# Bonding with BlockBot: a field exploration of the effect of common locus on human-robot bonding

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**Abstract.** The increased presence of robots in human-inhabited environments provide a new frontier in the research of human-robot interaction. Currently, we lack a comprehensive understanding of how humans make sense of robots in their daily lives. We observe a growing body of examples in which humans show behavior that is indicative of a strong social engagement towards robots that do not possess any life-like realism in their appearance or behavior. We propose an extended framework of social robotics, that next to appearance and behavior, includes the concept of a common locus as a relevant factor for passing a social threshold. The common locus is understood as the impression of sharing a life - time, space and experiences - between a human and a robot. This paper theorizes that a common locus can facilitate an experience of a robot as a social agent, regardless if this robot displays low life-like appearance qualities and low life-like behavioral cues. We present the BlockBots - minimal cube-shaped robotic artifacts - that are deployed in an unsupervised, open-ended and in-the-field experiment. Participants host the BlockBot in their domestic setting before passing it on. Qualitative data - messages, photos and videos about the BlockBot - is generated through Whatsapp communication. The data shows that the BlockBot successfully establishes a common locus with participants and that participants refer to the BlockBot as a social agent, which suggests that it passed a social threshold. Participants attribute identity, state of mind and agency to the BlockBot and maintain a common locus by keeping it in their proximity between locations and taking it on trips and activities with them. The results of this study suggest that the presence of robots in human-inhabited environments will impact how humans perceive them. However, results are only indicative and we also discuss alternative interpretations of the data and future studies.

**Keywords:** Human-Robot Interaction · Human-Robot Bonding · Social Robotics · Common Locus · Creative Robotics · Field Study · Open-ended

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## 1 Introduction

There has been a concentrated effort to make machines social. Increasingly, robots are leaving factories and laboratories and entering human-inhabited environments; homes, hospitals, public spaces and war zones. They clean our floors, entertain us as pets, deliver packages, defuse bombs, and assist in therapy for the elderly and children with developmental issues [1] [2]. This trend can also be observed in familiar domestic objects: lighting or domestic appliances are being upgraded to smart interactive agents [3]. However, while robots are joining human-inhabited environments in growing numbers, we do not have comprehensive knowledge on how people make sense of these new robotic co-inhabitants [4].

In order to create robots that are socially capable and thus improve the functionality of the robot in a social setting, the research field of social robotics has focused on, among other things, identifying mechanisms that allow robots to reach a 'social threshold' [5]. The theory of this social threshold focuses on two concepts: realism in appearance and realism in behavior. It is hypothesized that a strong realism in either human or animal-like appearance or autonomous movement or behavior "allows a robot to reach the "social threshold" where humans experience its presence as that of another social agent and are disposed to socially interact with the machine" [5]. This theory argues also that strong realism in behavior is more effective as a catalyst for passing a social threshold than realism in appearance. This approach to social robotics takes a technical stance towards the social capacities of robots; social presence is understood as an appearance or behavior-based quality that can be incorporated in a robot.

While there is ample laboratory-based evidence that appearance and behavior are important factors in establishing a robot as a social agent, there is a growing body of cases in human-inhabited environments in which humans show behavior that indicates a strong social engagement towards robots that do not possess a life-like appearance or show life-like movement or behavior. How can we explain these examples?

One common element between such robots is that - for often prolonged periods of time - they exist in close proximity to humans in a human-inhabited environment, often cooperating on tasks together with humans. Another common element seems to be that humans are prone to regard these robots as subjects, as artificial creatures that they project certain qualities on, and not as inanimate objects such as smart thermostats or fridges, for example.

Objects, tools and machines function beyond their practical application also as a formative agent of social complexity. Cars, for example, facilitate the formation of memories through road-trips and holidays, contain an idea of "freedom", "responsibility" or "status" and, through years of usage and upkeep, provide users with a certain sense of identity and a potential emotional bond [6]. This idea of 'the social life of things' stresses the two-way directional influence between humans and objects and the social experiences some objects can evoke in humans [6]. In other words, a human's perception of a robot as a social agent -

and possible subsequent attachment - could arise from the presence of a robot in a human-inhabited environment in itself and not be solely reliant on the robots appearance- or behavior-based social cues. We call this the common locus: the experience of sharing a life - time, spaces and activities - with a robot.

The aim of this paper is to explore the relevance of the common locus in relation to a robot passing the social threshold. This paper considers the common locus a relevant factor when passing the social threshold. We propose an extended framework of social robotics, that next to appearance and behavior, includes the concept of a common locus: the ABC-framework for social robotics (Appearance, Behavior, Common locus) (see fig. 1 and 6). These factors are theorized not to be mutually exclusive, but to potentially strengthen the experience of the robot as a social agent together.

Conventionally, when a human-robot interaction is desired, the perception of the robot as a social agent is not the final goal in itself, but is often there to capture attention or affection and redirect this for a certain purpose. One example is therapy: interaction with a social robot seems to improve social engagement of autistic children in human-human interaction [7]. Another example is teamwork: human-robot teams perform better when humans are emotionally attached to the robot [8]. The common locus could provide a new factor in establishing human-robot relations for these types of therapy, behavioral interventions and cooperation. If a social interaction or bond with a robot is a feature that is preferable by design, being aware that a (prolonged) proximity of a robot in the social life of a human can facilitate social engagement, might in turn inform the design and usage of such a robot. Of course, engagement is not a good thing in itself and could also be used for goals that may be unwanted: such as engagement with a robotic entity that encourages a human to gamble. Unintentionally, a strong human-robot bond could also cause a scenario in which a human puts him/herself in harms way to 'save' a robot. In these types of situations the common locus implies that the presence of robots in the proximity of people should be curbed, since merely removing anthropomorphic qualities could be insufficient to prevent human-robot engagement or bonding.

As an initial exploration of the common locus, we designed and deployed the BlockBot: a small cube-shaped robotic artifact with an open-ended purpose that makes an arbitrarily low claim to appearance or behavioral realism, but aims to maximize a common locus with humans (see fig. 2). By deploying the BlockBot unsupervised into a domestic setting, we aim to explore how people make sense of, interact with and potentially bond with this ambiguous robotic artifact. In the process, we hope to get a better understanding of the relevance of the common locus in passing the social threshold.

This paper theorizes that the act of living or working in close proximity or cooperating with a robot for an extended period of time can facilitate an experience of a robot as a social agent and the impression of having a shared experience, regardless of whether this robot possess low life-like appearance and behavioral social cues.

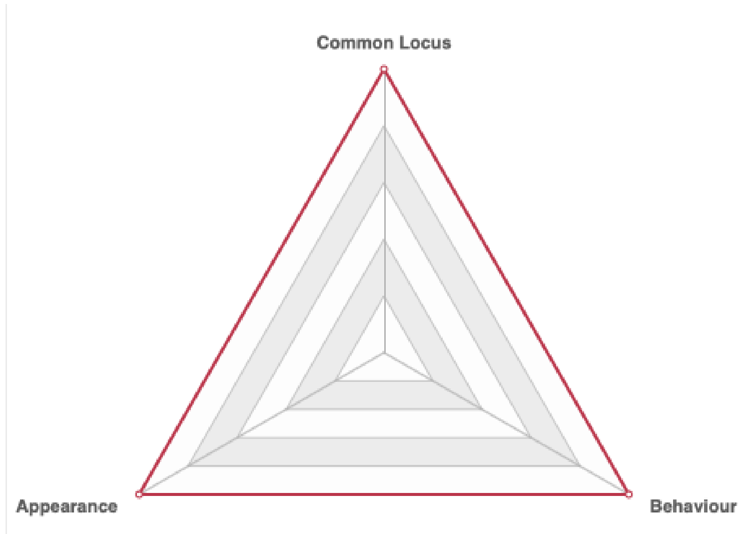


**Fig. 1.** ABC-Framework

In this study, the BlockBots are presented as autonomous creatures that want to meet people and travel the world. This approach is inspired by the hitchBOT, a robot that hitchhiked across Canada and several European countries [9]. In contrast to hitchBOT, however, the BlockBot has no specific location as its end-goal; its function is ambiguous. This narrative mainly serves to facilitate BlockBot interaction with a multitude of participants in a natural setting without supervision. To ensure naturalistic interactions, our methodology takes an unobserved, autonomous and open-ended approach. The BlockBots do not collect data through sensors. Instead, participants could send their thoughts, feelings and activities with the BlockBot to a phone number attached to the back of the box. This qualitative data will be analyzed to study how participants engage with the robotic artifact and whether the robotic artifact is perceived as a social agent. Regardless of minimal design and non-existent functionality, we expect that participants will be disposed to socially interact with the BlockBot. We discuss a possible framing effect - that is if the BlockBot deployment narrative could influence how people experience the BlockBot from the start - in section 7 (Discussion).

This study aims to contribute to the growing research field of studying human-robot interaction outside the laboratory. Jung and Hinds note that research on human-robot interaction has been "dominated by laboratory studies, largely examining a single human interacting with a single robot" [10]. This has led to a large body of scientific research in which technical mechanisms affect human-robot interactions. However, there is a disconnect between these studies and the socially complex environments robots are aimed to be - and exceedingly are - placed in [10]. Controlled laboratory studies offer helpful insights, but would

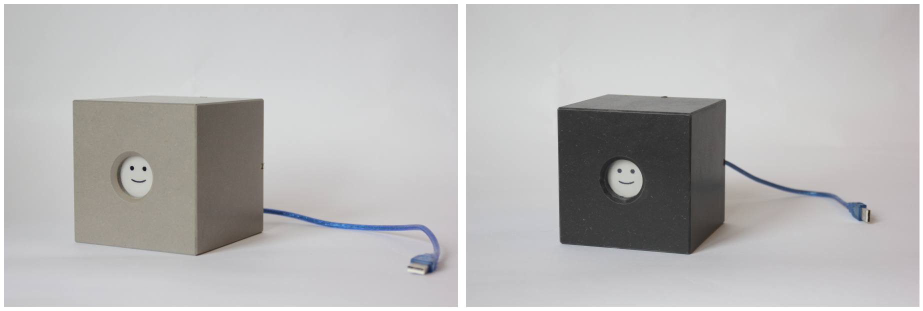

**Fig. 2.** A grey and a black BlockBot

benefit from supplementary studies on human-robot interaction in the proverbial wild. Since the concept of the common locus puts emphasis on the experience of a shared life within a human-inhabited environment, we considered it appropriate to use an 'in the field' approach.

The design and deployment of the BlockBot was an iterative process. An important part of this process was an impromptu preliminary study which we undertook in order to identify certain engagements people would make towards an artificial creature in a human-inhabited environment and to test several mechanisms of the BlockBot deployment narrative, such as the willingness of participants to take the bot, to communicate about the bot and pass it on. We positioned a cardboard version of an early BlockBot prototype - called TouristBox - into public space and observed how people would engage with this creature. This preliminary study provided us with several key insights and valuable feedback concerning the design and deployment of the BlockBot. It also gave us certain expectations as to which forms of communication and engagement to expect and provided us with an initial indication on the relevance of the common locus. For the sake of completeness, since this preliminary study functioned as an important step in our iterative design process of the BlockBot, it is incorporated in this paper.

This paper is structured in the following manner: In the second section (Background), we discuss related work on human-machine interaction, anthropomorphism and passing the social threshold. In this section, we also briefly discus the definition of a robot and the subsequent problems it poses. In the third section (Common Locus), we will introduce the concept of the common locus and propose our extended framework for social robotics: the ABC-framework. In the fourth section (Methodology), we will discuss the used methodology. In the fifth section (Preliminary Study), we discuss a preliminary study that we undertook to gather feedback on the future design and deployment of the BlockBot. In section six (BlockBot), we will present the design of the BlockBot and the available results from our field experiment. Finally, in section seven (Discussion), we provide an interpretation of the results, highlight some methodological limitations of our study, offer alternative explanations for the data and discuss potential future studies.

