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Rozendaal, Marco; Boon, Boudewijn; Kaptelinin, Victor

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Objects with Intent: Designing Everyday Things as Collaborative Partners

MARCO C. ROZENDAAL and BOUDEWIJN BOON, Delft University of Technology
VICTOR KAPTELININ, Umeå University

In HCI there is an increasing trend to approach computing artifacts as agents. In this article, we make a case for "Objects with Intent" (OwI's) as an emerging type of agents that take advantage of the meaning of everyday things as the site for their intelligence and agency. After reviewing relevant existing research in HCI and related fields, we demonstrate how OwI's provide a new perspective on human–agent interaction. We then elaborate on how the notion of OwI's is informed by Dennett's theory of intentionality and Leontiev's Activity Theory. Thereafter, we illustrate the application of OwI's through the design case of Fizzy, a robotic ball used to stimulate hospitalized children to engage in physical play. We end by discussing the nature and merit of OwI's and reflecting more broadly on the challenges involved in designing OwI's.

CCS Concepts: • **Human-centered computing → Interaction paradigms**; **HCI theory, concepts and models**; *Empirical studies in HCI*; *Interaction design*;

Additional Key Words and Phrases: Activity theory, objects with intent, interaction design, smart objects

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1 INTRODUCTION

In Human-Computer Interaction (HCI) there is an increasing trend to approach computing artifacts as agents, which provides new conceptual and practical challenges for the field. As far as back in 1997, Donald Norman wondered about what human–agent interaction (HAI) would be like in the future when agents will help us do things that we cannot do, or prefer not to do (Norman 1997). The main difficulties he foresaw were social and psychological: "*How will intelligent agents interact with people and perhaps more important, how might people think about agents?*" (p. 68). Related to these issues, some of the difficulties he mentioned were people's overblown expectations of what agents can do, feelings of control in relation to the confidence that people have in the agents' automated actions, and issues of safety and privacy, as agents may access personal data and act on this information without human intervention.

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Authors' addresses: M. C. Rozendaal and B. Boon, Delft University of Technology, Faculty of Industrial Design Engineering, Landbergstraat 15, 2628 CE, Delft, The Netherlands; emails: {m.c.rozendaal, m.j.b.boon}@tudelft.nl; V. Kaptelinin, Umeå University, Department of Informatics, 901 87 Umeå, Sweden; email: victor.kaptelinin@umu.se.

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Now, 20 years later, many of the products we use are agents. Robotic vacuum cleaners, self-driving cars, and personal assistants can all act on our behalf without requiring our explicit involvement. Their technical sophistication even reached the point that it is discussed whether some agents might have actually passed the Turing test (Sample and Hern 2014). There have also been significant developments in the academic field. Terms such as *mixed-initiative user interfaces* (Hearst et al. 1999; Horvitz 1999) and *human–computer symbiosis* (Jacucci et al. 2014) denote the changing interactions between humans and computers considered as agents. New conferences have emerged, such as HAI and human–robot interaction (HRI), which specifically address issues related to HAI. The discourse indicates that the main issues raised by Donald Norman in 1997 may continue, and perhaps even increasingly so, to be our concerns today.

A central theme in current HCI research is considering computers as *partners.* A partnership between humans and computers involves two (or more) autonomous entities, each having their own goals and agency (Jacucci et al. 2014). In this new framing, computers do not assist us simply by taking orders, but they *negotiate*, similar to negotiations between humans who form a partnership (Farooq and Grudin 2016). Collaborating with computers as partners, then, requires that we see each other's actions and understand the motivations behind them (Jacucci et al. 2014).

The aim of this article is to contribute to this developing practical and theoretical work by focusing on one particular type of agents that exploits the meaning of everyday things as the site for their intelligence and agency, namely, "Objects with Intent," or "OwI's" (Rozendaal 2016). An increasing number of everyday things, such as household products, toys, furniture, and clothing are designed to collect data from their environment, react on it, and exhibit their own intent through behavior that can be described in terms of "politeness," "playfulness," "tactfulness," and so forth. In our view, the growing popularity of this type of agents reflects an emerging trend in the design of "smart objects" that is highly relevant to current interaction design research and practice (Taylor 2009; Kuniavsky 2010; Rose 2012; Van Allen et al. 2013; Auger 2014; Marenko 2014; Cila et al. 2017; Marenko and Van Allen 2016; Levillain and Zibetti 2017).

This article is organized as follows. We first introduce the notion of "OwI's" and demonstrate how OwI's provide a new perspective on HAI by comparing OwI's with three other types of agents (i.e., ambient agents, conversational agents, and social robots). We continue by elaborating on how the analysis of OwI's as an emerging type of agents can be informed by Dennett's theory of intentionality and Activity Theory (AT), and construct an analytical framework to deepen our understanding of this concept. Hereafter, we illustrate the application of OwI's through the design case of "Fizzy," a robotic ball intended to stimulate hospitalized children to engage in physical play. We will use our analytical framework to interpret the empirical data gathered during a field study and discuss the implications of our findings for the analysis and design of OwI's.

2 OBJECTS WITH INTENT: INTRODUCING THE CONCEPT

In his book "Enchanted Objects", David Rose (2014) provides a new perspective on smart objects that embraces the tactility and materiality of computational things. Rose proposes a future scenario, in which we interact with multiple, animated, hyper-specialized devices. One of these future scenarios frames smart objects as agents. He provides a vivid example of an umbrella than can sense rain coming based on on-line weather data, and actively prompts you to take it with you when going out. If this type of intelligence were integrated in mundane products (Holmquist 2017), what would such agents look like?

Much of the psychological research that has been done from the 1950s, starting with the classical work of Heider and Simmel (1944), points toward an inherent human ability to frame inanimate things as agents. In these studies, people were found to attribute intent, sociability and intelligence to rudimentary animated abstract shapes. In 1994, Nass et al. have introduced the

Fig. 1. Design examples of "Objects with Intent." Still-image taken from video made of the jacked that wants you to be safe (left). Photo of the prototype of the bedside lamp that lulls you into sleep (right).

term *ethopoeia* to address the attribution of humanness to computers that do not look human and that people know are not humans (Nass et al. 1994; Reeves and Nass 1996). More recently, Takayama (2009) explored a similar phenomenon when analyzing agentic objects in the context of HRI. She explains that "agentic objects are those entities that are perceived and responded to *in-the-moment* as if they were agentic despite the likely reflective perception that they are not agentic at all." (p. 239). Marenko (2014) refers to the notion of *animism* to investigate this perception of agency. "Traces of animism—the idea that objects and other nonhuman entities possess a soul, life force, and qualities of personhood—are evident in the way we talk to our computers, cars, and smartphones, and in our expectations that they will reply more or less instantaneously." (p. 219). Cila et al. (2017) discuss the agency of products in the Internet of Things, by contrasting how products might collect data, share and act upon it, and even might become creative in the type of data they produce.

Rozendaal (2016) introduced the notion of "OwI's" as a specific type of agents that take advantage of their meaning as *everyday things* as the site for their intelligence and agency. Everyday things in this context refer to the objects that we are familiar with and that have a meaningful place in our day-to-day activities. As such, the objects are recognizable as being familiar cultural artifacts. Imagine how these things may have intentions when they interact with us. For example, consider a lamp that wants you to have a good night's sleep by automatically dimming the light as the evening progresses to make you sleepy. Additionally, the lamp makes it more difficult for you to increase the brightness of the light. The longer bedtime is postponed, the more assertive the lamp becomes in its behavior (Figure 1: right). Or consider a jacket that wants you to feel safe. People who suffer from anxiety disorders might tend to avoid public spaces because of the fear or panic that can be triggered by unexpected events, sudden noises, or being exposed to human crowds. The jacket encourages the wearer to calm down by mirroring the stress level of its wearer through biofeedback, communicated through the fabrics of the jacket, and by actively helping the wearer to relax through deep abdominal breathing (Figure 1: left).

Thus, a distinctive feature of OwI's is that they are ordinary products (e.g., lamps, jackets, or toys) and, at the same time, intelligent agents. In the context of this article, we discuss these objects as *collaborative partners*. First, interactions with these objects can be considered collaborations, in which OwI's can take on different tasks within an overall goal in an autonomous fashion, and can communicate and negotiate about these tasks with humans. Second, these objects may form a *partnership* with humans. Such partnerships are empowering when they complement humans in some way. As such, OwI's are particularly useful when these objects have abilities that may help people attain specific goals or tasks, or when these objects provide people with the motivation to learn new skills or develop new forms of behavior. However, this partnership is different to human–human partnerships. These objects do not have needs independent of other people, and thus people have ultimate control.

As the design explorations described above are just the first steps in developing an understanding of OwI's, the aim of this study is to clarify the concept of OwI's, i.e., what makes them a specific type of agents, and to better understand how OwI's work by empirically investigating how people interpret, interact with, and value these types of agents in real-word settings. In this article, we further aim to make a contribution to interaction design practice by reflecting on the methodological challenges that follow from our insights gained.

2.1 Comparing OwI's with Other Types of Agents

How are OwI's different from other types of agents in HCI? Generally speaking, agents are entities that are *autonomous,* acting without a direct intervention of humans; *social*, having the ability to interact with other agents (including humans); *reactive*, perceiving the environment and reacting to changes in a timely fashion, and *pro-active;* being able to exhibit goal-directed behavior by taking the initiative (Wooldridge and Jennings 1995). In order to better articulate how OwI's provide a new perspective on HAI, we compare OwI's with three agent archetypes known in HCI—*ambient agents, conversational agents* and *social robots* (Figure 2). We will reflect on these different types of agents by considering key qualities of interest: the *grounding metaphor* of their intelligence and the *type of interactions* they afford. We consider these notions helpful to understand how OwI's fill a niche as a new type of agents.

Ambient agents are agents in Ambient Intelligent environments (AmI). AmI, as described by Aarts and Wichert (2009), are technical infrastructures composed of sensors and devices that are distributed in the physical environment. Multiple agents are used to interpret and respond to collected data. For example, some agents can be involved in interpreting sensor data from individual sensors, while other agents are involved in aggregating different data sources to make an assessment of the "context" (Hagras et al. 2004; Cook 2009; Tapia et al. 2010). Thus, the multiple agents that make up the ambient intelligent infrastructure are experienced collectively as a supportive ambient intelligent presence in the environment.

