to reach human-set goals.

They embed capabilities that industrial products never had. They can learn users' preferences and accordingly adapt their responses, but they are also powerful means to shape people's behavior and build new practices and habits. Nevertheless, the way these products are used is not fully exploiting their potential, and frequently they entail poor user experiences, relegating their role to gadgets or toys.

Furthermore, AI-infused products need vast amounts of personal data to work accurately, and the gathering and processing of this data are often obscure to end-users. As well, how, whether, and when it is preferable to implement AI in products and services is still an open debate. This condition raises critical ethical issues about their usage and may dramatically impact users' trust and, ultimately, the quality of user experience.

The design discipline and the Human-Computer Interaction (HCI) field are just beginning to explore the wicked relationship between Design and AI, looking for a definition of its borders, still blurred and ever-changing. The book approaches this issue from a human-centered standpoint, proposing designerly reflections on AI-infused products. It addresses one main guiding question: what are the design implications of embedding intelligence into everyday objects?