## 2 Background

In this section, we discuss why humans would be disposed to socially interact with a robot, which social behaviors have been observed and which mechanisms that allow a machine to pass the social threshold have been studied extensively. We also briefly discus the definition of a robot and the subsequent problems it poses.

### 2.1 Robot Definition

There is no universally agreed definition of a robot. Most often, a robot is defined along its technical capabilities: its capacity to sense and act in the physical world. For example, in her book The Robotics Primer, roboticist Maja Mataric answers the question 'What is a robot?' along the following lines: "A robot is an autonomous system which exists in the physical world, can sense its environment and can act on it to achieve some goals." [11].

While definitions such as these are helpful to a certain extent, they could be argued to be problematic from an usage perspective. This technical definition of a robot include examples of machines that are rarely referred to as robots. At the same time, this definition excludes machines that we would call robots.

For example, Mataric's definition does not include any remote-controlled robots such as drones or bomb disposal robots, because these machines are teleoperated by humans, which makes them not 'autonomous' anymore. The definition, however, does include a common vending machine. It's an autonomous system which exists in the physical world, can sense its environment through the touch of its buttons and scanners in its coin receptacle and can act on these sensations by achieving the goal of moving a soda to a more easily humanly reachable position. However, few people would call a vending machine a robot.

Another problem is that a formal definition of a robot often creates more questions than it solves. What about machines that can operate autonomously, but are more often controlled by humans such as cars or airplanes with cruise control? When is a machine autonomous enough to become a robot? This is just one example that illustrates the difficulty when providing a satisfactory definition of a 'robot'.

While there is no consensus on the exact definition of a robot and it is not in the scope of this paper to provide a conclusive answer that question, we would argue that it might also be beneficial to think about robots, not along mechanical lines, but along the lines of how they are perceived- an 'external' definition, compared to an 'internal' definition. Consider the following: does a mechanical artifact or machine need to possess certain qualities in order to earn the moniker of 'robot' or is it sufficient that a human merely believes that it has those qualities? One could argue that if a human believes a machine has the above-mentioned capacities of a robot, it is irrelevant (for example, when studying their engagements) if the machine they engage with actually possesses them. This would shift the definition of a robot from its inner workings, to how their presence is perceived. Hence, we would consider a robot those machines or artifacts that are 'subjectified' - that are deemed artificial creatures onto which humans project features such as identity, state of mind, emotion and capacities commonly associated with robots such as the ability to sense and act.

It is not unwarranted to define robots as those artifacts that are deemed artificial creatures. It seems robots inhabit a new ambiguous ontological category, separate from machines. Damiano and Dumouchel note that people across age groups perceive robots as "ambiguous objects" in relation to traditional ontological categories [12]. Robots seem to inhabit a place on a spectrum between alive and not alive, sentient and not sentient, intelligent and not intelligent [13]. Defining a robot as a 'subjectified' artifact could, therefore, be argued to be more in line with their ontological character. Therefore, when considering a definition of robots, it is perhaps more useful not to make a distinction between objects, machines and robots, but between those entities that pass a social threshold and those that don't solicit this perception. In other words: those machines that people 'subjectify' and those machines that people 'objectify'.

For the purposes of this paper, in order to mitigate the debate of defining what a robot is, we understand the definition of a robot as a mechanical artifact or system in the physical world that possess a certain level of autonomy, agency and sensory capacities. Hence, we have refrained from calling the BlockBot a robot. Instead we have called it a robotic artifact. This definition is supposed to refer to the fact that the object has certain qualities that potentially could evoke a connotation of a robot, but might not qualify as a robot according to some definitions [11]. However, perhaps the BlockBot can function as a starting point to discuss the boundaries of the concept of a robot, one not defined necessarily by its inner workings, but how humans perceive its presence.

### 2.2 Anthropomorphism

People have been observed to show rich emotional and social behavior when interacting with robots. One example of this, is behavior that is indicative of empathy towards robots. A study using electroencephalography (EEG) found that humans are able to empathize with robot pain [14]. Another study using fMRI showed that violent interaction towards humans or robots resulted in similar neural activity compared to an inanimate object, which indicates that humans and robots elicit similar emotional reactions [15]. Similarly, other studies have showed that people have strong reservations about torturing or 'murdering' a robot. Participants were less likely to turn off an agreeable and intelligent machine when it begs for its life compared to one that is not agreeable nor intelligent [16].

There is also ample anecdotal evidence from non-scientific sources. In an experiment covered in an episode of the radio show Radiolab, participants were more uncomfortable holding a Furby upside down that started to cry than a barbie doll [17]. In a workshop participants showed strong reservation about hitting a dinosaur-like robotic toy called Pleo that they had just spent an hour playing with [18]. When the social domestic robot Jibo was discontinued, media outlets reported on people that were mourning its ‘passing’; with some parents having to explain to their children that ’Jibo was not going to be around anymore’ [19]. After Boston Dynamics showcased the balancing capabilities of their quadruped robot Spot - which showed life-like movement - by kicking it in an online video, there was online outcry over the supposed cruelty displayed [20].

Why would a human be disposed to form a strong bond with robot, feel emotions about it or socially interact with it, such as act polite against a computer [21]? It is commonly hypothesized that strong realism in either human-like appearance or autonomous movement or behavior “allows a robot to reach the “social threshold” where humans experience its presence as that of another social agent and are disposed to socially interact with the machine.” [5].

In response to life-like or social cues that an object or machine emits, a robot might pass this ’social threshold’, after which people tend to project human-like qualities or traits such as emotion, agency or intention on the machine. This tendency is known as anthropomorphism [22,5]. While anthropomorphism has largely been viewed as a cognitive bias [23,5] in other fields of study, the concept fulfills a positive and central role in the fields of human-robot interaction and social robotics and is theorized to lead to a natural and intuitive human-robot interaction [24,25,12]

Several explanations for this phenomenon have been proposed; e.g. anthropomorphism arose as an active mechanism to make non-human like entities more familiar, explainable or predictable [24]. Alternatively, anthropomorphism has been argued to be a passive cognitive process as a response to the life-like or social cues that the object emits [24]. Dennett’s theory of intentionality [26] states, however, that attributing intention is a fundamental aspect of human interaction with the world, which “helps explain and predict the behavior of living and non-living things” [27]. Epley argues that the tendency to anthropomorphize arises from two motivational factors: “to interact effectively with the surrounding world” and the “human need and desire to form social bonds with other humans which in the absence of humans can easily extend to forging human-like connection with non-human entities” [23].

Anthropomorphic strategies can be split into two complementary categories: life-like appearance and life-like behavior [5]. The balance between these factors is hypothesized to be asymmetrical: behavior seems to be a stronger cue for a robot to pass the social threshold than its appearance [5].These categories have been divided into several subcategories, which we will discuss in the next part of this section (see fig. 3).

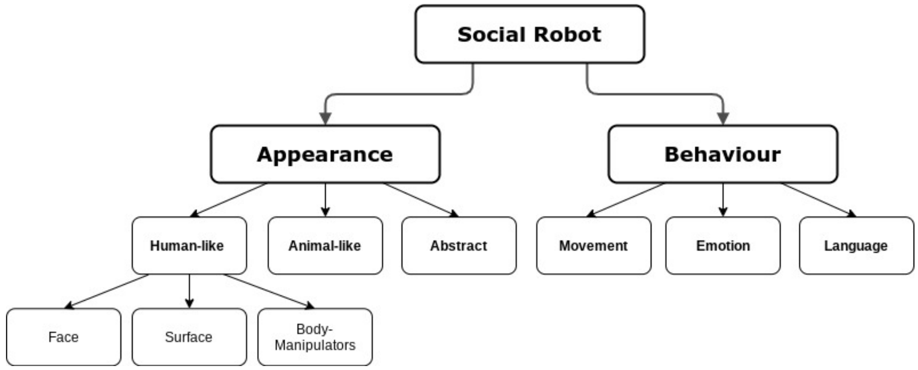


**Fig. 3.** The traditional framework of Social Robotics

### 2.3 Appearance

The appearance of a robot can function as cue for social interaction. Appearance-based strategies can be clustered into two categories: animal-like robots and human-like robots. Robots can also have an abstract appearance, however, this in itself does not function as a social cue. Abstract robots often use a behavioral approach to solicit social engagement (for further reading see: [28]).

One strategy in designing a social robot is to use human-like appearance. Often, the motivation behind this design choice is practical: our world is designed with the human body in mind and if we want robots to navigate our spaces, they should be designed along similar dimensions. There are conflicting studies on how and in which capacity the human form functions as a positive social cue for human-robot interaction. One study showed that humans react more empathetically towards robots that are more human-like compared to non-human-like appearances [29]. On the other hand, the human form can raise expectations about intelligence, intent, agency and physical capabilities that contemporary robot technology might not be able to deliver on, which in turn might generate negative feelings [30]. Regardless, there have been several projects developing robots with a highly realistic human appearance such as the android clone of Hiroshi Ishiguro [31] or Bina48 developed by Hanson Robotics [32] (see fig. 4). Unsurprisingly, the appeal of sex robots is also largely tied to their human-like appearance [33]. In order to map out the concept of human-like appearance, the ABOT database has constructed three distinct dimensions of human-like appearance - body-manipulators, face and surface - based on a collection of 251 real-life robots [34].

Another appearance strategy explores animal-like forms. Research suggests that humans have a more positive attitude towards animal-like or toy-like robots than human-like robots [35]. For example, the robot seal Paro stimulates feelings of attachment and engagement [36] and that children formed a very quick attachment to the robot dog AIBO [37].

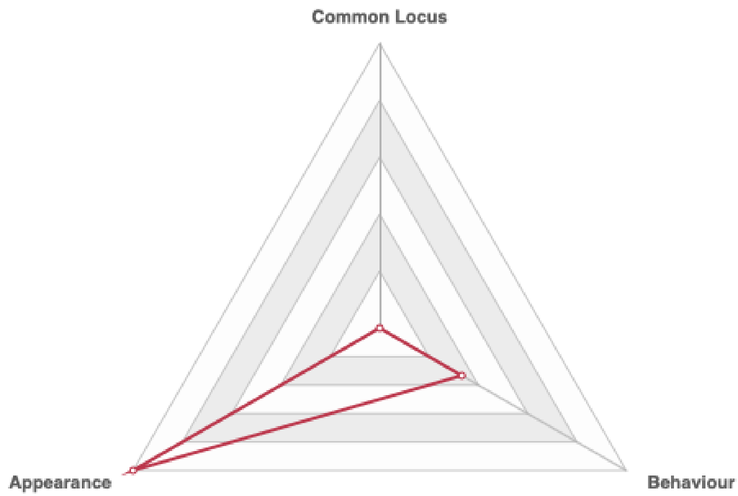


**Fig. 4.** A robot that mainly use appearance as a social cue, such as an android clone, plotted on the ABC-framework

### 2.4 Behavior

While the appearance of a robot is considered an important factor in establishing a social interaction with a human, it is generally agreed that realistic behavior or movement is a stronger cue for social interaction than appearance [5]. Behavior is a multi-faceted domain and is discussed here in terms of movement, emotion and language.

Movement can give the impression that it is carried out with intent, is pursuant of goals or the result of some sort of intelligence. The expressive nature of movement to the human observer as a carrier of information has been an important focal point of research in analyzing, designing and implementing behaviors for robots as well as non-anthropomorphic objects. Strong behavioral realism is not necessary needed for an entity to pass the social threshold. Already in 1944, Heider and Simmel showed that humans project intentions on simple geometric shapes that move around a screen [38]. Braitenberg argued that even the simplest movement of small robotic creatures in reaction to their environment can lead to the attribution of complex behavior. Movement towards a location seems indicative of interest and therefore curiosity, while movement away from a source seems to indicate fear or disgust [39]. Lifelike movement also influences the level of empathy a human feels for a robot [40].