Conversational agents are agents that rely on natural language to interact with humans through written text or speech. They have been increasingly popular as chatbots (Følstad and Brandtzæg 2017). Conversational agents need to make sense of what humans say, manage ongoing conversations, and be able to express themselves through language (McTear 2000; Zue and Glass 2000; Allen et al. 2001). Conversational agents have been embedded in graphical user interfaces (Klopfenstein et al. 2017), implemented as part of virtual embodied characters (Cassell et al. 2000), or incorporated in physical devices (McTear et al. 2013). Because of the use of language, they are designed to make an impression of speaking to another human, and emphasis is given to making interaction natural and believable from this perspective.

Social robots are mechatronic agents that are designed to communicate and physically interact with humans (Breazeal 2003). Social robots resemble humans or animals, with eyes and ears, mouths, and so on, serving as interactional means. They often incorporate models of human–human communication as blueprints governing their behavior. Studies of anthropomorphically shaped robots indicate that robots' intelligence is often overestimated as people ascribe higher level of intelligence to them and that they can appear to be "uncanny" when they start to look too lifelike (Mori et al. 2012).

We can now investigate how these types of agents are different from each other and from OwI's (Table 1). First, the agents differ in terms of the *grounding metaphor of intelligence* with reference

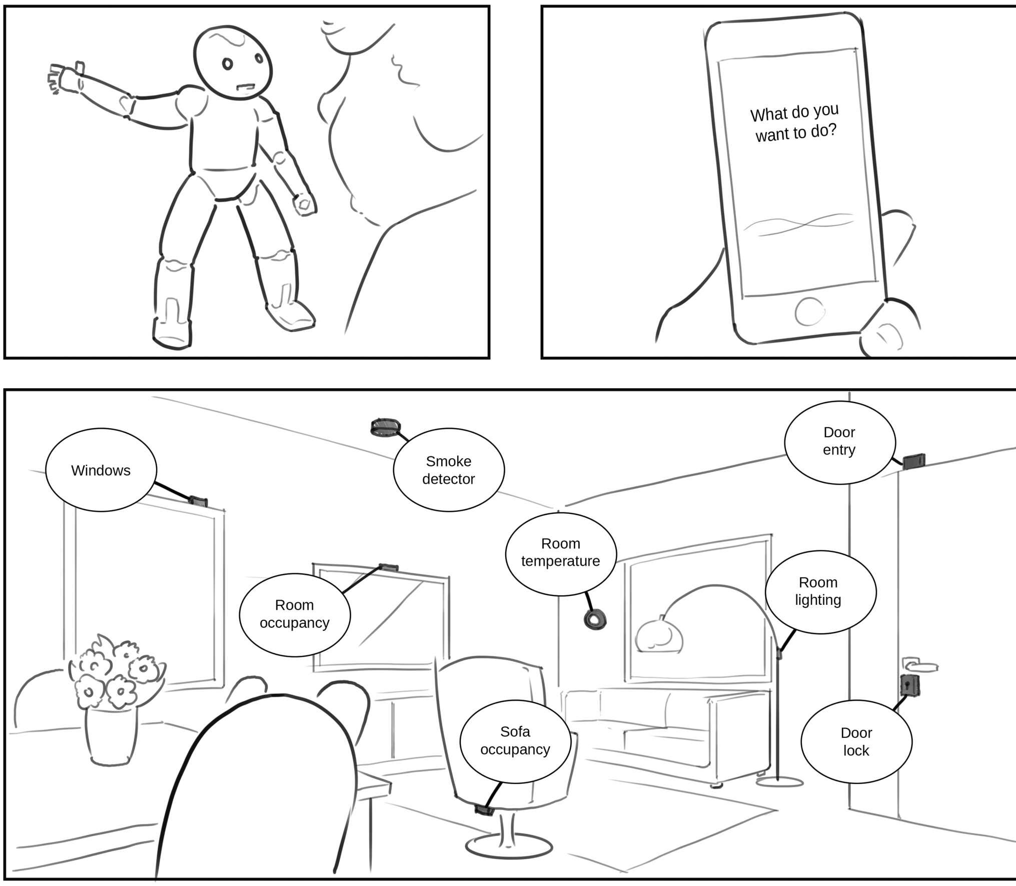

Fig. 2. Depiction of three common agents described in HCI. Social robot (top left), conversational agent (top-right), and ambient agents (bottom).

Table 1. A Comparison of Owl's with Three Different Types of Agents

	Grounding metaphor	Interaction: explicit vs. implicit	Interaction: direct vs. semantic
Ambient agents	environment	implicit	direct
Conversational agents	human	explicit	semantic
Social robots	being	flexible	semantic
Objects with Intent	thing	flexible	direct

to people's understanding and prediction of their behavior. Janlert and Stolterman (1997) describe *non-functional metaphors* as the metaphors behind the interpretation of a new technology or artifact. From this perspective ambient agents can be understood as intelligent *environments* because in AmI multiple agents act at different points in space concurrently. The underlying metaphor for conversational agents is *humans,* as natural language is the communication medium. Social robots are similar to conversational agents, with the difference that they are embodied as agents, and that besides the mimicking of human beings we also see more animal-like forms that appeal to other kinds of beings as well. OwI's on the other hand, take *everyday things* as their grounding metaphor for interpreting their intelligence.

Another way, in which these types of agents differ, can be described in terms of *explicitness* or *implicitness* of the interaction. Ju and Leifer (2009) describe different forms of interaction depending on whether an interactive system acts in a reactive or proactive manner, and on whether users need to attend to these system actions or not. They propose that explicit interactions are ones that require our full concentration and hands-on engagement. Implicit interactions do not require any attention from users and are valuable in situations where people are engaged physically, socially, or cognitively by focusing on their main task, and where a design requires some form of interpretation of users' intentions on the basis of which the system then is allowed to respond. Interactions with *ambient agents* (the type of agents within the context of AmI) are typically implicit, e.g., the environment may act proactively without requiring a user's conscious attention. Interaction with *conversational agents* is explicit, as it involves speech, and the initiative is at the person uttering a command that the agent then performs, which may also involve restating questions, asking for clarifications or acknowledging acceptance. *Social robots* are versatile. Communicating with social robots may be an explicit type of interaction, similar to communication with conversational agents. However, as social robots physically co-inhabit the spaces that people dwell in, social robots sometimes can be merely present and in this state do not require the conscious attention of people, while they still might act. *OwI's* have a similar type of flexibility. OwI's can function in the background when the interaction is developing as intended by the object, but could move into the foreground when the object prompts the user, for example, in the case it considers the interaction be negotiated.

Lastly, we can compare the interaction in terms of whether it is *direct* or *semantic*. Dourish (2004) distinguishes between direct physical types of interactions (i.e., *pre-ontological* interactions), and interactions that make use of labels and concepts (i.e., *semantic* interactions). *Ambient agents* interact with people in mostly direct ways, as ambient intelligent environments are designed to support people in their everyday activities by providing physical adjustments, for example, by changing lighting conditions in rooms, or otherwise changing the physical set-up by adjusting the furniture, doors, curtains, and so on. *Conversational agents* support a semantic means of communication, that is, the use of spoken and written language. Similarly, interaction with *social robots* can be semantic, as interaction with such robots is designed to be communicative. However, social robots can also be designed to communicate in a semantic way through non-speech sounds and body language. In case of *OwI*'s, the mode of interaction is direct, as the interaction with OwI's is designed to fuse with people's everyday activities. In this respect, OwI's bear similarity to ambient agents.

By reflecting on these comparisons we can identify the combination of qualities that makes OwI's a different type of agent compared to ambient and conversational agents, as well as social robots. First, OwI's take advantage of the meaning of everyday things as the site for their intelligence and agency, and therefore make it easy for people to understand and approach them as agents. This further might prevent people to overestimate the degree of their intelligence. Further, similar to social robots, OwI's can interact with people both implicitly and explicitly depending on the way the interaction is developing. Finally, OwI's are similar to AmI in that they are primarily designed for direct forms of interaction.

3 THE ANALYTICAL FRAMEWORK USED IN THIS STUDY

As the previous discussion indicates, while OwI's bear some similarity with other types of agents, they are also substantially different. To better understand the unique nature of these artifacts, as well as the possibilities and challenges associated with their design and use, in this section we turn to two theoretical frameworks in order to find support and guidance for our inquiry. We identify Dennett's theory of intentionality (Dennett 1989) and Activity Theory (Leontiev 1977; Kaptelinin and Nardi 2006) as conceptual approaches that can inform our analysis of OwI's as intentful artifacts and help understand their place in meaningful human activities. After discussing the theories, we combine insights from both of them to form an analytical framework, which is intended to structure our exploration of OwI's by identifying key issues to focus on and key questions to address.

3.1 Dennett's Theory of Intentionality

To help us better understand the unique nature of OwI's we turn to Dennett's theory of intentionality (1989). According to Dennett, people's attribution of intention to objects is a fundamental aspect of human interaction with the world. Attributing intention helps people explain and predict the behavior of living and non-living things.

Central in his work is the notion of the *intentional stance*, which he distinguishes from the *physical stance* and the *design stance*. Let us shortly explain the latter two first. With the physical stance as a predictive strategy, one reasons that a rock will drop to the ground when you throw it because of its gravitational pull. Predictions from this stance are based on the assumption of cause and effect, governed by *natural laws*. Adopting a design stance means approaching things as having functions. Examples include, for instance, understanding the working of the human heart or knowing how to control a microwave oven given its functions and control mechanisms. The design stance is based on the assumption that *things work as they should*, as determined by their biologically evolved or designed functionality, and it is more efficient than the physical stance in understanding and predicting behavior.

When systems become more complex, the *intentional stance* comes into play, for example, when explaining the behavior of animals, human beings, or complex non-living things, like robots. Adopting the intentional stance implies assuming that things have *beliefs* and *desires* and that things act *rationally* according to these beliefs and desires. In our everyday social conduct we continuously rely in the intentional stance. For example, when we see a person moving about, we predict their behavior according to our reasoning about their motives in relation to what they are actually doing. Based upon this type of understanding we can predict their next steps. This strategy also holds for predicting the behavior of animals and complex machines.