Movement has also been a central strategy for imbuing artifacts with robotic life. These artifacts are known under several monikers: Objects with Intent [27], familiar domestic object robots [3], robjects [41], the object-based robot design approach [42] or abstract robotics [28]. These objects differ as to how much they resemble familiar cultural artifacts and to what extent they are functional in re-

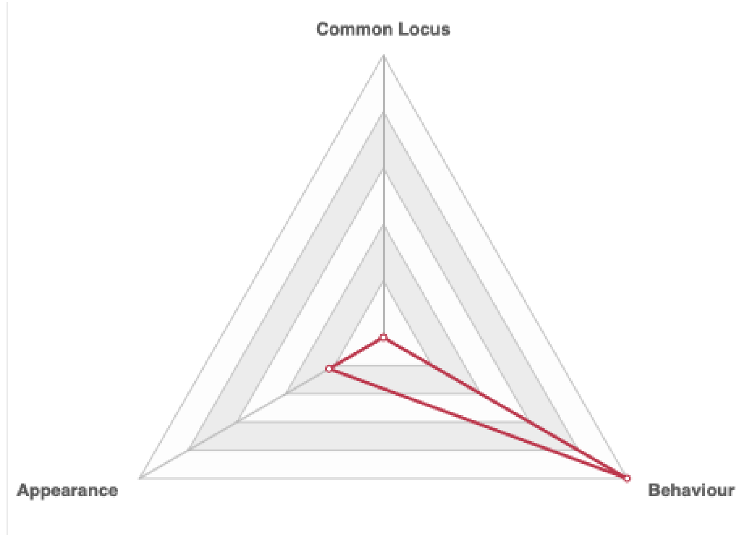


**Fig. 5.** A robot that mainly uses behavior as a social cue, such as The Senster, plotted on the ABC-framework

lation to humans. The appearance of these robotic artifacts exists on a spectrum between common household object and abstract shape. The reactive potential of these non-anthropomorphic robotic artifacts reinforces the possibilities of their apparent behavior [5].

Interestingly, movement does not have to be - for lack of a better word - 'successful' to function as a social cue. Kaplan notes that we tend to start attributing intentions to technology not when it functions as intended, but when those technologies malfunction [43]. For example, 'the washing machine is acting up' or people speaking words of encouragement while trying to start their 'protesting' car. Similarly, fallibility in robots can also facilitate certain attributions. When an AIBO robot dog trips while walking, it is not perceived as malfunctioning but endearing [43]. According to Kaplan, the first wave of artificial pets such as AIBO and Tamagotchi were successful because they were designed on the basis of uselessness as a design principle; as free - not functional - creatures that do not always obey their owners [43].

Artistic projects using robots or robotic artifacts have also deployed movement as a social cue to solicit attributions of curiosity or feelings of empathy. There are plenty of examples of (creative) robots that are perceived as useless, helpless, misbehaving or curious (for an extensive collection of these kinds of robots see [44]). The interactive robotic sculpture Senster, for example, created by artist Edward Ihnatowicz, moved its 'head' towards sources of relative loud sound and low levels of movement which caused exhibition guests to attribute curiosity and a more complex intelligence to Senster than actually programmed [45] (see fig. 5). Another example is Tweenbot, a cardboard robot on wheels, that was able to reach the other side of Central Park in New York while only being able to drive forward. Its destination was written on a flag it carried [46]. The robot would continuously get stuck but passers-by would pick it up and move it in the right direction.

Aside from motion, the ability to communicate emotion is also a strong catalyst for social engagements. A robot mimicking facial expressions strongly influences the level of human empathy [47]. A robot that adapts his mood to the mood of a human, through facial and verbal expressions of a robot head, will also increase a feeling of helpfulness towards that robot [48] Robots that behave emphatically themselves are perceived as friendlier [49,50].

Lastly, the use of spoken or written language has also been a mechanism to establish a social interaction. Robots that need to communicate frequently and clearly for their function, such as robotic assistant in hospitals, often rely on natural language to establish a social interaction [51]. In another study, participants were hesitant to turn off a robot when it begged for its life [16]. In a domestic setting, disembodied chatbots or monolithic home assistants such as Amazon's Alexa rely on spoken language as a social cue. Some creative robotics projects have also utilized language as a social cue. The Beggar Bot used human language to successfully entice people to give money to it - even in the presence of actual human beggars - although they obviously have no use for this [52].

The traditional framework for designing robot sociability can thus be characterized as a spectrum between high or low appearance cues and/or high and low behavioral cues (see fig. 7). In the next section, we will extend this framework with the concept of the common locus (see fig. 6 and 7).

## 3 Common Locus

In this section, we present an extended framework for social robotics. As robots have left the compounds of the factory and laboratory and have entered the domestic, consumer and creative spheres, there is a growing body of examples where humans form a strong bond with - or at least engage socially with - robots that are explicitly machine-like in their appearance and express limited to no behavior. Often these robots have a primary non-social function and a functional design that does not appeal to anthropomorphic realism. However, these robots have emerged as social agents nonetheless.

For example, one study from the University of Washington that researched the interaction between US military Explosive Ordnance Disposal personnel and their bomb disposal robots found that soldiers make rich psychological attribution to these robots and form strong bonds [53]. Interestingly, these robots are not capable of autonomous movement and look distinctly machine-like: often not more then four wheels with an robotic arm and a camera. Nonetheless, soldiers attribute a gender and nickname the robot and show behavior that can be categorized as grief and sadness when one is lost in action [53].

We also find several examples of human bonding with robots that were not designed to solicit a social engagement in non-scientific sources such as media

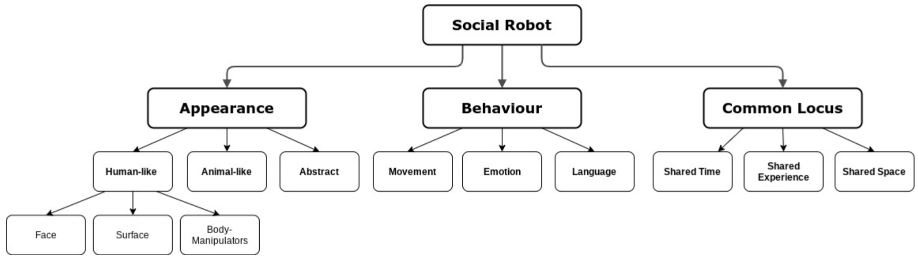


**Fig. 6.** The extended ABC framework of Social Robotics including the Common Locus

articles. A MARCBot, a type of bomb disposal robot which was nicknamed Boomer, was reportedly given a burial and gun salute after exploding on duty [54]. When NASA's Mars Rover Opportunity was discontinued, the crew sent it a farewell song and the press statement reportedly "amounted to a funeral" [55]. A study researching what language was used on social media about Opportunity's discontinuation, found that people "verbally mourn robots similar to living things" [56]. The Canadian Broadcast Company (CBC) reportedly threw a retirement party for their five bulky mail delivery robot colleagues which employees had named and attributed a personality. During the retirement party, employees discussed shared experiences with and memories of the robot, such as one robot blocking the door while a presenter was late for a live-broadcast [57].

The aforementioned robots are explicitly machine-like in their appearance and express limited to no behavior. However, they are situated in highly social environments such as places of work, the home and war zones which allows for frequent human-robot interaction. This indicates that a social setting can be an important factor for non-social robots to emerge as social agents. This paper theorizes that the act of living or working in close proximity or cooperation with a robot for an extended period of time can facilitate an experience of a robot as a social agent, regardless if this robot possess low appearance and low behavioral social cues. We propose an extended framework of robot sociability, that next to appearance and behavior, includes the concept of a common locus, understood as the shared social elements between human and robot: the ABC-framework for robot sociability (Appearance, Behavior, Common locus) (see fig. 6). These three domains provide sufficient conditions for a robot to pass the social threshold to be perceived as a social agent.

The common locus is a term introduced by Nikolaos Mavridis in an interview with Wired journalist Emmet Cole in the context of long-term human-robot interaction [58]. This research field focuses on how people's perception and attitudes towards a robot evolve over time and which design strategies will reinforce a positive long-term relationship [59]. Since maintaining user interest after the novelty effect has worn off is challenging, an important quality for a social robot is therefore the capability for long-term interaction [60].

In this interview, Mavridis hypothesizes that the "concept of "Sharing", and more specifically building and maintaining a metaphorical "Common Locus" ...

forms the backbone of a meaningful and sustainable Human-Robot relation" [58]. Mavridis argues that what unites two friends is all the shared elements between them - a Common Locus - which grows over time. According to Mavridis, this Common Locus is made up of: "shared memories (what they have lived together, and what they have experienced in common), their shared acquaintances and friends (given that we don't live in isolation; but are deeply embedded within our social network), their shared interests and tastes; including also more fundamental shared elements, such as a shared language of communication" [58].

This idea functioned as the basis for Mavridis and colleagues to develop a robot called Sarah the FaceBot that would exploit online published information such as Facebook to create a pool of shared memories and shared friends [61,62]. While interacting with Sarah the Facebot, it would, for example, refer to past events that the human and the robot were both present for or mention that it had seen a common friend the other day.

While the term 'common locus' seemed to be limited to this interview, we believed that the concept aptly described a crucial factor for human-robot bonding and for non-social robots to emerge as social agents. This study provides a more elaborate definition of the common locus. Specifically, we stress the importance of frequent interaction through time and a spatial proximity, both allowing frequent interaction to maintain and strengthen the common locus. We identified three sub-components that would facilitate a common locus, namely 1) a shared space or close proximity for the human-robot interaction to happen, 2) shared time or a repeating opportunity for engagement with the robot through time and 3) a shared life experience which includes specific encounters, events, activities and conversations that a robot and a human are both present for, certain goals that a human and a robot both work towards and interacting with similar social contacts. These three components facilitate the establishment of a common locus between a human and a robot and allows people to have the impression that they have 'shared' memories, social contacts and experiences with the robot, which could potentially lead to the projection of life-like attributions.

The three domains in the ABC-framework are not mutually exclusive. A good example of this is iRobot's Roomba$^{TM}$ - a non-distinct disc-shaped vacuum robot that moves around to clean floors, while avoiding obstacles. When its battery is depleted, it can find its own way back to a charging station. While it's primary function is to clean, studies in long-term human-robot interaction showed that people are eager to personify their vacuum robot Roomba with names and ascribe personal traits to the robot [63] [64] [65]. The Roomba is a good example of a robot becoming a social agent through both its Behavior (movement, collision-avoidance) as a Common Locus (sharing time and a home with a human). This combination can explain why people are so eager to personify their vacuum cleaner and explain the abundance of online video's of Roombas interacting with pets and babies or people modifying and customizing the bot, which in turn, arguably, reinforces the tendency to attribute life-like cues to the Roomba.

The common locus is not just relevant for robots that are non-social by design, but also robots or other robotic artifacts that do aim to solicit social behavior. The success of the hitchBOT project - a robot that hitchhiked across Canada and several European countries by itself - can also be explained from a common locus perspective [9]. HitchBOT was anthropomorphized - a bucket as a body, a LED display as face and swimming pool noodles as arms and legs. It was also not an unsophisticated robot - it had GPS, could hold conversations, move it's arm to emulate a hitch-requesting motion and had an in-built camera that periodically took pictures. [9]. However, we argue that the central reason that people bonded with hitchBOT was not its appearance or behavior but its (digital) presence in the human-inhabited environment, where humans could feel part of its journey. People could follow hitchBOTs adventures and locations online on its social media account, spend time with it in their car, take it on activities and could relate over memories of having hitch-hiked themselves. The fact that people could compare their own activities with hitchBOT with that of others, further fueled, in a self-reinforcing way, the attributions ascribed to hitchBOT and the type of activities humans took it along with. However, hitchBOT seemed more than just a object. It seemed to have a life of its own. When hitchBOT was found beheaded in the streets of Philadelphia, people took to social media to grieve about the 'murder' [66].

One other example is the Tamagotchi - which is not a robot, but a little virtual creature that functions as a digital pet that needs to be 'fed' and given attention and care. It is small and portable, so possible to always carry around, which allows it to be present in the life of an owner: in school, on the bus, at home. An owner also needs to invest time to maintain the well-being of its digital pet. If an owner does not take proper care of a Tamagotchi, the pet will 'die'. This creates a positive feedback loop of user investment [43]. The more time an owner invests in the Tamagotchi, the more it grows and the less the user want to see his pet die. After all, he has spent considerable time in his digital pets well-being, maintaining and strengthening a bond of care. A relationship emerges from this self-reinforcing dynamic [43].

## 4 Methodology

We currently lack a comprehensive understanding of how humans perceive robots outside the laboratory. The aim of this study is to contribute to this understanding by exploring the relevance of the common locus of a robot in passing the social threshold outside the laboratory. In order to study whether a common locus is a sufficient condition for a robot to pass the social threshold, we aimed to design a robotic artifact which would be able to facilitate a common locus, but possessed low life-like realism in appearance or behavior. Referring back to the ABC-framework, we aimed to design a bot low in appearance and behavior, but high in common locus (see fig. 12). The result of this process was the robotic artifact called BlockBot that was designed to solicit behavior through a common locus (see fig. 2, 12 and 13). We elaborate on its design in the section called BlockBot. In this section, we discuss the used methodology.

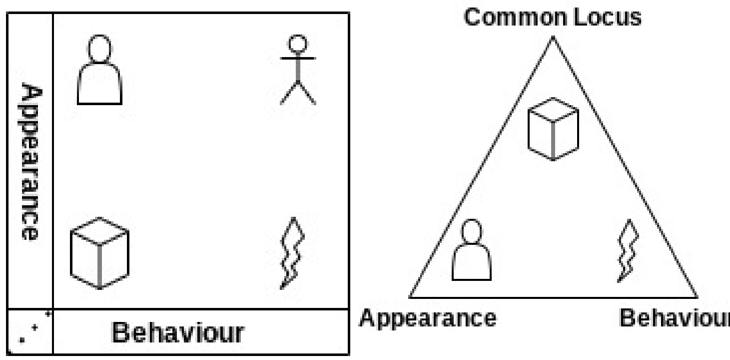


**Fig. 7.** Left: The traditional framework of Social Robotics as a spectrum between high or low appearance-based cues and high or low behavioral cues. Right: the extended ABC-framework

Jung and Hinds note that research on human-robot interaction has been "dominated by laboratory studies, largely examining a single human interacting with a single robot" [10]. This has led to a large body of scientific research on which technical mechanisms affect human-robot interactions. However, there is a disconnect between these studies and the socially complex environments robots are aimed to be - and exceedingly are - placed in [10]. Laboratory studies do not "provide insights into the aspects of human-robot interaction that emerge in the less structured real-world social settings in which they are meant to function" [4]. Controlled laboratory studies offer helpful insights, but would benefit from being supplemented with studies on human-robot interaction in the proverbial wild [4]. Robot field studies have, for example, focused on how humans react to robots in public spaces that approach them [67], listen to them [68], greet them in hotel lobbies [69] or give tours in museums [70]. Creative robotics projects such as hitchBOT [9] or the BeggarBot [52] have also employed an 'in-the-field' approach to have people interact with relevant human-robot interaction topics - such as trust between humans and robots in a natural setting. Giusti and Marti note that social robotics is "an extraordinary opportunity to design technologies with open-ended possibilities for interaction and engagement with humans" [71]. Citing William Gaver, they argue that systems that are designed to be open-ended can lead to "an intrinsically motivated and personally defined form of engagement", instead of an "experience to be passively consumed" [71]. In an interview, the creators of hitchBOT mention that the overall result from their experiment led them to theorize: "that robotic technologies that afford creative shaping by their users are more likely to become socially integrated" [72].

Following these proposals, we conceived of a robotic artifact with a minimal design and an ambiguous, open-ended functionality that would allow participants to actively and creatively shape its social role: the BlockBot. In order for BlockBot to be able to establish a common locus, we aimed to release it on a journey outside the laboratory and into the world, where it would be able to exist in domestic settings outside our supervision or control. In this study, the BlockBots are presented as autonomous creatures that want to meet people and travel the world as inspired by the hitchBOT. This narrative mainly allows the BlockBot to facilitate a common locus with people by being hosted in their homes. It also functions to keep the BlockBot moving to new participants in order to increase data collection.

Qualitative data is gathered through Whatsapp communication. Participants can send their thoughts, feelings and activities with the BlockBot to a phone number on the back of the box. This qualitative data will be analyzed based on how participants engage with the robotic artifact and how they make sense of it. We expect that people will be prone to socially engage with the BlockBot and observe behavior that is indicative of anthropomorphism such as ascribing mind and agency attributions to the BlockBot.

Our unsupervised approach ensures a naturalistic engagement of people with the BlockBot that is as close as to how they would interact with other robotic technologies in a domestic setting. The trade-off is that a controlled research environment would have provided the ability to single out certain factors. We expand on this in the Discussion section.

As stated earlier, since we were curious about the types of engagements we could expect from participants towards this ambiguous object in an early stage of the design process, we conducted a preliminary study that used a cardboard box with a face called the TouristBox to identify some of the codes that we could expect to pick up in the BlockBot data. We elaborate on this preliminary study in the next section.

## 5 Preliminary Study

During the design process of the BlockBot, we conducted a preliminary, open-ended experiment called TouristBox to gather initial insights on how humans interact with an artificial creature that appealed to a common locus. The TouristBoxes were low-cost impromptu creatures that were made out of small cardboard boxes that were left out in public on the Dutch island of Schiermonnikoog, a popular holiday destination (see fig. 8). The TouristBox had cardboard strips as limbs and a smiley drawn with a marker as a face. Its cardboard box body was weighed down by sand to make him resilient against the wind. We assumed that the weight would also help sell it as an entity rather than a empty cardboard box. The design of its appearance was meant to be nonthreatening and to invite for closer inspection. Most importantly, TouristBox held a sign that said (original in Dutch): "I want to see the island. Are you taking me along? Let my parents know how I am doing at: [phone number]".

This establishes TouristBox as an open-ended object, up for any activity, and as an ambiguous object, towards which people have to take an active role in shaping its engagements. We expected that this would also lower the bar for people to integrate the TouristBox into their own (holiday) plans. Secondly,


**Fig. 8.** TouristBox 1 and TouristBox 2

it directly addresses people who read its message: it wants to see the island with you. Both these points aim to establishes a common locus between the TouristBox and the participant.

All the data was retrieved through WhatsApp communication with participants. We deliberately chose not to give TouristBox a social media account, in order to ensure that each engagement with the box was as natural as possible. We theorized that if participants knew about the TouristBox engagement history - where it had been, with who and what it had done - that this could potentially influence their own subsequent engagements.

In total three TouristBoxes were constructed and left on the Dutch island Schiermonnikoog. The location was chosen because of its small size - the box would stay within a manageable playing field (or so we thought) - high number of passing people who would likely identify with the box's goals. We theorized that these conditions would ensure quick results. A third TouristBox was destroyed in the rain an hour after deployment. After we had repaired it and deployed it again, it disappeared without any notification. Therefore our results will focus solely on the responses gathered from the first two TouristBoxes.

This preliminary study was valuable in several ways. From an aesthetic standpoint, it informed us which elements of the BlockBot to change. Specifically, it gave us opportunity to reflect on its human-like appearance and the need to minimize this in a final version of the BlockBot (see fig. 9). From a methodological perspective, this preliminary study showed us that participants were quite willing to host an object that they found in public space, pass it on and communicate about their experiences with it. We were pleasantly surprised by the amount of images and messages the cardboard box managed to generate which provided us with the confidence to move forward with the chosen methodology

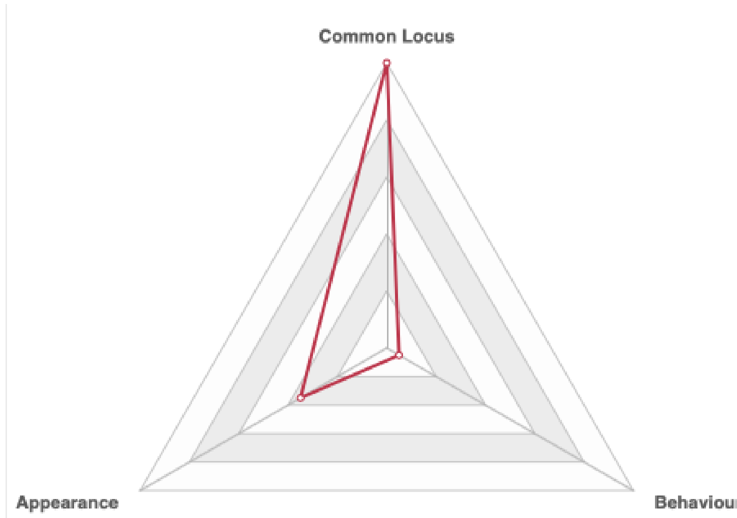


**Fig. 9.** Design for the TouristBox: high common locus, medium appearance, low to no behaviour.

(see fig. 10 and 11). It also provided us a certain set of expectations for possible attributions that participants in the BlockBot study might make during its deployment.

### 5.1 Results

The first TouristBox was employed on 16th of June 2020. We have received notifications up until the 2nd of July. The second was deployed on the 17th of June. We have received notifications up until the 30th of June. Communication lasted in both instances for about two weeks. Last known, the first TouristBox now lives in a small village called Koedijk in the Dutch province of North-Holland, about 132 kilometers linear distance from its starting point. It was picked up by a couple that took it home with them from their holiday and interacted with it for two weeks. The second TouristBox interacted with at least six different participants groups (couples, families, friend groups) and was last seen in a bar on the island. When people pass the box on, they tend to leave the box at a touristic site or at another public space, such as the center of town.

While the quantity of interaction data differs greatly between the boxes, similar social engagements were observed. We identified five distinct action groups that the TouristBox is doing in the received pictures and six attribution types that are ascribed to the box in messages (see table 1 and table 2).

Attributions were identified in the following way: if a participant noted that the box was in good shape, doing well or was repaired this would be an attribution of well-being. Messages that referred to the box with a name or with an article that revealed gender (he, she, him, her) that would count as attributing it a name or gender. If a participant made a specific reference to the box and a certain emotion, this would count as a state of mind, for example, characterizing the box as afraid of rain. References to the box 'wanting', ' preferring' or 'liking' something was a sign of attributing intention. Finally, stating the box was a friend, was friendly or was making friends would be noted as attributing friendship.

| TouristBox 1 | Amount of pictures | Amount of messages |
|---|---|---|
| Participant 1 | 28 | 25 |

**Table 1.** Available data for the TouristBox 1

| TouristBox 2 | Amount of pictures | Amount of messages |
|---|---|---|
| Participant 1 | 3 | 5 |
| Participant 2 | 0 | 5 |
| Participant 3 | 2 | 2 |
| Participant 4 | 2 | 1 |
| Participant 5 | 1 | 1 |
| Participant 6 | 1 | 0 |
| Average | 1.5 | 2.3 |
| Total | 9 | 14 |

**Table 2.** Available data for the TouristBox 2

| What do the boxes do in received pictures? | Total pictures: 36 | Percentage |
|---|---|---|
| The box is at a touristic site | 9 | 25 |
| The box is resting or waiting | 8 | 22.2 |
| The box is eating, drinking or smoking | 7 | 19.4 |
| The box is being social (makes friends, is held, goes out) | 7 | 19.4 |
| The box is traveling | 5 | 13.8 |

**Table 3.** Activity data for the TouristBox 1 and 2

An interesting observation about how people communicate about the TouristBox is that messages about the box are often written from the first perspective. In these communications, participants do not write on behalf of the box, but embody the box while writing. For example: "I am going out biking later". While not specifically requested, the majority of responses focus on reporting the location of and shared activity with the box next to reporting its physical well-being and possible emotional states. We replied with simple messages assuming the role of caring parents, but made sure only to copy attributions after participants

| What is attributed to the box in messages? | Total participants: 7 | Percentage |
|---|---|---|
| Well-being | 6 | 85.7 |
| State of Mind | 5 | 71.4 |
| Gender | 4 | 57 |
| Name | 4 | 57 |
| Intentions | 2 | 28.6 |
| Friendship | 2 | 28.6 |

**Table 4.** Attribution data for the TouristBox 1 and 2

had made them. For example, we always referred to the box as an 'it' unless participants wrote about it with a specific name and gender. The majority of the messages about the TouristBox focus on its presence at touristic sites on the island and other typical leisure holiday experiences such as time at the beach, biking around, spending time on a terrace, looking at views or camping. A prominent element in the holiday experience of the box is consumption such as having breakfast, having coffee, having a beer or ordering pizza. One participant also let the box smoke and drink Bacardi.