In general, all stances can be applied in predicting the behavior of things: they are all "real" as Dennett would frame it (Dennett 1991). For example, thermostats can be described and understood from the three stances. Seen from the *physical stance*, the thermostat "acts" because of the expansion of fluids caused by heat, as well as physical properties of the valve. From a *design stance*, a thermostat acts because it is designed to do so, that is, to monitor the temperature and adjust itself according to a set value. Seen from the *intentional stance*, the thermostat has beliefs about temperature, and acts on it based on its desire to maintain a specific temperature. For a simple thermostat, the intentional stance does not provide a more efficient understanding compared to the design stance. However, the more complex thermostats become—for instance, when they start to collect data about people's location, daily patterns, individual preferences, and especially when they start to control the temperature by taking into account human comfort, energy-saving, and costs—the more effective the intentional stance is as an interpretive frame for understanding how the thermostat works.

3.1.1 Relevance of Dennett's Theory for Conceptualizing OwI's. The relevance of Dennett's theory for conceptualizing OwI's is in how it accounts for people's inherent ability to consider things as being intentional. Dennett shows how applying the intentional stance as a *folk-psychological* framing of the behavior of things comes naturally and can be an effective predictive strategy in everyday circumstances. Dennett's work further opens up our notion of everyday things being *collaborative partners,* as collaborating with something assumes it has intentions of its own.

3.2 Activity Theory

Another theoretical approach informing our analysis is Activity Theory (AT), which offers a comprehensive conceptual framework for analyzing human activity as a hierarchically structured, mediated, social, and developing interaction between human beings and the world. Originally proposed by Alexey Leontiev as an approach in Russian psychology (Leontiev 1977), AT was strongly influenced by the work of other Russian scholars, especially Lev Vygotsky (1978) and Sergey Rubinshtein (1946). In the last decades, AT has become widely known and further developed internationally, most notably by Yrjö Engeström (2014), and applied in a variety of fields, including HCI (Bødker 1991; Kuutti 1996; Kaptelinin and Nardi 2006).

Since its introduction to HCI over 25 years ago (Bødker 1991), AT has firmly established itself in the field. A recent bibliographic meta-synthesis study of applications of AT in HCI (Clemmensen et al. 2016) indicates that in the last two decades the theory has supported, in a substantial way, numerous conceptual analyses, empirical studies, and design explorations. In recent years, AT has been one of the key theoretical influences behind HCI's turn to practice (e.g., Pierce et al. 2013; Kuutti and Bannon 2014).

AT is not the only influential conceptual framework in HCI. For instance, in an authoritative overview of HCI theories, Rogers (2012) also discusses a variety of other approaches, such as information processing psychology, distributed cognition, and ethnomethodology. In addition, some theoretical analyses in HCI have been conducted from the perspective of philosophy of technology (Verbeek 2010, 2015; Fällman 2011), which perspectives has been recently employed in a number of empirical studies and design explorations (Hauser et al. 2018; Wakkary et al. 2018).

While any theoretical approach in HCI can, arguably, provide some potentially useful insights, we consider AT especially suitable for the purposes of our study.[1] In AT, using technology to achieve meaningful goals of individual and collective subjects is not contrasted to other types of relationships between humans and technology, but rather comprises an integral part of a complex system of relationship between people, technology, and the world. By offering an elaborated system of concepts for analyzing technological artifacts *in the context of meaningful, purposeful human activity*, the theory provides valuable support for our understanding OwI's as collaborative partners.

At the most general level the theory is formed by two basic ideas. First, the unit of analysis in AT is *activity*, that is, purposeful need-based interaction between the *subject* (actor) and the *object* (world). Activity is considered a generative relationship that actually produces the subject. The human mind is argued to be a product of biological evolution and historical development that has emerged and evolved as an organ of adaptation in ever more advanced forms of subject–object interaction (Leontiev 1977; Kaptelinin and Nardi 2006). Second, human activity is considered inherently social. Not only collective activities, collaboratively carried out by a group of people, but also individual activities, carried out by a single person, are social in the sense that they follow social rules and norms, employ culturally developed tools, and are dependent on activities of other people (Leontiev 1977). These two basic ideas can be further elaborated through a set of more specific notions: *object-orientedness, mediation, hierarchical structure* of *activity, internalization/ externalization*, and *development* (Wertsch 1981; Kaptelinin and Nardi 2006).

[1]A systematic comparative analysis of activity theory in relation to other conceptual approaches in HCI is beyond the scope of this paper. Such analyses can be found elsewhere (e.g., Kaptelinin and Nardi 2006; Rogers 2012).

3.2.1 Object-orientedness. The notion of object-orientedness makes explicit a key idea that follows from defining activity as a "subject–object" (S–O) relationship: it states that all subject's efforts and experiences are directed toward certain entities, which objectively exist in the world. *Object-orientedness* means that activities and subjective phenomena are about the world and are inseparable from it, and that activities are defined by the objects at which they are directed. Two aspects of object-orientedness are especially relevant to the analysis of OwI's. First, *people* and *things* constitute two fundamentally different types of objects—and different types of orientation—of activity (El'konin 1977). Second, objects in the world do not exist independently from other objects, so S–O interactions are embedded in entire contexts or environments.

Object-orientedness also implies that from the perspective of the subject the world comprises two large classes of entities: (a) objects of subject's activities and (b) other entities, which are not directly involved in subject's activities (i.e., are "just things in the world"). Leontiev (1977) used different Russian words to refer to these classes of entities, respectively, "predmet" and "object," a distinction that cannot be directly expressed in English, since both of these words are translated as "object" (Kaptelinin and Nardi 2006).

3.2.2 Mediation. Mediation is a central concept in AT, which refers to the role that physical tools and signs (such as language) play in shaping the relationship between humans and their environment. Humans hardly ever act directly in the world. Instead, we rely on artifacts that mediate the relationship, and this is what has made us such a successful species. As opposed to some other animals, we do not have claws or thick fur, but we compensate (and overcompensate) that by using knives, coats, and other artifacts. Tools that mediate our activities do not just simply come into existence; instead, they are a result of the historical development of activities of other people (Petroski 1992). Seen in this light, humans and tools co-shape each other in a reciprocal relationship: *we shape tools and tools shape us.* This historical development of tools leads to the production and use of artifacts that can be seen to have culturally determined affordances (Bærentsen and Trettvik 2002).

AT further specifies that the agency of an artifact relates to the type of mediation it enables. According to Kaptelinin and Nardi (2006), all objects are considered to have *conditional agency*, which simply means that objects produce effects because of their physical properties. Some objects, such as technological artifacts, can possess *delegated agency*, i.e., the agency delegated to them by someone or something (for instance, the designer). Certain entities, such as human beings or animals, have *need-based agency*. From this perspective, as opposed to some other theoretical accounts (such as actor–network theory, Latour 2005), a human–artifact relationship is understood as an asymmetric one. However, as discussed below, while technological artifacts cannot have a genuine need-based agency, they may appear to have one.

3.2.3 Hierarchical Structure of Activity. In AT, human activity is described on three levels of a hierarchy. On the top-level, the level of *motive-oriented activity*, people's motives are considered the ultimate reason for people to engage in activities. The motive, corresponding to a certain need, determines the purpose of the activity. For example, when you experience hunger and decide to find something to eat, "finding food" is an activity and "food" is the motive that drives the activity. One step lower in the hierarchy, at the level of *goal-oriented action*s, conscious goals drive the actions that are required to complete the activity, such as taking a plate from the cupboard and opening the fridge to grab a sandwich. Goals are meaningful in the context of achieving the overall purpose (*motive*) of the activity. On the level of *condition-oriented operation*s physical conditions determine how actions are to be *perform*ed. The handle of the cupboard door allows it to be physically opened and given the shape of the plate it can be held in a certain way (idem for opening the fridge and grabbing the sandwich). Levels in this hierarchy are not fixed but can change depending on the person and the circumstances: what once was a *motive* can turn into a *goal* and what was a *goal* turns into a *condition* once the action is sufficiently mastered.

3.2.4 Internalization/Externalization, Learning, and Development. Human activities are physically and socially distributed and constantly re-distributed. In the process of *internalization*, external components of an activity, e.g., using fingers when doing basic math calculations, can transform into internal ones, e.g., doing math "in the head." Similarly, an action, such as riding a bicycle, which initially can only be performed collectively, together with other people, can eventually be performed individually. Increased physical and social distribution of activities is achieved through opposite types of transformation, *externalization*. In the process of externalization, internal components become external, for instance, when design ideas are expressed through sketches or prototypes. Individual activities can transform into collective ones, e.g., when one asks for (and receives) help or starts a collaborative project. The notion of *development* in the context of AT refers to the dialectical process driven by tensions or contradictions in current activities. Resolving a contradiction brings an activity to a new phase, at which new types of tensions and contradiction can be expected to emerge (Engeström 2014).

3.2.5 Relevance of AT for Conceptualizing OwI's. How does AT inform our understanding of OwI's? The notion of *mediation* in AT is relevant to the analysis and design of OwI's. Above we discussed how tools mediate human activity and are being produced by the activities. Things allow us to act in the world; they have cultural-historical significance that people perceive and recognize, as previous activities have been crystalized in our cultural artifacts. In this regard, a question, which is particularly relevant to our study, is as follows: What are the implications for mediation of conceiving these cultural artifacts as collaborative partners? Further, *object-orientedness* is of importance for designing OwI's as it acknowledges the connection of human action to human goals embedded in the physical and social environment, in which OwI's are embedded as well. Lastly, the notion of *development* is of importance in the design of OwI's as we consider human–OwI partnerships *transform* over time, because of changing circumstances and learning.

3.3 Analytical Framework

We have synthesized an analytical framework out of the two above theories with the aim to more deeply understand *how OwI's mediate activity as collaborative partners* (Table 2). We propose three concepts that together are believed to shed light on understanding the ways in which OwI's function. The first involves the *framing* of the object, how the object is interpreted. The concept of framing is informed by Dennett's different "stances" and AT's different "types and levels of agency." The second concept specifically points to the *embedding* of the object in its context; the concept is informed by AT's notion of "object-orientedness." Lastly, the third concept, *transformation*, refers to how the collaborative partnership *develops*, which is primarily informed by AT's dialectical approach to development. In addition, AT's principles of mediation and the hierarchical structure of activity have been employed to inform the analytical framework as a whole (rather than its specific aspects).

Considering the *framing* of the object, the analytical framework is used to pinpoint how people interpret objects differently and to understand why people change their perspectives. We then can ask the question of whether the object can be perceived to have intentions of its own or it mediates the intentions of others. This is considered to determine the way the object mediates activity and therefore of importance considering the nature of their partnership. For example, when the object is perceived as having intentions of its own, the object might be experienced as a "partner" when interacting with it. However, when the object is perceived to mediate the intentions of others, it

Table 2. Outline of the Analytical Framework: Key Concepts and Questions

Concept and Explanation	Informing concepts and theories	Questions
Framing How people *frame*, or interpret, OwI's when interacting with them.	Different types and levels of agency (AT), and different stances (Dennett).	Can the object be framed as a *designed artifact* that can have *intentions of its own*?
		How is this framing *established*?
		Can the object be successfully employed as a *collaborative partner*?
Embedding How the use of OwI's is *embedded* in a particular context.	"Object" orientedness, inseparability of subjects and objects in contexts (AT).	In which ways is the interaction with the object *enmeshed* and *coordinated* with the environment?
		Is there a *two-way interaction* between the object and the context?
		How can the object be successfully embedded *in the environment?*
Transformation How the collaborative partnership *transforms* over time.	Development, internalization/ externalization (AT).	How does the object promote *change* on an *individual* and *collective* level?
		Can *different phases* be identified through which these changes occur?
		How can the object be successfully employed for making an intended *long-term impact*?

might be approached as a "tool" for a specific aim defined by the person who uses the object (or as is intended by the designer of the object).

Considering the *embedding* of the object, the framework is used to identify how the object mediates activity as a collaborative partner by being embedded in a context. It is important to understand how the object interfaces and enmeshes with its environment. Therefore, it is required to carefully look into how different people might be involved, e.g., are they involved as active participants or as spectators? How is the object used in activities that also involve other objects, and how does the physical structure of the setting enable and constrain the activities that can be carried out with the object?

Considering how a human–object partnership transforms over time, our analytical framework is used to look for transitions that indicate *qualitative shifts*. AT specifies that activities are always developing on different levels through different phases that are determined by tensions and contradictions, such as the physical and social redistribution of an activity that takes place due to learning. As OwI's are intended to empower people, it is critical to understand how objects and humans co-evolve in their partnership on an *individual* and *collective* level.

For each concept, we have generated three key questions that help researchers more deeply understand how OwI's mediate activity as collaborative partners by observing human–OwI interactions in naturalistic settings. The first question sensitizes and guides the researcher towards the concept, as a phenomenon of interest. The second question helps the researcher look for specific behaviors that provide evidence for that phenomenon. The third question then helps the researcher judge if the functioning of the OwI was successful. This last question brings a design perspective in the observation, helping to inform the design of OwI's. The validity of the framework is shown

Fig. 3. Impression of Fizzy as it lies still, shakes wildly, and rolls around.

in its ability to find evidence that we will more elaborately discuss in the results and discussion section.

4 DESIGN CASE: FIZZY THE BALL

We illustrate OwI's though a design case of Fizzy that was designed to stimulate physical play in hospitalized children. The aim of this design project was to understand what stimulates young children to be physically active during hospitalization, with the underlying goal to positively contribute to children's rehabilitation and physical development. Physical play here refers to physical activity in the form of *spontaneous and self-directed play of the child.* The study was set-up and conducted within the context of a PhD project that focused on developing "Playscapes" as a design perspective (Boon et al. 2016).

4.1 Design Rationale

Young children develop their motor skills by engaging in physical activity in the form of unstructured and spontaneous play. In hospital environments, opportunities for such physical play are often missing and children show low levels of physical activity. Yet it is precisely in these situations that physical activity is vital to children's recovery and wellbeing. Opportunities for play generally come in the form of organized activities that children can participate in, such as playing sessions, or exercise sessions provided by physiotherapists. However, as children's physical play is spontaneous and intermittent, they would benefit from having opportunities for play in their proximity.

Fizzy is a proactive ball designed to be a positive trigger for children to play in a physical manner in the patient room (Figure 3). Designing Fizzy as an OwI entailed developing its embodiment with the look and feel of a ball that can be expected of a ball that is used in rough and active play, and by thinking about its movements as expressing its intent as an agent. For example, Fizzy *wiggles* to signal to the child that it wants to be played with, *rolls away* from the child to tempt the child to follow it, *wildly shakes* when it gets stuck or when it is being picked-up, and *vibrates* when it is stroked, entering a calmer state. Thus, we can imagine how children might play with Fizzy by *noticing* it, *following* it, *catching* it, and *letting go of it* or *calming it down* once they caught it.

4.2 Field Study

A prototype of Fizzy was used in a field study conducted in a hospital for pediatric oncology. The goal was to understand how Fizzy stimulated children to engage in physical play by observing how children and their parents experienced playing with Fizzy. In our observations, we used the

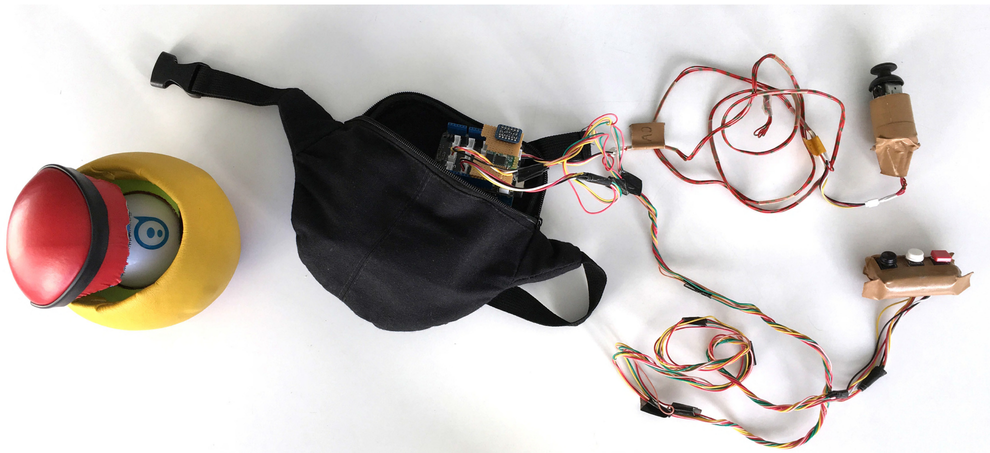

Fig. 4. The prototype of Fizzy with components: Sphero^{tm} in a soft shell (left), Arduino^{tm} and Bluetooth^{tm} module in fanny pack (middle), and controllers (right).

analytical framework, discussed above, to more deeply understand how Fizzy mediates physical play *as a collaborative partner*.

4.2.1 Participants. Seven playing sessions were organized in patient rooms that involved eight families in total. Five boys and three girls between the age of 3 and 6 were included in the study. We included only inpatients, meaning all participants were staying in the hospital for several days up to several weeks. Taking into account the vitality of the children and the stressful situations families might be in during hospitalization, an oncologist of the hospital judged what families were capable of and if they might be open to participation. The same oncologist approached the families at a later stage, and introduced the researcher to them. The families were then informed by the researcher about the goal of the study, and were provided with an information letter and an informed consent form. The families were offered a week to consider their participation.

During a study, the researcher visited the participating families in their patient rooms for sessions of about 40–60 minutes. Families were visited separately with the exception of two families that occupied the same patient room at the time of the visit. The visits consisted of an introduction, an actual playing session with Fizzy that took about 30 minutes and a short concluding interview. In some cases nurses were present, doing administrative tasks and providing care.

4.2.2 Wizard of Oz. In this study, we have used a Wizard of Oz approach. This means that the researcher made a prototype of Fizzy that could be controlled remotely by the researcher to make it appear as if Fizzy were an autonomous robotic ball. The prototype consisted of a Sphero^{tm} 2.0 with a soft foam shell finished with Skai leather and an Arduino^{tm}-based remote control using Bluetooth^{tm} (Figure 4). The remote control could neatly fit in the palm of the researcher's hands, the Bluetooth^{tm} module was carried in a fanny pack, and the wiring was hidden underneath the researcher's clothing. Care was given that participants did not know that the researcher was controlling Fizzy. The researcher could roll Fizzy around in the hospital room by using a joystick and used three dedicated buttons to elicit Fizzy's *wiggling*, *shaking*, and *vibrating* behavior.

Fizzy was introduced to the families as a robotic ball that they could play with and they were told that it was totally up to them how they wanted to play with Fizzy. The researcher finally said he would collect Fizzy from the hallway, and subsequently rolled Fizzy into the room while walking behind it. The researcher's arms were either crossed or behind the back, hiding the hands from the participants. In controlling Fizzy, the researcher played out Fizzy's behaviors as described in Section 4.1 while staying open to opportunities for physical play that arose during the session. For example, the researcher would roll Fizzy toward a child when a parent initiated a game of tag. Thus, controlling Fizzy occurred in an *improvisational* way in response to play opportunities that emerged while remaining within the confines of the physical capabilities of the prototype and its predefined behavioral repertoire.

4.2.3 Data Collection, Processing, and Analysis. The interactions and short concluding interviews were captured on video using two GoPro^{tm} cameras and an audio recorder. These were installed before the introduction and removed after the interview. The video streams were combined and anonymized in Adobe Premiere Pro^{tm} using a Find Edges filter and removing personal data (in particular, names) from the audio. The resulting video files were analyzed by using our analytical framework as a tool to observe how Fizzy mediated play activities. The key questions in the framework guided the researchers in their observation of the video data. Events of interest were then elaborately discussed among the researchers to arrive at a consensus.

4.3 Findings

In this section, we will present the findings of the study as they have been interpreted according to our analytical framework. The findings are organized according to (1) the ways in which Fizzy was *framed* by the participants as they were interacting with it, (2) how the use of Fizzy was *embedded* in the particular context of the patient room, and (3) how the collaborative partnership with Fizzy *transformed* over time. We illustrate each of these findings with illustrations of our observations of children and parents during the study. In these illustrations, fictional names are used to safeguard anonymity.

4.3.1 Framing. We observed a variety of ways in which children and their parents interpreted and played with Fizzy. For example, we saw instances in which Fizzy was played with as a *thing* that could be explored and fiddled with to understand its material qualities and behaviors. We also saw how children and parents employed Fizzy as a *tool* in different types of games: Fizzy was used to play soccer, bowling, game of tags, and hide and seek. We further saw how people interacted with Fizzy as a *creature* when trying to take care of it, communicating with it, or attempting to train it to show certain types of behaviors.