Almost all participants report on the well-being of the box and over half attribute a gender or a personality in written messages. The box has been called Leopold, Marion Karton or Rombie. Over seventy percent of participants ascribe a state of mind to the box: emotions such as content, doubt, preference, excitement, fear, hope, loneliness and appreciation when it finds a spot to stay over. One participant was so attached to the bot, she took it home, ascribing it a desire to see the world, instead of just the island as its sign mentioned. One morning, four days after deployment, we received an emotional message from TouristBox 1 saying that it loved us a lot, but wanted (even needed) to see the world and that it was leaving the island. The participant would send regular updates of the bot in front of a screen showing a location to advance its narrative and even built it a cardboard girlfriend called Annabelle. The narrative took a distinct turn after leaving the island. The box starting drinking, smoking and going out. Its cardboard girlfriend Annabelle set it up for a job and they moved in together into her squatters apartment. In its last message, it was on a yacht in the Caribbean bringing back a package for a certain Boris.

### 5.2 Discussion

This preliminary study has provided a valuable initial expectation of what actions and attributions we can expect from participants. The TouristBox solicited some very interesting engagement. It was saved from the rain, fed, touched and patched up. People showed to be quite willing to pick up a box from the street with a sign. They take it along on their holiday, take photos of it at several locations, are engaged in several activities and write about its well-being, state of mind and its location. The inanimate, anthropomorphized cardboard box managed to see the island, meet people and survive out in the wild for at least two

**Fig. 10.** Visual results from TouristBox 1

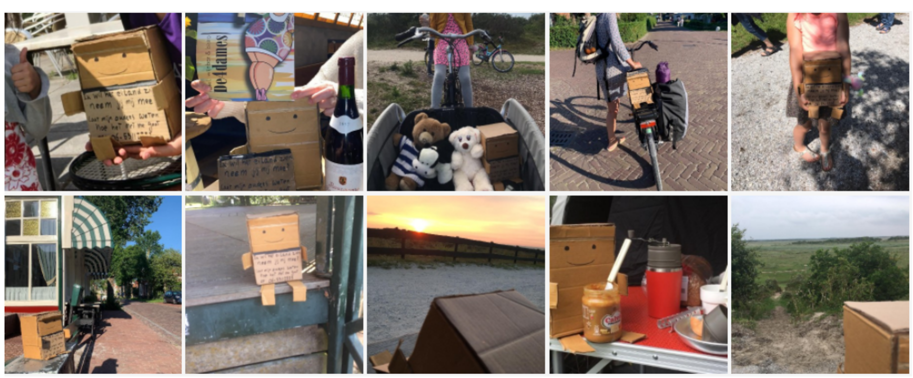

**Fig. 11.** Visual results TouristBox 2

weeks. Participants seemed to shape the social role mainly as a fellow traveler that joined their holiday for a while before letting the box go its own way again.

Since this preliminary study was only aimed at our own design process, we refrain from making general claims about the limited data. While the low sample size make any results inconclusive, we do observe that most participants communicate about the box as if it were a social agent, which indicates that it did pass a social threshold. We argue that the established common locus was an important factor in this. It would be unlikely that people would take the TouristBox along without its request on its sign. Subsequently, by being present in close proximity on a participants holiday, the box potentially evokes a sensation of a shared holiday experience and memories, which can enable a participant to experience the presence of the box as that of a social agent. However, the human-like features of the TouristBox, such as limbs, torso and face, may have had a considerable impact on these attributions as well. The question arises as to what extent we can attribute the box passing a social threshold to its common locus, its appearance or a combination of these factors. Consequently, in the final BlockBot design we removed much of these realistic appearance qualities.

A final aspect that is noteworthy, is the fact that the creators of the TouristBox also showed behavior that was indicative of attachment. We called the first TouristBox Sjors and the second one Fat Sjors, due to its larger size. We would feel worried when we had not heard from a box for a while, feel relieved and happy when we received news and even biked to a box's last known location to see if it was picked up. Since its location was not known to us at all times, it was exciting to suddenly spot the box in the center of town or in the arms of a small child. There was a feeling of responsibility and worry. Potentially, it's fragile cardboard composition and the threat of destruction by the elements contributed to this experience of responsibility of a cardboard box that we had left on the streets.

## 6 BlockBot

In this section, we elaborate on the design and technical aspects of the BlockBot: an abstract cube-like ambiguous robotic artifact that displays low realism in appearance and behavior, which can easily be integrated in a socially complex environment. After, we discuss how we deployed the BlockBot for our in-the-field experiment. Finally we present the results that the BlockBots generated and notable differences between the TouristBox and the BlockBot.

### 6.1 Design

There were several considerations that went into the design of the BlockBot (see fig. 13 and 14) First, the design of the BlockBot aimed to minimize anthropomorphic or zoomorphic appearance and as well as its life-like behavior in order to explore the relevance of the common locus in relation to a robot passing the social threshold. Secondly, the BlockBot needed to evoke robot-like connotations.

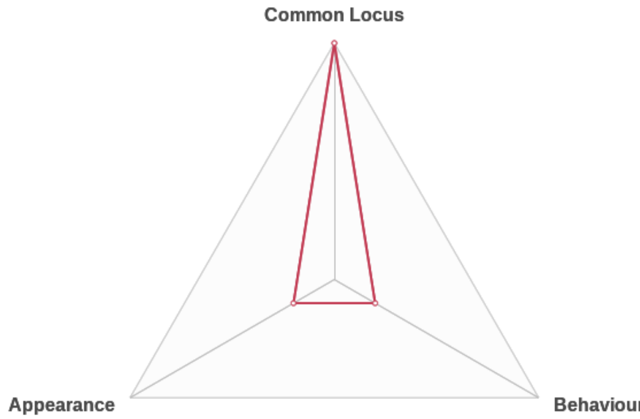


**Fig. 12.** The design aim for BlockBot plotted in the ABC-framework

Thirdly, the BlockBot needed to have a size that would be convenient to keep in proximity of participants and would be easy to pass on from one participant to the other. Finally, the BlockBot needed to be durable and chargeable since it would be deployed unsupervised into human-inhabited environments.

The results of the TouristBox informed the design of the BlockBot in several ways. For example, the design of the TouristBox potentially leaned too heavy towards a human-like appearance. The TouristBox's appearance still incorporated humanoid aspects such as limbs, upright posture and a face located at the top of the creature. Hence, the BlockBots design was considerably more abstract and removed several of the appearance-based social cues that were present in the TouristBox. For example, BlockBot has no limbs so it does not appear to be sitting or holding anything. It's face sits in the center of its body, instead of at the top, as was the case with the TouristBox. The proportions of its body are also less rectangular and more cubical. All these choices were made to provide the BlockBot with little anthropomorphic or zoomorphic qualities and have its appearance evoke more artificial, robotic connotations. The charging cable and the sleek monotonous color also added to its artificial look, comparable to a monolithic home assistant. The results of the TouristBox experiment also helped us make several changes to the BlockBot deployment. We elaborate on this in section 6.3 (Deployment).

Our design aim was to minimize the anthropomorphic appearance or behavioral realism of the BlockBot to the bare minimum, not to remove it completely (see fig. 12). Hence, we decided to keep the simple face as part of the design of the BlockBot, providing us with an element that provided both a minimal sense of realism of appearance and behavior. Changing the face to a sleeping face at night imbued the BlockBot with a minimal notion of behavior. We did not add any other emotions aside from the smile to curb any further realism in the BlockBots appearance and behavior. The sleeping face was also meant initially to function as a reminder to charge the BlockBot prototype for the night. However, second generation BlockBots did not need to be charged. In section 7 (Discussion), we discuss the possibility that the face impacted the results of this study and suggest to display different shapes - or nothing at all - instead of the BlockBots face in future studies.

The exterior of the BlockBot was a cube of 12x12 cm (4,7 x 4,7 inch). The BlockBot's size allowed for enough space for the display and Arduino Uno micro-controller board inside the bot and was small enough for people to easily transport. There is a hole in the front of the cube through which the display is visible. The display is sunken into the bot in order to prevent the likelihood of it getting damaged. On the back of the cube there was an USB-cable running out of the cube. A small plastic plaque was attached on the back - in order to not get separated from the BlockBot - which read in English: "I want to travel and see the world. Can I stay at your place for a bit? Please hand me to a friend afterwards! You can charge me using my tail. Let my parents know how I am doing and where I am at: [phone number]". The message establishes the BlockBot as an ambiguous robotic artifact that aims to built a common locus between the BlockBot and a (potential) participant. We chose to write the message in English to allow a wider possible demographic to interact with it.

As with the TouristBox, we deliberately chose not to give BlockBot a social media account or a similar insight for participants to its social history - where it had been, with who and what it had done - in order to ensure that each interaction with the BlockBot was as natural as possible and not informed by previous encounters. Qualitative data was gathered through messages and pictures received from participants.

Through the above-mentioned design choices, we aimed to design a robotic artifact that would facilitate a common locus, possessed low life-like realism in appearance and in behavior and would be durable during a long-term, unsupervised, in-the-field experiment.

### 6.2 Technical

BlockBot was designed to be durable and able to operate for long-term in the field. The BlockBot prototype is made out of medium-density fiberboard (commonly known as MDF) which has been processed with water resistant polish (see fig. 13). The display is a Waveshare 2.7 inch e-ink, which is operated by an Arduino Uno micro-controller board. The protoype's code works in the following manner: due to the library used, every two seconds, the Arduino wakes up from sleep, checks the time, changes the BlockBot's display accordingly and re-enters sleep. Every day a new random 'schedule' is generated within predetermined constraints. BlockBot goes to sleep between 23:00 and midnight. Wakes up between 8:30 and 10:30 and changes from its sleep face to a smile face. Power is regulated through an AdaFruit Powerboost 500 which pushes the 3.7V that is supplied by the lithium-ion battery to the Arduino's requested 5V. The Powerboost 500 also allows for simultaneous charging - which charges the battery and

**Fig. 13.** BlockBot Prototype in the field

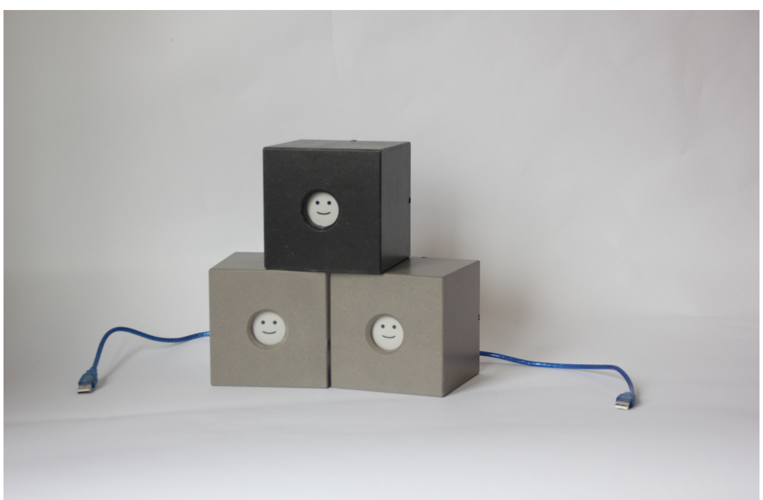

**Fig. 14.** Second generation BlockBots

powers the device - when the USB cable which exits BlockBot's back is plugged into a standard 5V adapter. With its current battery, the prototype BlockBot could stay powered for a day. This short operation time was solved in the second generation of BlockBots. Regardless, even if the power fails, the e-ink display will retain the image it's projecting indefinitely. With regards to participant privacy, no other sensors such as a microphone, GPS or touch sensors were added to the BlockBot.

After the deployment of the BlockBot prototype, three new 'second-generation' BlockBots were designed, constructed and deployed to gather more data and to adress some of the technical problems of the BlockBot prototype (see fig. 14). The technical aspects of the BlockBot were stripped down to make it cheaper, more durable and programmable while assembled. The lithium-ion battery and AdaFruit PowerBoost 500 were removed and a Robotdyne RTC (real-time clock) with a three year battery life was added to keep track of time. The USB charging cable now lead directly into the BlockBot. When the BlockBot is connected to power, it checks the independently powered clock to check which face to display. After 6:30, it wakes up. After 22:00, it goes to sleep. When the BlockBot is not attached to power, the e-paper display retains the image. This approach has several benefits. Firstly, this means the BlockBot will never be out of power and does not need to go in sleep mode, since it operates mostly without any battery. Secondly, this also makes the BlockBot safer, since the PowerBooster can get quite hot, and cheaper, since the RTC is signifanctly cheaper compared to a LiPo-battery with a Powerbooster. Finally, this allows for new code to be uploaded on the BlockBots while assembled, making its capacity as a research platform more versatile. On the downside, the BlockBot will not switch face unless it's plugged into power. However, the deployment narrative that it should be charged at night could potentially solve this problem.

### 6.3 Deployment

Three BlockBots were deployed in Amsterdam, The Netherlands. To break this pattern, a fourth was released in Nijmegen, a city at the other side of The Netherlands, close to the border with Germany. Except for the prototype, the three second-generation BlockBots are currently 'in the field'. The initial seed participants were selected from the author's own social circle and differed in the social make-up of their domestic setting: young family, a couple living together, a student and a self-employed person with roommates. All initial seed participants were within a 22 to 32 age range. The demographic of participants would be outside our control after the initial seed participants had passed the BlockBot onto a new participant of their choice.

To ensure that the initial participants were not biased in their engagements with the BlockBot, they were told limited details about the goal of the study. The initial participants were aware that the BlockBots were part of a study on human-robot interaction in human-inhabited environments, but were not instructed on the specific aim of this study such as its research question or hypothesis.

Neither were participants specifically encouraged to name the BlockBot or make attributions of agency or mind. The initial participants were simply instructed to host the BlockBot for a period of their own choosing, encouraged to send an update on the BlockBot via the number on the back of the box in whatever form they chose and to pass the BlockBot to another host that they would feel would pass it on themselves as well. To subdue concerns considering the BlockBot infringing on participants privacy, the initial participants were informed to a degree on the BlockBot's inner workings, such as the fact that it did not have any sensors and did not store any data. Participants were also told they did not have to worry for the BlockBot's battery to run out but were encouraged to charge it occasionally. It was emphasized that the initial participants could do whatever they liked with the BlockBot short from destroying it. Concerning passing on the BlockBot, the initial participants were requested to not mention that the BlockBot is part of a study or project, but that it had been traveling for a while before them already. This would ensure - as far as possible - that the next series of participants interaction was as natural as possible and as uninformed about the BlockBot as possible. We observe no apparent differences in the data gathered from the initial seed participants or the participants after that could implicate that the initial participants were biased in their engagements.

The BlockBot prototype was deployed on Monday 13th of July. After communication of the BlockBot prototype went silent, we constructed three second generation BlockBots in order to start generating more data and update the technical problems of the BlockBot prototype. These three new BlockBots were deployed on Wednesday the 19th of August. On the 25th of August, we heard back from the BlockBot prototype whose host had been out of the country for a month and had failed to pass it on before. Since they reported that it was broken, we retrieved the BlockBot prototype for repairs. As of the 5st of October, the second-generation BlockBots are still in the field.

Two important differences in the deployment methodology between the TouristBox and the BlockBot must be noted. First, while the TouristBox was specifically aimed at tourists visiting a holiday destination, the BlockBot has no specific target demographic. Being on holiday, generally frees up a person's time considerably to potentially spend taking along a cardboard box creature, which might influence results. Hence, we wanted the BlockBot to appeal to no specific demographic.

Secondly, while the TouristBox was left out in the open, where people would be able to run into it and subsequently leave it, the BlockBot was intended to be passed on between people. This was done to ensure that the BlockBot would get the chance to interact with people. Since the BlockBot was considerably more costly to produce, we thought it would be a shame if the bot would get lost or destroyed by people or the elements before it could generate any data. Because of its non-descriptive look, we were also slightly worried about a potential bomb scare if it would be left unattended in a crowded public space or a major transport hub such as a train station or airport. While the aforementioned hitchBOT and Tweenbot project showed that robots can safely exist in the world with the help of people, deploying the BlockBot in the public space remains an act for a future study. However, this decision means that participants in the BlockBot experiment need to adopt a more active role in finding the next participant, compared to the TouristBox which participants could just leave somewhere in the public space. For the BlockBot, this heightens the bar for audience participation since passing the bot on requires a more active approach. This leads us to predict that the BlockBot will 'travel' slower between participants. On the other hand, there will be less danger of the bot being destroyed or lost between two participants.

### 6.4 Results

In this section, we present the results of our experiment (see tables 3-6 for the results and the appendix for examples of photographic data). As mentioned in the previous section, a total of four BlockBots have been deployed in a domestic setting. Currently, the BlockBot prototype has been retrieved, while the three others are still out in the world living with people. The currently deployed BlockBots ended up in quite different locations. The first BlockBot was not moved from its starting location at all, the second one still roams in the vicinity of Amsterdam, while the third traveled through Belgium and is currently back in the Netherlands. One BlockBot has even been affected by the COVID-19 pandemic and has been stuck in quarantine for ten days due to one of its host's roommates testing positive for the coronavirus. Reportedly, the BlockBot did not show any symptoms. It has since been passed to a new host who has not reported any symptoms either.

The open-ended nature of this study allows for indefinite gathering of data, since there is no clear end goal to the BlockBot's journey. The BlockBot prototype was deployed for six weeks from 13-07-20 until the 26-08-20. The second generation of BlockBots were deployed in the field on 18-08-20 and are still currently deployed. For practical reasons, we have decided to make the cut-off point the 1st of October for all data that will be analyzed in this study. This period has been selected for the sake of completeness and reflects all the data we have from the moment of deployment until the completion of this paper. In other words, the period is an arbitrary time period dictated by practical constraints but nevertheless incorporates all the available data up until the 1st of October. Data that arrived after this date has not been included in this study. See table 3 for the total number of participants, received messages and photos.

The received results show that participants are disposed to communicate about the BlockBot. On average, participants send slightly more pictures than messages concerning the BlockBot. We observe differences between participants in the frequency and quality of communication. While some participants only send a few messages and photos or just a series of minute long videos, others share detailed page-long reports on how they experience the BlockBot's presence and how this changes over time. Since participants are not instructed to communicate about their engagement with the BlockBot in any particular manner,

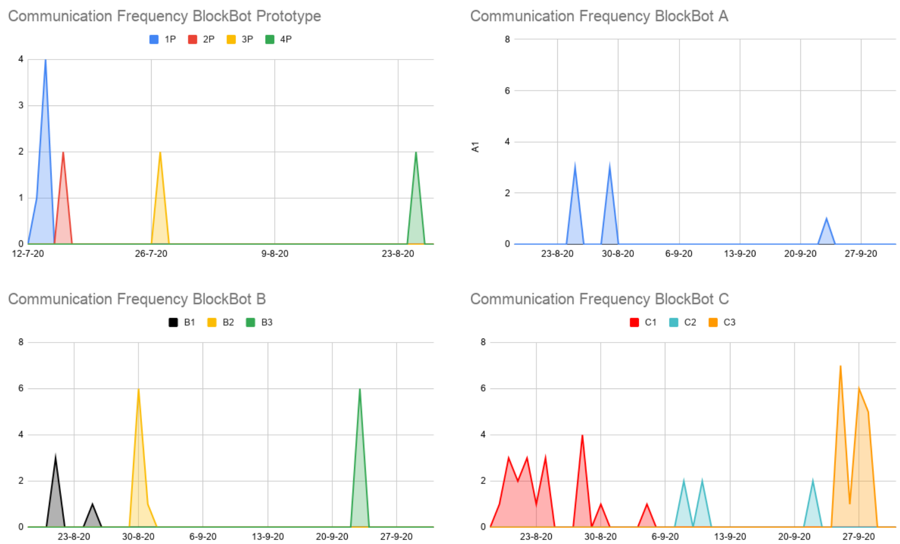


**Fig. 15.** Communication Frequency and Quantity BlockBots. The Y-axis denotes the number of combined messages and images send by a participant. The X-axis denotes time of deployment.

we suspect this difference is due to personal choice and preference of the participants. One observation that we can make is that participants seem to be disposed to communicate with a decreasing frequency and quantity (see fig. 16). Often participants send one or two messages with photos after which either the frequency and quantity drops or they pass it along. Even with participants that are highly frequent communicators, we note a decline in the frequency and quantity of communication over time. We discuss this further in section 7 (Discussion).

Through a textual analysis of the received qualitative data, which exists of messages, photos and videos, we gain a sense of how participants engage with the BlockBot. We discuss our data along three lines. First, to what extent does the BlockBot manage to establish a common locus with their host. In other words, is the BlockBot actually in proximity to the daily lives of the people that host it? Secondly, what do people report about the BlockBot and their experiences with it? Specifically, we discuss this along three domains that we identified in the available data: identity attributions, mind attributions and agency attributions. A general rule from the available data seems to be that identity attributions precede mind and agency attributions. This was the case for all participants, except for one, who was the only one to communicated in the first person about the BlockBot. Finally, what differences can we observe between the results of the TouristBox and the BlockBot?

**Common Locus** The BlockBot appears to successfully establish a common locus. Participants keep the BlockBot in their proximity until they pass it along to another host. Participants uniformly keep the bot in their homes, most often their living room and sometimes bedroom. From the received messages and pictures, we can observe that participants move the BlockBot around the house and take it, for example, to a balcony to sit in the sun, to a study to be present while studying or to bed with them.

Participants also often physically move the BlockBot along with them to maintain a common locus outside the domestic setting. For example, one participant received the BlockBot in one city where she hosted it for a couple days and later moved it along with herself to another city. After several weeks, she then moved it back to the original city, where she passed it on. Another participant took it on a trip to a farm in Belgium, back via several Dutch cities and on several trips since. To name a few other examples, the BlockBot has joined participants to a construction job, a university robotics laboratory, a barbecue in the park and a walk in the woods. Extra-domestic activities are reported by around half of the total participants (see table 4).

These examples showcase that the BlockBot solicits in some participants an active engagement in maintaining a common locus by keeping it in close proximity inside and outside a domestic setting and a tendency in participants to turn experiences or activities into joint experiences or activities. This shows that participants are motivated to build a common locus by placing it in the home, spending time with it and including it in activities. It also shows that participants aim to maintain and strengthen the common locus with the BlockBot once established up to a certain point.

**Attributions of identity** What do people attribute on the BlockBot? The received messages show that the vast majority of participants refer to the BlockBot with a gendered article (he/she). Only one participant refers to it as ‘it’, the other communicates in the first person and hence refers to the BlockBot as ’I’. The bot has largely been attributed a male gender. The vast majority of participants also give the BlockBot a name. Some names clearly refer to an assigned gender, such as Brenda and Jules, while others reflect more on the robotic nature of the BlockBot, for example, Boxxie, Robbie and Botje (Dutch for ‘little Bot’). In most cases, attributing an identity to the BlockBot, such as gender and/or giving the bot a name, seems to precede mind attributions (state of mind, preferences, intentions) and agency attributions.