We observed how Fizzy was framed as a *thing*, mostly during the first moments of contact with Fizzy when people did not know exactly how to frame it. These moments involved *inquisitive interactions* to understand what Fizzy was made of and what it could do. A vivid example is provided by David, a six year old boy, who tried to figure Fizzy out together with his father.

> *As Fizzy rolls into the room father says to David "Look! Here he comes!". David grasps Fizzy and he notices that it shakes. This results in laughter. David invites his father to join in his discovery. After some more investigations David asks the researcher up front "What is this for?" As he points to the shaking ball, he asks "does it move by itself or is it remote controlled?" Then he holds Fizzy firmly with both hands. David tries out different movements to find out to which movement exactly Fizzy will respond to.*

We observed many instances, in which Fizzy was framed as a *tool* to play various types of games. For example, Fizzy was used to play soccer, bowling, a game of tags, and hide and seek. In another episode, a 5-year-old boy named Vincent was sitting on a couch with his grandma, as they started to bowl with Fizzy. Fizzy was lying in the window sill behind them, which was forming a rectangular playing field on which Fizzy could roll around without being able to fall down on the floor.

> *"Bowling!" mum says as she brings to the room several empty plastic cups, which she carefully positions in the windowsill. Vincent rolls the ball towards the empty cups, and they are knocked over. Fizzy starts to shake in response. "Ha that's too easy, now we only place one cup to make it more difficult" Grandma says. Vincent rolls Fizzy again. "Ha, a success!" grandma says. Then they take turns: now Vincent positions the cups and grandma tries to knock them over with with Fizzy.*

We also observed many instances in which Fizzy was framed as an *agent*. In these cases, Fizzy was approached as a creature that should be communicated with, trained, or be taken care of. We first provide an account of Tina, a 4-year-old girl, who is in the patient room with her parents. Tina sits on the floor and is connected to an IV-pole drip that her father rolls along with her. Mother watches from the couch how her daughter and husband play with Fizzy.

> *"Where are you going?" Tina asks Fizzy. "Go and follow him," dad says to Tina, "it's alright." Tina follows Fizzy around, and wonders where it will go next. As Fizzy starts to shake after she picks it up, Tina asks mum "why is he doing that?", to which mum replies "because he wants to roll". Tina puts Fizzy back on the floor and it starts to roll around. Tina then starts to call Fizzy "Bally" and asks it to come to her.*

Another account of Fizzy being framed as an *agent* comes from Ed, a 6-year-old boy, who is in the patient room with his mum and dad. It is a double room so it is quite spacious. Ed is also connected to an IV-pole. The infusion tube is quite long so he can move around relatively freely within the patient room.

> *"Maybe you should call Fizzy" father says as Fizzy had just rolled into the patient room. "Fizzy!" father calls out. Fizzy shakes in response as if hearing his call. Here after Ed rolls Fizzy away from him and shouts "Fizzy come!" while clapping his hands. Fizzy rolls back to Ed. Happy about noticing that Fizzy listens to him, Ed continues with his attempts to train Fizzy. This time he rolls Fizzy far away into the hallway outside of the patient room. "Fizzy come!" he shouts out loud into the hallway.*

The last example is of David, the 6-year-old boy who we have introduced earlier. This time we observed how he wanted to take care of Fizzy.

> *Dad drops Fizzy on the floor. "Be careful!" David says to his father "Now he is going to cry!" "Then go comfort him" dad says. David brings Fizzy to the bed and starts to sing a lullaby to it. He gently holds and rocks Fizzy. David mentions how Fizzy starts to 'purr' in response.*

Our observations also provide accounts of how these different framings can blend into one another. One of these instances is how Zaïf, a 3-year-old girl, was playing the game of "tag" with Fizzy and her father. This example provides an illustration of how Fizzy served as a *playing partner*, and was framed both as a *tool* and an *agent*. Zaïf and her father were located in a double patient room, occupied by two families. Zaïf was connected to an IV-pole that her father rolled along with her.

> *Dad calls out; "Let's play tag!" He takes his daughter by the hand and they walk away from Fizzy. Fizzy starts to follow them! Zaïf shouts to Fizzy "Try to catch me if you can!" When Fizzy continuous to roll after them, the girl responds with laughter and excitement. When dad is 'caught' by Fizzy, he says in response "now is the time for us to catch it!" Fizzy rolls away, urging them to follow it.*

Another account of Zaïf and her dad illustrates how the blending of Fizzy as a tool and agent occurred in a slightly different way and led to Fizzy being played with as a *pet-like creature* in a familiar play activity, in which Fizzy's autonomous behavior brought an additional feature in play.

> *Zaïf and her father are sitting on the floor, their legs connecting and making a confined playing field. Zaïf and dad are rolling Fizzy back and forth. "Roll it to me. No! Look, it wants to escape!" "Don't let it escape!"*

4.3.1.1 Summary. We have observed how Fizzy could be framed as a *thing*, *tool*, and *agent* and how these framings could *shift* over time and could *blend* into one another. As a tool, Fizzy was used to play games with, and interactions with Fizzy were *instrumental* for the games people wanted to play. As an agent, Fizzy was played with as a creature; children spoke and gestured to Fizzy, tried to understand its intentions, and took care of it. Interactions with Fizzy were mostly *empathic* and *communicative*, and in some cases children just observed Fizzy, for instance by following it or creating obstacles and watching Fizzy overcome the obstacles, without attempting to communicate.

As a *thing,* Fizzy was the object of examination and experimentation in order to understand what it could do (in terms of its materiality and interactivity) and how the object could be used in their play activities. Considering the *shifting* and *blending* of these framings, we observed how at one moment Fizzy was played with as a creature (agent) that in the very next moment could be kicked or be thrown like a normal ball (tool). In their combination (agent + tool), Fizzy could become a *playing partner* when the intentions of Fizzy aligned with others (i.e., Fizzy "played along") or it could become more like a *pet* when its intentions did not align. In the latter case, Fizzy made playing games more exciting, difficult, or challenging. Based on these combined observations, we conclude that understanding OwI's as collaborative partners specifically involves understanding this blending of Fizzy as a tool and agent into a *hybrid character artifact.*

4.3.2 Embedding. We observed different ways in which interaction with Fizzy was enmeshed and coordinated with other things and people in the patient room. Nurses walked in and out of the room, performing tasks of administration and care, parents were talking to staff or with each other, in some cases food was delivered or the room was being cleaned. We saw how physical play emerged out of the coordination between Fizzy's behavior, children's spontaneous responses to it, and parents' active involvement. Further, we have noticed how the layout of the hospital room and other objects present in the room were integrated in playing with Fizzy.

We first like to share how the children's *spontaneous responses* influenced how Fizzy was played with. Illustrative is a comparison between the interactions of Vanessa, a 6-year-old girl, and David, the 6-year-old boy introduced earlier. Vanessa is in the patient room together with her father. Upon seeing Fizzy rolling into the patient room, Vanessa engaged in rough physical play almost immediately.

> *Vanessa takes a quick glance at Fizzy. Without much thought, she walks up to it and gives it a hard kick. Bam! Fizzy is being kicked around in the patient room, from one corner to another. Then she starts to throw Fizzy, first away from her and then up in the air, over her head.*

As opposed to Vanessa, David engaged in a more careful explorative play.

> *David sits on the bed with Fizzy and explores what Fizzy feels like when it vibrates and shakes by holding it close to his body. As he lies down on the bed, he feels Fizzy's movement with his feet and his legs. Then he holds Fizzy against the top of his head, enjoying the sensory experiences that Fizzy provides.*

Parents further had a great influence in how their children framed and played with Fizzy. In some cases, parents were actively involved in *projecting intentions* upon Fizzy's behavior and *suggesting games to play*. In the case of Zaïf, we saw how her parents provided her with a rich narrative about what Fizzy wanted to do and how one could play with Fizzy.

> *Zaïf and her father are playing with Fizzy, when her father says, "He is shaking see? He wants to escape! Don't let him get away!" Zaïf starts to chase Fizzy. After some time, while Zaïf is sitting on a chair with Fizzy on her lap, the mother of Zaïf's roommate explains to her, "See, he wants to go home; he wants to be with you." Upon Fizzy's vibrating she says, "Feel it! He is purring like a cat!"*

We observed how the spatial layout and stuff in the patient room, *enabled, constrained*, or became *integrated* in the playing activity. For Ed, the hallway was essential in enabling the way he was playing with Fizzy; rolling it far into the hallway and calling it back. However, the infusion line of the IV-pole restricted his movement, and constrained him to walk into the hallway. For Tina, the layout of the hospital room, in particular the couch and hospital bed, was critical to play hide and seek; Fizzy was able to roll underneath the bed in order to hide itself, and was later also hidden by Tina underneath the bed sheets.

Other examples refer to how other materials were *integrated* in play. For example, the mother of Vincent introduced empty plastic cups, so that she and Vincent could bowl with Fizzy. David surrounded Fizzy with other toys to see if Fizzy could escape from it, while Vanessa put Fizzy in a drawer to see how Fizzy would respond.

During these playing sessions, the researcher who controlled Fizzy needed to process many of the things that were going on in the patient room. Based on these impressions, the researcher was prompted to make choices about how to control Fizzy. Considerations had to be made like, "do my actions lead to physical play or not?" or "should I accommodate to people's initiated course of action or try to initiate another type of activity?" Our key observation here is that in controlling Fizzy, the researcher spontaneously responded to the opportunities that presented themselves (*bottom-up*) while keeping in mind the purpose of Fizzy to stimulate children to play physically (*top-down*). Thus, the embedding of Fizzy in the context of the patient room can be considered a *two-way interaction* between Fizzy's (i.e., the researcher's) intent, and the context from which play opportunities emerged.

4.3.2.1 Summary. We observed different ways in which children's interaction with Fizzy was enmeshed and coordinated with other things, people, and spaces. Playing with Fizzy was coordinated with other activities taking place in the setting, such as going to the bathroom, eating, conversing, and routine tasks carried out by nurses. Playing with Fizzy was also coordinated socially, for instance, children's spontaneous responses to Fizzy could be influenced by parents' suggestions. In addition, we found that the physical space and things within it could enable or constrain playing or could become integrated in the play. Finally, we observed how Fizzy's embedding in the patient room can be considered a *two-way interaction* between Fizzy's intent (as controlled by the researcher), and the context from which play opportunities emerged.

4.3.3 Transformation. We observed a variety of ways in which the introduction of Fizzy in the patient room promoted change in both the setting and people in the setting.

We saw how Fizzy's presence in the patient room changed the room from a space used primarily for care into a *space for play*. Normally, children remain rather passive in the patient room as they lie on their beds for most of the time. Care activities include regular visits by nurses, waiting for treatments and/or results of treatments. Besides the received care, children often watch television, play a game on a tablet, or converse or have a meal with their parents. The presence of Fizzy in the patient room created a distraction from these "normal" routines, installing a playful mindset in children and parents.

Playing with Fizzy transformed the *subjects*. For example, we observed how people's learning about Fizzy's behavior over time enriched how people framed and played with Fizzy. At the start of play, Fizzy was being explored in terms of what it could do. Fizzy's responses to the initial actions of children and parents were critical. For example, in one case the researcher had Fizzy respond to the verbal call of the father of Ed, and Fizzy was framed as a creature that could "listen" and to which "commands" could be given. This discovery was an ongoing process because each discovery led to a new one, providing transitions in observed play activities.

We also observed how children could be frightened in the unfolding process of learning about Fizzy and required help in order to engage with it. In the case of Zach, a 4-year-old boy, this anxiety transformed into a more confident state of mind with some help of his father.

> *Zach seemingly ignores the ball when it rolls into the room and then quickly walks to his father. "No!" Zach says as his dad tries to approach Fizzy with Zach. When Zach picks up Fizzy and it starts to shake, Zach is startled by it, drops Fizzy, and clamps to his father. Dad picks up Fizzy while it shakes, and makes silly moves with it. Zach laughs. He starts to feel less scared and finally dares to engage with Fizzy by himself. When dad gives Fizzy a first kick they start to play soccer together.*

We also saw individual transformations, with reference to developing skills while playing different kind of games. A nice example of how children and adults build upon their previous learning is how Vincent and his mother first simply roll Fizzy around toward each other, which then develops into a ludic game of playing tricks on each other, and finally results in mum introducing empty cups as targets in a game of bowling.

We also observed how play activities developed due to boredom or tiredness. When a specific play activity started to become boring (either for the child or for the parents) a new play activity was initiated. Further, tiredness caused a natural ending of the playing activity after about 20 minutes to half an hour. For example, in the case of Vanessa, interactions became less playful during the last minutes of her interactions with Fizzy.

> *After having played for a while, Vanessa remained seated on a chair most of the time. Fizzy rolled away several times, leading her to collect him again; while doing so, Vanessa expressed her displeasure through sighs and saying "He doesn't listen!" Finally, she lets her dad know she wants to stop."*

Considering the observed impact of Fizzy, we noticed that for the period of time that Fizzy was present in the patient room, children and parents had quite actively played for most of the time. The results of the concluding interviews with parents also support our impression. Parents mentioned that they had not seen their children being so active since their hospitalization. We provide an account of parents commenting on Tina's way of playing with Fizzy.

> *While Tina is following Fizzy around the room, her father says to her "this is the most active you have been in the last three days!" "Yes", mother confirms while she is laughing.*

Later, during the short concluding interview, Tina's father elaborated on that.

> "*Tina normally plays in a much more quiet way in the patient room, for example by drawing or making a puzzle. Fizzy directly brings about movement and gives energy*"

4.3.3.1 Summary. How do these results provide us with an understanding of OwI's? More specifically how do OwI's transform activities that both Fizzy and people engage in? Our evidence indicates that the unfolding interaction with OwI's is inherently *a developmental process* that proceeds through different *phases*. On the *collective* level (i.e., referring to the social context of the setting), we have observed how the patient room changed from a space primarily used for care into a space for play. This changed the mind-set of the people in this setting, and altered the activities that took place there. On the *individual* level, playing with Fizzy changed children and parents as they discovered more about Fizzy (resulting in new ways of playing) and became more skillful in playing games with it (resulting in finding new challenges). Further, play activities were found to change when playing became boring or when playing was interrupted by events outside the context of play. The playing sessions naturally ended when children started to become *tired*. See Table 3 for a summary of our overall findings.

5 DISCUSSION

In this article, we have introduced OwI's as an emerging type of agents that takes advantage of their meaning as everyday things as the site for their intelligence and agency, and thus provides a novel perspective on HAI. OwI's are a particular type of agents, one that predominantly supports direct interaction and with which people interact both implicitly and explicitly. We then have presented an analytical framework to provide structure and focus to our empirical study, in the form of key questions we wanted to find answers to. In this section, we discuss the findings of our empirical study to address the overall aims of the article, that is, (a) gaining an insight into the nature of OwI's and how people interact with them, and (b) identifying key issues that need to be taken into account by designers to realize the full potential of OwI's for supporting and enriching human activities. The discussion will deal with both the specific case of Fizzy and OwI's in general, and will be organized around the notions specified in the analytical framework proposed in this article, namely *framing, embedding*, and *transformation.*

5.1 OwI's Being Hybrid Character Artifacts

As an instance of an OwI, Fizzy by its nature is a hybrid character artifact, i.e., an everyday thing, which at the same time is an intelligent agent. In our study, we observed how children and parents effortlessly framed Fizzy interchangeably (and simultaneously) as an ordinary ball and as a kind of creature or playing partner. The meanings and affordances of the ball provided the *grounding metaphor* that helped people discover and explore Fizzy's intelligence, and made it easy for them to understand how to approach the object and how to play with it. For example, the intelligence of Fizzy is expressed by its movements, which naturally connect to its embodiment of being a ball (i.e., rolling, wiggling). The very design of Fizzy suggested that it could be picked up, thrown, rolled, bounced, and explored. These expressive features might not be so easily provided by "black-boxed" technologies that hide their intelligence from its users.

As an OwI, Fizzy has been quite effective in motivating children to engage in physical play. The presence of Fizzy in the patient room created a playful mindset in children and parents, and stimulated them to play physically generally continuously for about half an hour. Compared to a normal ball, Fizzy's intelligent behavior raised children's curiosity, created excitement during play, and further provided additional triggers to keep the play interesting.

In our study, we further saw how different framings of Fizzy—as a *thing*, a *tool*, or an *agent*—resulted in different types of interactions, i.e., *inquisitive, instrumental*, and *communicative* interactions, respectively. This finding prompts us to reflect on the nature of Fizzy as being a collaborative partner. As a hybrid character that makes the thing being perceived as both a tool and an agent, the collaboration can be described as involving both instrumental and communicative interactions

Table 3. Table Showing a Summary of the Findings

Facet	Questions	Findings
Framing	Can the object be framed as a *designed artifact* that can have *intentions of its own*?	Yes, people framed Fizzy as an *agent* with intentions, but also as a *thing* or *tool*. These framings shifted and blended over time, leading to a mixture of *inquisitive, instrumental*, and *communicative* interactions.
	How is this framing *established*?	It was established by the child through an ongoing *exploration* and use of Fizzy, based on its *material and interactive properties*, as well as through *suggestions provided by parents*.
	Can the object be successfully employed as a *collaborative partner*?	We found Fizzy successful because it enabled openness and versatility in play, resulting from its *hybrid character* of being a sequence or combination of a thing, tool, and an agent.
Embedding	In which ways is the interaction with the object *enmeshed* and *coordinated* with the environment?	Playing with Fizzy was *enmeshed* and coordinated with other activities taking place in the setting, the physical setting *enabled, constrained*, or became *integrated* in play.
	Is there a *two-way interaction* between the object and the context?	Controlling Fizzy's behavior to stimulate physical play required accommodating to (and taking advantage of) play opportunities of a particular setting.
	How can the object be successfully embedded *in the environment?*	Children actively played with Fizzy when right *behavioral strategies* to control fizzy were employed, based on the right *type of cues*.
Transformation	How does the object promote *change* on an *individual* and *collective* level?	Fizzy changed the patient room into a playful setting for the family; playing with Fizzy enriched individual understandings of Fizzy and skills of using it.
	Can *different phases* be identified through which these changes occur?	Playing with Fizzy passed through different phases; the transitions were caused by *discovering* new possibilities of Fizzy, becoming more *skillful, boredom/tiredness,* and *contextual influences* (other people and activities).
	How can the object be successfully employed for making an intended *long-term impact*?	This is difficult to assess as the playing sessions lasted for about 30 minutes. Long-term studies are needed to assess this more accurately.

(Bødker and Andersen 2005): instrumental in the sense that OwI's (as everyday things with recognizable functions) are used for goals for which they are designed (e.g., throwing, kicking rolling, in the case of Fizzy), and communicative in the sense that the thing has a desire to interact in a certain way, and thus appeals to communicating and negotiating with it (e.g., Fizzy inviting the child to follow by rolling away). Due to their hybrid characters then, OwI's are *versatile* and *open* as collaborative partners. Experimentations conducted to understand the nature of OwI's (as *things*) then involve both physical experimentation to understand its *affordances* (Norman 2013) but also involves social experimentation to understand what OwI's can achieve on their own, and to see how it can be manipulated or controlled so that it responds to one's solicitations (Ackerman 2005). As mentioned, in all experimental sessions there were periods of empathic and communicative interaction but we could also observe children simply follow and watch Fizzy, especially in the beginning. Therefore, an intriguing question for further research is how people discover that not only Fizzy (or another OwI) has its own intentions, but can also recognize the intentions of people interacting with it.

As discussed earlier, human collaborators can be described as having *need-based* agency. From a user's perspective, playing with OwI's such as Fizzy is significantly different from playing with other people (i.e., in our study, participants were unaware that the researcher was actually controlling Fizzy). Other people can have their own, completely independent, intentions and plans. OwI's, on the other hand, can only be *perceived* as having need-based agency. Their relative independence is limited, and the limits are defined by people (in case of Fizzy, by either children or adults). Within the "magic circle" (Salen and Zimmerman 2003) of a game, in which Fizzy plays the role of a playmate or pet, it seems to be perceived and treated as a creature possessing need-based agency. However, when the child stops playing or changes the game, the perception appears to immediately change: for instance, Fizzy can be abandoned, put aside, or treated as a regular ball.

5.2 Human–OwI Interaction as Embedded in a Physical and Social Context

Our study has shown how physical play afforded by Fizzy was embedded in the patient room (i.e., the space, things within it, patterns of people) and was interweaved with other types of (non-play) activities. Being a ball, Fizzy was intuitively understood as something that could be played with and due to its small size, could easy maneuver through the patient room. We saw children play different types of ball games with Fizzy, alone, or together with their parents. When children were engaging with Fizzy by themselves, parents observed their child playing with Fizzy or engaged in other types of activities.