**Mind attribution** Participants often refer in their messages to certain qualities of mind that they attribute to the BlockBot (see table 6). When attributed a state of mind, the BlockBot is ascribed a positive state of mind: happy. This is perhaps unsurprising since its display depicts a smiling face. However, participants of the TouristBox - which had a very similar expression - did make more varied state of mind attributions such as feelings of fear and hope, which do not directly relate to the smiling face of the TouristBox. Perhaps, this is because the BlockBot is almost always positioned in a safe domestic environment where it is not exposed to any danger that might make it feel anything but happy in the eyes of participants. Another explanation could be that it is a result of the reduced realism of appearance of the BlockBot.

Participants also make other mind attributions. One participant, that had taken the BlockBot to a farm, referred to the BlockBot as gaining experience and growing up, implying a certain ability to learn and to mature. The BlockBot has also been attributed certain preferences, such as sitting in the sun on the balcony, sitting with the plants or observing people in the living room.

One participant wrote that the "adventurous" BlockBot hopes to leave town soon. This could be marked as an attribution of intent, but could be influenced by the BlockBot's deployment narrative that states that it wants to see the world. We discuss the effect of the deployment narrative on mind attributions further in the discussion section.

**Agency attributions** We observe in the results that participants also ascribe agency to the BlockBot. The ability to see, for example, is an often made agency attribution. The BlockBot is described as liking to observe people in the living room and to have seen three different cities. The face on BlockBots display most likely contributes to this attribution, as well as the expectation that robots can 'see'. This is also stated in the deployment narrative: the BlockBot wants to 'see' the world. We discuss this further in the Discussion section.

Another ability that has been ascribed to BlockBot is the ability to make friends. The friends of BlockBot so far include either animals, or toys and statues with an animal likeness: a cat, a stuffed animal, a statue and a pig. One participant referred to a BlockBot and a cat as 'buddies', another to the BlockBot and a pig as 'friends'. These attributions also give us an indication what kind of entities participants associate with the BlockBot; what they consider objects or entities in a similar ontological category (see table 5). We expand on this in the Discussion section.

A final interesting observation is that some participants do not mention that they take the BlockBot to places or put him in certain location. Instead, they use a more active but ambiguous wording, as if the BlockBot is able to move independently. For example: "Jules has seen three different cities", "He likes to sit with the plants watching the room" or "he has been to the forest with us and we have played a game together".

**Differences** While we have already mentioned some differences in the results between the BlockBot and the TouristBox throughout some of the previous paragraphs, here we discuss some other notable ones that don't fit in those categories.

The first notable difference with participant communication about the BlockBot is the fact that only one of the participants communicate in the first person perspective; performing as if they are the BlockBot. This is a tendency that

| Participant ID | Amount of pictures | Amount of messages | Amount of videos |
|---|---|---|---|
| P1 | 5 | 1 | 0 |
| P2 | 1 | 2 | 0 |
| P3 | 1 | 1 | 0 |
| P4 | 0 | 1 | 0 |
| A1 | 3 | 4 | 1 |
| B1 | 2 | 2 | 0 |
| B2 | 3 | 3 | 0 |
| B3 | 3 | 2 | 0 |
| B4 | 1 | 1 | 0 |
| B5 | 1 | 1 | 0 |
| C1 | 5 | 10 | 1 |
| C2 | 0 | 1 | 3 |
| C3 | 13 | 10 | 0 |
| C4 | 1 | 0 | 0 |
| Total | 39 | 39 | 5 |
| Average | 2.8 | 2.8 | 0.36 |

**Table 5.** Combined total data received for all the BlockBots.

we often observe in people's communication with the TouristBox, but is almost completely absent from BlockBot communication. So far, participants in the BlockBot experiment write almost exclusively about the BlockBot in the third person, referring to it as he, she or the (ro)bot.

Communicating in the first person seems related to an increase in the quantity of pictures and messages, an effect that we also observed in the TouristBox. First person communicators seem highly engaged with the BlockBot, taking it to several locations, sharing a high number of messages and photos with a range of different people, animals and sites. The only BlockBot participant who photographed the BlockBot together with food or drinks was the participant that communicated in the first person perspective.

Secondly, the BlockBot is always faced with the display towards the camera. It has never been portrayed with the display facing away from the camera. This is a pose we would often see with the TouristBox, often accompanied with a message that it was 'watching' a view. There seems to be a general tendency among participants to keep the BlockBot 'upright' and facing the front to the camera, never on its head or face-down. The exception is a video we received of a participant handing the BlockBot to his toddler to play with. After briefly inspecting the BlockBot, the toddler seems mainly interested in playing with its charging cable, holding it up from the cable.

Finally, the BlockBot is never positioned in such a manner as to which it would appear it was engaged in a specific activity, the exception being one photo in which the BlockBot is photographed sleeping in a bed. The TouristBox would often be photographed 'engaged' in eating, holding a drink or 'watching' the view. The photographs of the BlockBot generally indicate either where it is and/or who it is with. Accordingly, BlockBot has been photographed and filmed

| ID | Keep in home | Take outside | Take on activity | Put on bed | Play | Travel | Study |
|---|---|---|---|---|---|---|---|
| P1 | X | X | X | X | - | X | - |
| P2 | X | X | X | - | - | X | X |
| P3 | X | X | - | - | - | - | - |
| P4 | X | - | - | - | - | - | - |
| A1 | X | - | - | - | X | - | - |
| B1 | X | - | - | - | - | - | - |
| B2 | X | X | - | - | X | - | - |
| B3 | X | - | X | - | X | - | - |
| B4 | X | - | - | - | - | - | - |
| B5 | X | - | - | X | - | - | - |
| C1 | X | X | X | X | - | X | - |
| C2 | X | X | X | X | - | - | X |
| C3 | X | X | X | - | - | X | X |
| C4 | X | - | - | - | - | - | - |
| Total | 14 | 8 | 7 | 4 | 3 | 4 | 3 |

**Table 6.** What do people do with the BlockBot?

in cars, at job sites, farms, at a laboratory, on beds, on balconies, on a tractor, in the grass and with plants, toys, animals and with people.

In conclusion, this paper theorized that the act of living or working in close proximity or cooperation with a robot for an extended period of time can facilitate an experience of a robot as a social agent, regardless if this robot possesses low appearance and low behavioral social cues. The BlockBot was designed with a low realism in appearance or behavior, but able to establish a common locus with its hosts. The results of its deployment show that participants are motivated to engage with the BlockBot, take photos of it and take the time to write about it and communicate about it. The results suggest that the BlockBot successfully establishes a common locus with participants. It is present in the domestic proximity of participants and participants show motivation to keep this common locus intact when they move to a different location in or outside the domestic setting. The data shows that participants almost uniformly refer to the BlockBot as a gendered entity, to which the majority give a name. Over half of the participants also ascribed a mind attribution or an agency attribution to the Blockbot, such as a state of mind, intention, preference or a form of agency such as the ability to observe and make friends. Hence, this data is indicative of the BlockBot passing a social threshold and participants experiencing its presence as that of a social agent.

| ID | Humans | Animals | Plants | Robots & Computers | Toys & Statues | Food | View |
|---|---|---|---|---|---|---|---|
| P1 | - | - | - | - | - | - | X |
| P2 | - | - | - | X | - | - | - |
| P3 | - | - | - | - | - | - | X |
| P4 | - | - | - | - | - | - | - |
| A1 | X | - | - | - | X | - | - |
| B1 | X | X | - | - | - | - | - |
| B2 | - | - | - | - | X | - | - |
| B3 | - | - | X | - | X | - | - |
| B4 | X | - | X | - | - | - | - |
| B5 | X | - | X | - | - | - | - |
| C1 | - | - | X | - | - | - | X |
| C2 | - | - | - | X | - | - | - |
| C3 | X | X | X | X | X | X | X |
| C4 | X | - | - | - | - | - | - |
| Total | 6 | 2 | 3 | 3 | 4 | 1 | 4 |

**Table 7.** What is the BlockBot portrayed with?

| ID | Gender | Name | Emotion | Intentions | Preferences | Agency | Friends |
|---|---|---|---|---|---|---|---|
| P1 | M | - | - | - | - | - | - |
| P2 | F | Brenda | Happy | - | - | - | - |
| P3 | F | Boxxie | Adventurous | Leave town | Sitting in the sun | Travel | - |
| P4 | M | Boxxie | - | - | - | - | - |
| A1 | M | - | - | - | - | - | - |
| B1 | M | Robbie | - | - | Sitting with plants | Observing | Cat |
| B2 | M | Botje | - | - | - | - | Cat doll |
| B3 | - | Botje | - | - | - | Gaming | - |
| B4 | - | - | - | - | - | - | - |
| B5 | M | - | - | - | - | Found a new place | - |
| C1 | M | Jules | Happy | - | - | Sightseeing | - |
| C2 | - | Rust | - | - | - | - | - |
| C3 | M | - | - | - | - | Walk in the Park | Pig |
| C4 | - | - | - | - | - | - | - |
| Total | 8 | 8 | 3 | 1 | 2 | 6 | 3 |

**Table 8.** Attribution data in the messages for the BlockBots.

# 7 Discussion

In this section, we first briefly reiterate our problem statement. We then provide a cross-association analyse of our results, an interpretation of the results and discuss the implications to the field of human-robot interaction 'in the wild'. We also discuss several alternative factors that could explain our data. Finally we discuss the methodological limitations of our approach and discuss opportunities for future studies.

Robots, behavioral objects and robotic artifacts are increasingly entering the less structured, noisy, human-inhabited environments such as homes, offices and public spaces. However, we know little yet about how humans make sense of these new entities in their environment. This study adds to a growing body of work on understanding how people will perceive robots in their social environment by providing an initial exploration of the relevance of the common locus - the experience of sharing a life with a robot - on the experience of a robot as a social agent. This paper theorized that the act of living or working in close proximity or cooperation with a robot for an extended period of time can facilitate an experience of a robot as a social agent, regardless of whether this robot possesses low appearance and low behavioral social cues. To research this hypothesis, we have positioned a minimal robotic artifact called BlockBot in close proximity to people's daily lives where they could engage with the entity in a naturalistic and unsupervised manner and self-report on engagements made with the BlockBot.

## 7.1 Cross-associations

Up until this point, our results section has mainly been 'univariate': discussing each observed variable separately in relation to the hypothesis. In this paragraph, we will discuss possible cross-associations between the variables themselves. Although we are working with a low sample size, possible cross-associations could provide us with interesting insights.

Taking the BlockBot outside could be argued to be an effective way to maintain or build a common locus, since proximity is preserved even outside the domestic setting. It could also signify motivation from a participant to keep the BlockBot close. When we sort our data in two groups, those that do take the BlockBot outside and those that do not, several possible correlations can be observed.

Firstly, almost all the participants that take the BlockBot outside, also take the BlockBot on an activity. This can be argued to be unsurprising, since most activities take place outside the domestic setting. Regardless, it shows that the majority of this group of participants don't simply put the BlockBot on their balcony or in their garden but also take it on activities. Secondly, participants who take the BlockBot outside account for the vast majority of identity, mind and agency attributions. Specifically, they account for all the attributions of emotion and intention, the majority in the category gender, name agency and friends, and half the attributions of preferences. We also find identity, mind and agency attributions in the group of participants that did not take the BlockBot outside, but in a consistent smaller amount than the group that does (see Table 9).