Within the patient room setting, Fizzy's presence provided the people in the room with concrete opportunities for play. In the study, we observed how Fizzy could *trigger* play and how it could *accommodate* for play activities that were initiated by children and parents. However, its agentic quality was specifically pronounced when Fizzy would *suggest* new directions for play when the researcher noticed that the playing did not lead to physical activity or when children started to become bored or tired, and a change was required to reactivate them. Furthermore, Fizzy *challenged* children during physical play as children became more skillful. Thus, when reflecting on Fizzy as being a collaborative partner for physical play, collaboration involved *ongoing negotiations* between Fizzy and others, which depended upon the intent of Fizzy as an agent, and on the intentions, goals, and plans imposed on Fizzy as a tool and material artifact. Thus, in controlling Fizzy effectively, the researcher needed to know if the child felt engaged during interaction, if the child was becoming bored or tired and what kind of games they felt like playing. Knowing these types of cues is important when modeling the behavioral strategies of Fizzy that it eventually should perform autonomously.

When focusing on Fizzy's physical embedding, we discuss how OwI's are *enabled* and *constrained by,* as well as and *integrated in* a physical context. As described earlier, its small size made it easy to roll around in the patient room. However, Fizzy could not roll anywhere because of obstructions, e.g., cabinets, IV-poles, and sometimes got stuck there. In some cases the physical setting became an integral part of playing with Fizzy. For instance, we observed how children experimented with Fizzy by putting it in a drawer, played hide and seek by hiding Fizzy underneath the bed sheets, and used it in a game of bowling by making it hit empty plastic cups. Therefore, OwI's should be analyzed as a part of an entire ecology of artifacts, with which people are interacting (Forlizzi 2008).

The interaction with Fizzy took place in a social context. The patient room was inhabited and visited by multiple people having different motivations and concerns. We observed how children actively played with Fizzy together with their parents, how nurses who frequently visited the patient room to provide care, witnessed the playing activity. Also physiotherapists and oncologists that entered the room knew about the study with Fizzy, although they did not participate in play directly. Within this group of stakeholders, we can speculate about how collaborating with Fizzy might be *empowering* for the different people involved: Fizzy helped children and parents play by providing concrete play opportunities and its proactiveness may have compensated for their lack of initiative. Parents might also have enjoyed the bonding that Fizzy made possible and nurses might have appreciated the liveliness that Fizzy brings to the ward without obstructing their work. Physiotherapists and oncologists may have valued Fizzy as a means for patient's rehabilitation. Empowerment then, defined as the ability to attain one's goals, and approached from people's embedding in a social context, refers to *webs of mediation* (Bødker and Andersen 2005). The implication for OwI's is then, how OwI's can be designed to be empowering by fulfilling different roles for different people and by being directly engaged in one activity (e.g., physical play), while also mediating other activities (e.g., rehabilitation).

5.3 Transformations of Human–OwI Interaction Over Time

We have learned how playing with Fizzy developed over time. To comprehend OwI's as collaborative partners, we need to better understand the *complementarity* of humans and objects (e.g., stated more specifically, how human actions and object behavior complement one another in a particular context of collaboration) and how the *dependency* this complementarity creates, develops over time. Key here is the notion that people learn and develop while they engage in activities. Consequently, people perceive their environment differently over time. For example, they might see new possibilities for action or learn automated behaviors and this prompts us to consider how OwI's should accommodate to these changes.

The exploratory nature of the interactions with Fizzy in our study brings in two intriguing questions. First, what makes people look for, find, and explore particular uses of Fizzy? And second, what makes people abandon these uses? Children themselves played a major role in this; their explorative actions and accidental discoveries of Fizzy continuously redirected the play activity. Also the learning of new skills could change the play activity, by opening up new challenges. Eventually, some children started to get bored with playing a particular game, or became physically tired. Other factors that influenced particular uses of Fizzy were the *social* and *physical* context; parents suggested certain ways of playing with Fizzy (*social*) and play activities could also change when new play opportunities with Fizzy were perceived in the environment (*physical*). To understand the phases of using OwI's in more detail, these multiple factors require thorough investigation in future studies.

How did people play with Fizzy individually and collectively? Our study shows how in some cases the focus of interaction shifts from individual exploration of Fizzy to involving other people and sharing with them the discovered uses. This was found to be a dynamic process in which *individual* and *collective* use of Fizzy transformed into one another over time. For example, a move from collective to individual oriented activity was seen when a child and father played together, making the child comfortable and less scared to interact with Fizzy. The other way around, we witnessed several cases in which children had discovered a specific type of use and wanted to share that or put it into use in a social kind of game. Thus, our evidence points toward *mutual transformations* from individual to collective levels, as described by Cole and Engeström (1993). Again, future studies need to properly address this issue.

Transformations over time can occur at different time-scales, defined in AT as consisting out of short and long cycles (Engeström 2014). As our study focused on short-term use, it is difficult to make claims about Fizzy's long-term use during hospitalization, which may last for weeks up to months. However, in the short-term, we did see development with implications for long-term use.

For example, we observed how people were able to quickly make sense of Fizzy as a novel type of product, which is likely to make a positive impact on its future use and adoption. We also saw how qualitative shifts took place in the interaction with Fizzy that were produced by the development of skills and the offset of boredom. These shifts can be expected to repeat itself in future play episodes in similar ways. However, long-term interactions do have their own kind of dynamics that need to be looked into (Karapanos 2013). We would be particularly interested in how Fizzy maintains its hybrid character over longer periods of time and how Fizzy will move into the background from which it may be able to develop new type of relations and routines with people and other objects in the patient room (Odom et al. 2014).

5.4 Implications for Design

We suggest that our findings are significant for interaction design practice, in particular in informing new *formgiving* methodologies in HCI that combine methods from the field of Industrial Design and those in the field of Animation. We further argue that *in-situ prototyping* approaches are needed to build up OwI's through multiple iterations that merge Wizard of Oz approaches with actual technology development. Further, OwI's need to be developed with a *critical understanding* of human and non-human agency.

How is Fizzy, as an instance of an OwI, different compared to other types of agents? In our earlier presented definition, *ambient agents* that make up an intelligent environment, would support physical play as it originates from the child rather than actively stimulating it. Engaging children in physical play through *conversational agents* would rely mostly on "talk" and "verbal instructions," thereby losing much of its physicality. A *social robot* like "Pepper" might be less supportive of the different kinds of physical play: it would be awkward to talk to Pepper in one moment and kick and throw around in the next, as we saw happening with Fizzy.

However, Fizzy's hybrid character challenged our initial classifications of agent archetypes, which should be revised in a more nuanced way. Although agents can be designed to look like everyday things, their behavior triggered zoomorphizing and even anthropomorphizing, blurring the distinction between OwI's, social robots and conversational agents, with respect to their underlying metaphor (Janlert and Stolterman 1997). This hybridity also blurred the distinction between direct and semantic forms of interaction (Dourish 2004). For example, we observed how children and parents talked to Fizzy, how Fizzy's rolling behavior was perceived to be communicative rather than pragmatic, and how a spoken command made Fizzy perform a specific physical task. Thus, our results hint at an agent classification that is multi-dimensional rather than existing out of mutually exclusive categories.

We propose that new *formgiving* methodologies need to be developed in HCI to support designing the intelligence of OwI's as a part of the overall character. Janlert and Stolterman (1997) introduced the notion of *character* as an entry point to understand computing artifacts as meaningful wholes. The character of an artifact is defined as the unity of its multiple characteristics, which involves the sustained impressions of aspects of the artifact's function, appearance, and manner of behaving, aggregated over time in a complete and coherent way. Giving form to intelligence this way requires that interaction designers need to work with the character of things, and need to be sensitive to the expressive potential of behaviors in order to make them communicative as agents. In Fizzy's case, its behavior of wiggling and rolling away was designed to be experienced as *teasing*, Fizzy's wild shaking when being picked up should give the impression of it wanting to *get away* and the vibrations of Fizzy when being held, should feel like pleasant *purring*. While we saw these attributions occurring, we also saw how some people interpreted Fizzy's rolling away as *guiding you somewhere* and where its wild shaking was interpreted as *joyful laughter*. Thus, different attributions could be given to the same manner of behaving. Therefore, it might be difficult to give form to the character of OwI's in an unambiguous way, and perhaps we should even embrace this ambiguity to exist in such characters.

We propose to iteratively develop OwI's from *low-fidelity mockups*—augmented by human intelligence and animated by human motion (i.e., Wizard of Oz approaches)—to *functional interactive prototypes* that are able to function autonomously as collaborative partners within specific settings. In the field of HCI, various design methodologies have been developed that incorporate *context* into the design process. A prominent approach, Contextual Design, developed by Beyer and Holtzblatt (1997), incorporates ethnographic methods for gathering data via field studies and feeding these findings back into the design process. An understanding of context is not only necessary to understand how people experience and appropriate OwI's, but is also required to design OwI's as intelligent agents that perceive their environment and are able to act autonomously within it. This prototyping approach reflects Brooks' (1991) embodied approach to intelligence, where robots are developed in multiple iterations within specific contexts, which then results in robotic systems that have levels of technical sophistication appropriate for their intended functioning within the setting for which they are designed. The human-controlled prototype of Fizzy, showed us how its mechatronic capabilities in terms of its rolling speed, power, and response times, were well-suited for the play activities that children engaged in. It further allowed us to understand the level of behavioral complexity that is required to get children interested and physically active. Fizzy's predefined behavioral repertoire confined the researcher's improvisations, which provided us with a baseline from which we are able to build-up and extend Fizzy's sensing capabilities and intelligence required to govern its autonomous behavior.

Lastly, designing OwI's requires a *critical understanding* of human and non-human agency. Designers must carefully consider how people in a specific situation may respond to, follow, or wish to overrule the autonomous actions performed by the object. For example, people could easily feel patronized or dominated by OwI's when they notice that the OwI can "take over." Designers should also consider human's dependency on things and how this develops over time. We can think of the nature of this dependency being different when augmenting human *abilities* compared to augmenting human *competences* or *awareness*. Augmenting human abilities might lead to a continuous dependency on OwI's. Augmenting people's competences and awareness might lead to a decreasing dependency on the object over time, because skills can be learned and awareness can be developed. We need to better understand how these different dependencies might impact collaboration and how OwI's should be designed accordingly.

5.5 Implications for Theory

In this section, we discuss the implications of our findings for AT in the context of HCI. Specifically, we discuss how AT can be further developed as a conceptual tool for dealing with issues related to the emergence of new technologies. It should be noted that it is not our aim here to present a comprehensive assessment of the theory. Instead, the section offers general reflections on the experience of using the theory in our study.

We argue that considering OwI's in light of their different framings as a thing, tool, or agent, indicates that there is a need for AT to develop a richer perspective on agency in HCI and on how different framings of OwI's are related to different types of mediation. Our study shows that children and parents can effortlessly frame Fizzy interchangeably as a thing, tool, and agent during play activities; this subsequently influenced the type of playful activities that emerged. In other words, our results show that OwI's can be interpreted from multiple stances proposed by Dennett (1946), i.e., the physical, design, and the intentional stance. The stances that people took frequently shifted as play activities alternated, indicating that children and parents were able to adopt different stances in a short period of time. The different types of agency described in AT further shed light on these various framings (Kaptelinin and Nardi 2006). As *things*, OwI's are considered to display *conditional agency,* which refers to (unintended) effects that artifacts can produce based on their materiality. As *tools*, OwI's display *delegated agency*, which refers to actions that are carried out on somebody else's (designer's or user's) behalf. Lastly, as *agents*, OwI's can be *perceived* as having *need-based agency*, which refers to the behavior of objects being perceived as driven by needs.

The versatility of OwI's in relation to these different framings foregrounds the need for further investigation of the dynamics of objects' agency in human activity. Within the general cultural-historical tradition to which AT belongs, El'konin (1977) has described how different kinds of activity take place depending on whether the objects of the activities are things or people. However, in the context of HCI, AT has not specifically discussed how objects of activities can be, or might appear to be, both things and subjects. Considering objects as *quasi-subjects*, a term introduced by Bødker and Andersen (2005), is a step in understanding objects in AT as being social and communicative. Furthermore, as activities are embedded in physical and social contexts, humans and tools should be seen not in isolation but in relation to other people and tools (Bødker and Andersen 2005; Kaptelinin and Nardi 2006) resulting in *complex forms of mediation.* In our study, we observed how Fizzy mediated physical play in the hospital room in the interplay between child and parents, and involving different objects and materials. A simple model including Fizzy as the only mediator was not sufficient to capture the type of complex mediation that we observed.

Bødker and Andersen (2005) present an approach to mediation, which provides a richer understanding of mediation compared to the singular human-tool approach. In an in-depth analysis of how people work in real-life technological settings they identify different types of complex mediation, namely *chains* and *levels* of mediators, as well as *multi-mediation* (i.e., different mediators being employed at the same time). While the general approach proposed by Bødker and Andersen (2005) is highly relevant to our analysis of Fizzy, the evidence we obtained cannot be completely described in terms of levels, chains, and multi-mediation. These concepts are undoubtedly suitable for describing the specific activities discussed by Bødker and Andersen, being wastewater plant management and ship navigation. These activities are, arguably, well established, stable, largely predetermined, and repeated, with some variations, over and over again. Such activities do not encourage (or probably do not even allow for) experimentation and significant deviations from a standard course of action. In this respect, interactions with Fizzy were very different. There was no standard course of action when people in the setting encountered Fizzy, and ambiguity and open-endedness were considered to be a resource (Boon et al. 2018). Children and adults were not only trying to achieve their existing goals but also, and at least equally important, what they did was exploring potential goals that could be achieved. The interactions we observed could be described as repeated cycles of discovering a new potential goal and then using Fizzy as a tool—in the particular physical, technological, and social context of the setting—for achieving it.

5.6 Limitations and Future Work

We have discussed and elaborated on OwI's through the example of Fizzy, a robotic ball used to stimulate children to play physically in hospital settings. Making any statements about the design and understanding of OwI's in general should therefore be made with care. In this section, we would like to reflect on the limitations of Fizzy being a particular kind of OwI, i.e., an OwI used to stimulate physical play, and the specific issues of using OwI's to engage children with cancer in hospital settings. Then, we end with outlining future work and the field of HCI to which it contributes.

Concerning OwI's flexible framing as a *thing, tool*, and *agent*, we do not expect to see major differences between Fizzy and other types of OwI's, such as the earlier examples of the bedside lamp that lulls you into sleep and the jacket that wants you to be safe. Considering their embedding, it can be expected that other types of OwI's will become enmeshed and coordinated in the environment in similar ways as Fizzy. However, the range of different activities that need to be acknowledged in the design might vary considerately. The bedside lamp, which functions in a rather stable environment, might be a less complex case compared to OwI's that are mobile, such as Fizzy or the jacket that is worn in a variety of public settings. We also expect developing partnerships for OwI's in general, similar to the development we have seen with Fizzy; having the purpose to empower people by complementing them in their activities. OwI's therefore need to accommodate to changes in knowledge and experience of the persons they are interacting with.

Play is a specific type of activity that can be highly improvisational and might be contrasted with other types of activities. Play is often described as being *intrinsically motivated*, being an end in itself, while work or task related activities can be *extrinsically motivated* activities, that is, are often a means to an end (Ryan and Deci 2000). From an AT point of view, play is an activity of which the motive lies in the process itself (Leontiev 1944). How might having a focus on play affect conceptualizing OwI's as collaborative partners? The intrinsic motivation of play and the child's ongoing interest in playing with the object for longer periods of time were crucial in the context of our study, but it might be different when OwI's are being designed to function more practically. For example, referring back to the design examples presented in the introduction, collaborating with a lamp that wants you to have a good night sleep is concerned with the ability to lull a person into sleep in a polite yet convincing way. Collaborating with a jacket that wants you to be safe is about guiding a person to a more relaxed state of being, by being tactful and considerate in its approach.

With regard to the particularity of the setting, the fact that we are dealing with children has an impact on our findings about intention attribution. Young children have an animistic frame of reference on the world (Piaget 1951). While this phenomenon is universal and can be observed at all ages (Heider and Simmel 1942), which our study confirms, it is likely to be experienced differently for adults. Understanding OwI's in the setting of a pediatric hospital has unique features compared to other contexts. Hospitals are complex, sensitive and highly structured environments with many processes that run in the background. In everyday life, people might have a more carefree mindset and feel more free to engage in other activities that involve less interruptions and scheduling.

In the empirical study reported in this article, we analyzed how people interact with technology that does not yet exist. The study, therefore, can be considered an example of "fieldwork of the future," understood in a broad sense. Such studies, as pointed out by Odom et al. (2012), have a significant limitation. In the scenarios employed in such studies people are typically explicitly instructed to use a certain technology, which places technology in the center of users' attention and makes it difficult to investigate ambient or peripheral interactions with the technology. Our study involved a more natural interaction than the staged "user enactments" discussed by Odom et al. (2012), but the activities that took place in the sessions we analyzed were still mostly organized and centered on Fizzy, rather than seeing Fizzy being a part of the "background." The question of how (or whether) peripheral interaction with OwI's can be supported as well as their transition from peripheral to central objects and back to the periphery (Ishii and Ulmer 1997) is an interesting question to address in future studies of OwI's.

To advance OwI's as a new interaction design paradigm, we propose several new directions for research to explore and further develop this new type of agent in the context of HCI. In particular, we propose the development of new *formgiving methodologies* that incorporate the character of things and the expressive capabilities of materials to develop agents as hybrid character artifacts. Such an inquiry will contribute to earlier work on formgiving and aesthetics in HCI (Janlert and Stolterman 1997; Laurel 1997; Lim et al. 2007; Robles and Wiberg 2010; Ross and Wensveen

2010; Hoffman and Ju 2014; Vallgårda 2014; Wiberg 2014). We also propose the further development of *in-situ prototyping approaches* required to design the intelligent behavior of OwI's. This connects to the ongoing discussion on prototyping in HCI and robotics (Hoffman et al. 2008; Lim et al. 2008; Šabanović et al. 2014) and further connects to the ongoing research on longitudinal approaches to assess the use and experience of computing artifacts "in the wild" (Odom et al. 2012; Chamberlain et al. 2012; Crabtree et al. 2013). Lastly, when designing or examining OwI's, HCI researchers and practitioners should adopt a *critical understanding* of human and non-human agency, given the potential benefits and threats that intelligent agents engender given their increasing autonomy, especially in relation to the ways in which agents are able to influence us in everyday life. Ongoing work on Value Sensitive Design (Friedman 1996), ethics of (persuasive) technology (e.g., Berdichevsky 1999; Verbeek 2011), and critical approaches in HCI (Fällman 2011; Stolterman and Croon Fors 2008; Bardzell and Bardzell 2008) can serve to help design OwI's more thoughtfully and responsibly.

6 CONCLUSION

In this article, we have introduced OwI's as an emerging type of agents that take advantage of the meaning of everyday things as the site for their intelligence and agency. We have discussed how OwI's have unique advantages to other agents commonly described in HCI. First, OwI's are easily approachable and intuitive in use, since their intelligence is made meaningful as everyday things (e.g., a lamp, jacket, ball), with familiar uses, anticipated contexts of use, and known ways of interaction. Second, OwI's predominantly provide a direct form of interaction. The agentic and communicative forms of interacting with OwI's blend in with their use as purposefully designed everyday things, resulting in unique forms of collaboration.

We have presented an analytical framework to better understand the nature of OwI's as intentful artifacts and help understand their place in meaningful human activity, as well as the possibilities and challenges associated with their design and use. We drew from Dennett's theory of intentionality and AT, which helped to structure our exploration of OwI's by identifying key issues to focus on and key questions to address. We then used the framework to analyze the results of Fizzy, a robotic ball designed to engage hospitalized children in physical play. We have discussed the design implications of these findings in the further design and development of OwI's.

The message of Donald Norman stating that the biggest challenges in HAI are psychological and social is still of great concern today. A new human–agent paradigm that approaches everyday things as collaborative partners is urgently needed as artificial intelligence is increasingly embedded in products and systems, permeating our everyday lives. We argue that the way in which intelligence is given form in such objects and systems is critical in order to meaningfully embed them in human activity. We are very much looking forward to help build a future where we can live, dwell, and collaborate with intelligent everyday things in empowering ways.

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