While the sample data is low, these two correlations could suggest a relation between actively maintaining a common locus through close proximity outside the domestic setting and project agency and mind attributions. This would be in line with our hypothesis, since we do observe that more attributions are made by participants that take the BlockBot outside - and preserve a common locus - then those that do not.

| **ID** | **Gender** | **Name** | **Outside** | **Activity** | **Emotion** | **Intentions** | **Preferences** | **Agency** | **Friends** |
|---|---|---|---|---|---|---|---|---|---|
| P1 | M | - | X | X | - | - | - | - | - |
| P2 | F | Brenda | X | X | Happy | - | - | - | - |
| B2 | M | Botje | X | - | - | - | - | - | Cat doll |
| B3 | - | Botje | X | X | - | - | - | Gaming | - |
| C1 | M | Jules | X | X | Happy | - | - | Sightseeing | - |
| C2 | - | Rust | X | X | - | - | - | - | - |
| C3 | - | - | X | X | - | - | - | Walk in the Park | Pig |
| P3 | F | Boxxie | X | - | Adventurous | Leave town | Sitting in the sun | Travel | - |
| P4 | M | Boxxie | - | - | - | - | - | - | - |
| A1 | M | - | - | - | - | - | - | - | - |
| B1 | M | Robbie | - | - | - | - | Sitting with plants | Observing | Cat |
| B4 | - | - | - | - | - | - | - | - | - |
| B5 | - | - | - | - | - | - | - | Found a new place | - |
| C4 | - | - | - | - | - | - | - | - | - |

**Table 9.** Data sorted on participants that take the BlockBot outside.

When we sort the data on participants that name the BlockBot - which provides an indication that a participant wants to built a certain bond or relation with the robotic artifact - one interesting observation that emerges is that there is an apparent hierarchy to the attributions made on the BlockBot (see Table 11). About half of the total participants makes a mind or agency attribution, while about two-thirds of participants makes an attribution of identity. We can observe that almost exclusively: identity attributions precede mind and agency attributions. Almost uniformly, if there is an attribution of mind or agency, a participant will have given the BlockBot a name and/or gender. This indicates that an attribution of identity is a relevant factor to communicate about attributions of mind and agency or possibly make attributions of mind and agency.

In total we therefore observe three clear correlations. First, if a participant makes an attribution of identity, it is highly likely that a participant will also make a mind or agency attribution and take the BlockBot on activities outside. Secondly, if a participant makes attributions of agency, it is very likely that he or she also makes attributions of mind and vice versa: attributions begat

| ID | Gender | Name | Outside | Activity | Emotion | Intentions | Preferences | Agency | Friends |
|---|---|---|---|---|---|---|---|---|---|
| B1 | M | Robbie | - | - | - | - | Sitting with plants | Observing | Cat |
| B3 |  | Botje | X | X | - | - | - | Gaming | - |
| B5 | - | - | - | - | - | - | - | Found a new place | - |
| C1 | M | Jules | X | X | Happy | - | - | Sightseeing | - |
| C3 | - | - | X | X | - | - | - | Walk in the Park | Pig |
| P3 | F | Boxxie | X | - | Adventurous | Leave town | Sitting in the sun | Travel | - |
| P1 | M | - | X | X | - | - | - | - | - |
| P2 | F | Brenda | X | X | Happy | - | - | - | - |
| P4 | M | Boxxie | - | - | - | - | - | - | - |
| A1 | M | - | - | - | - | - | - | - | - |
| B2 | M | Botje | X | - | - | - | - | - | Cat doll |
| B4 | - | - | - | - | - | - | - | - | - |
| C2 | - | Rust | X | X | - | - | - | - | - |
| C4 | - | - | - | - | - | - | - | - | - |

**Table 10.** Data sorted on participants that attribute agency to the BlockBot.

| ID | Gender | Name | Outside | Activity | Emotion | Intentions | Preferences | Agency | Friends |
|---|---|---|---|---|---|---|---|---|---|
| P2 | F | Brenda | X | X | Happy | - | - | - | - |
| P3 | F | Boxxie | X | - | Adventurous | Leave town | Sitting in the sun | Travel | - |
| P4 | M | Boxxie | - | - | - | - | - | - | - |
| B1 | M | Robbie | - | - | - | - | Sitting with plants | Observing | Cat |
| B2 | M | Botje | X | - | - | - | - | - | Cat doll |
| B3 | - | Botje | X | X | - | - | - | Gaming | - |
| C1 | M | Jules | X | X | Happy | - | - | Sightseeing | - |
| C2 | - | Rust | X | X | - | - | - | - | - |
| P1 | M | - | X | X | - | - | - | - | - |
| A1 | M | - | - | - | - | - | - | - | - |
| B4 | - | - | - | - | - | - | - | - | - |
| B5 | - | - | - | - | - | - | - | Found a new place | - |
| C3 | - | - | X | X | - | - | - | Walk in the Park | Pig |
| C4 | - | - | - | - | - | - | - | - | - |

**Table 11.** Data sorted on participants that name the BlockBot.

attributions. Lastly, if a participant takes a BlockBot outside, it is highly likely that he/she will also make mind and agency attributions.

However, these correlations could potentially be explained by an alternative effect. Some participants might just be more inclined to behave in an active manner towards the BlockBot. In other words, there might exist an underlying variable that causes participants to behave in a varying degree of activeness towards the BlockBot, ranging from barely interacting with the BlockBot at all to by naming it, taking it on activities and ascribing mind and agency attributions to it. This is not unlikely, since only half of participants project agency or mind attributions or take the BlockBot outside. For example, when sorting participants on if they make agency attributions to the BlockBot, we see that only half of participants that had taken the BlockBot outside or on an activity also made an agency attribution (see Table 10). This could suggest that taking the BlockBot outside or on an activity might have a weak or no influence on agency and mind attributions, since the results could be explained as pure chance: around half of participants could be susceptible to attributing agency and mind qualities to the BlockBot. However, this would raise the question what exactly causes some participants be susceptible to this kind of active behavior when interacting with the same robotic artifact. One study, for example, showed that people with higher levels of empathy were more positively influenced by a robot with a story than people with lower levels of empathy [40]. Perhaps, the BlockBot triggers a certain personality trait in over half of the participants that causes them to engage in a more active way towards the BlockBot compared to participants that rate less strong on this personality trait.

### 7.2 Interpretation

The data indicates that the BlockBot does succeed in establishing and maintaining a common locus with participants and that participants are prone to engage socially with the BlockBot. People are motivated to engage with the BlockBot and communicate about the BlockBot in written and photographic form. Participants show motivation to keep the BlockBot inside their homes, in close proximity to their daily lives, and maintain a common locus with the BlockBot between different locations and even take it along activities outside the domestic setting.

Furthermore, participants' communication about the BlockBot could be characterized as more similar to that of a social agent, than that of a lifeless object, since it is attributed human-like qualities. Participants almost uniformly refer to the BlockBot as a gendered entity, to which the vast majority give a name. Over half of the participants also ascribe a mind attribution, an agency attribution or an identity to the Blockbot. One interesting observation is that there is an apparent hierarchy to the attributions made on the BlockBot. Almost exclusively: identity attributions precede mind and agency attributions. If there is an attribution of mind or agency, a participant will have given the BlockBot a name and/or gender. Except for one participant, if the BlockBot has a name, it is addressed with a gender. Regardless of one participant that communicated in the first person about the BlockBot, we have not observed any attributions made to the BlockBot that were not named. This indicates that an attribution of identity is a relevant factor to communicate about attributions of mind or agency.

Since participants are disposed to anthropomorphize the BlockBot, this suggests that the BlockBot has passed a social threshold and is experienced, to a degree, as a social agent. These observations are in line with our hypothesis: a common locus between a human and a robot can facilitate an experience of a robot as a social agent, regardless of whether this robot possesses low appearance and low behavioral social cues. Given the fact that we minimized its realism in appearance and behavior, the results could suggest that its common locus was a relevant factor in passing the social threshold. Accordingly, the results point to the relevance of the ABC-framework.

While the results of our exploration are not conclusive, the data could suggest that a common locus between a person and a robot in itself functions as an important catalyst for a robot to be experienced as a social agent. A robot's proximity to a human's daily life can give the sensation of sharing time, spaces and activities with a robot, which influences the experience of a robot as a social agent, even if a robot possesses low life-like realism in its appearance and behavior. With an increase of robots, robotic artifacts and behavioral objects in the lives of people, what will be the consequences of this perception?

Conventionally, when a human-robot interaction is desired, the interaction is not the final goal in itself, but is often there to capture attention or affection and redirect this for a certain purpose. One example is therapy: interaction with a social robot seems to improve social engagement of autistic children in human-human interaction [7]. Another example is teamwork: human-robot teams perform better when humans are emotionally attached to the robot [8]. The common locus could provide a new factor in establishing human-robot relations for these types of therapy, behavioral interventions or cooperation. If a social interaction or bond with a robot is a feature that is preferable by design, being aware that a (prolonged) proximity to a robot in the social life of a human can facilitate social engagement, might in turn inform the design and usage of such a robot.

However, we can also imagine scenarios in which we explicitly want to prevent these types of social engagements towards robots. While attachment is a valuable quality in human-robot teaming, these attachments could potentially endanger human lives when an attachment to a robot drives a soldier to position himself in harm's way to rescue its robot [53]. In those cases, if such a social or emotional engagement is undesirable, one could argue that a robot should not only be "de-anthropomorphized" in its appearance and behavior, but a common locus between a human and a robot should be curbed as well, by for example storing it out of sight with other equipment when not deployed and frequently rotate which unit uses which bomb disposal robot. There also exists a sizable mistrust concerning the use of robots in care and therapy of children, elderly and the disabled, and a reprehension to the introduction of robots in other areas such as education, healthcare and leisure [7]. One concern is that the authenticity of human-robot attachments has possible negative effect on human-human or human-animal relationships (for further reading see [73] and [74]). The idea that a robot's proximity to ones daily life could lead to social engagement and even a certain bond, could provide a basis for some to argue that we should keep robots away from humans in order to prevent human-robot attachments deteriorating human-human relations.

### 7.3 Limitations

The results presented in this study are merely indicative and this paper does not claim to provide any definitive conclusions. In this study we used an open-ended and unsupervised methodology to study how people make sense of a robotic artifact called BlockBot. This choice came at the expense of several of the benefits that a laboratory study offers and limits the amount of factors that we can control as well as the quantity and quality of the data that we gather. Accordingly, we encountered several limitations of our methodology, which we will discuss below.

Firstly, the addition of new participants is slow. It takes considerable time for people to host a BlockBot and pass it on, making its movement between persons a lot slower than the TouristBox. This can be explained from the fact that people do not leave the BlockBot somewhere in the wild compared to the TouristBox, but are requested by the BlockBot to be passed onto a friend or an acquaintance, which heightens the bar for movement between people. Secondly, the quantity and frequency of data is irregular and differs greatly between participants. While some participants seem very disposed to communicate about the bot, others seem less disposed to this behavior. Accordingly, some participants send us two messages and a single photo before passing the BlockBot on, others keep it for three weeks and write three pages full of observations and experiences with the BlockBot. When a participant that receives the BlockBot does not communicate to the number, we are not gathering data and lose track of the BlockBot's location. Thirdly, the quality of the data that people send can vary between participants. While some take a very active role towards the bot and attributing life-like qualities to it, others merely describe where it is or do not report much about it at all. This leaves the potential that some engagement was under-reported. Finally, it is important to realize that people that participated in this study chose to do so voluntarily and were willing to host the BlockBot, which could suggest a pre-existing interest in robots. We are also aware that the demographic make-up of our initial participant pool is not representative for all age groups and ethnic backgrounds. Cross-cultural studies have shown that there are differences between cultures on how robots are perceived [75] [76] [77].

We acknowledge the possibility that asking participants to self-report their attributions and actions with the BlockBot might not paint a complete picture of their social interaction with the robotic artifact. A potential solution in future research, that would preserve the initial unsupervised interaction between participants and the BlockBot, would be to actively inquire participants about their engagement through interviews or surveys after they have hosted it. This can reveal more anecdotes, attributions or activities that were not reported on. Another possibility which would not preserve our more naturalistic approach, but could still be enacted outside the laboratory, would be to place a BlockBot at one household for a set amount of time and conduct interviews with participants about their connection to the BlockBot during and after its stay. Aside from the aforementioned potential benefit of revealing more interactions than self-reported in the current study, this would also be a good way to control the time each BlockBot stays at a household across participants and allows us to research potential changes in perception over time.

### 7.4 Future Studies

While our data can be argued to support our hypothesis, the question remains to what extent other factors might have influenced the results. Several alternative or complementary factors stand out: a possible framing effect, a novelty effect, the BlockBots appearance and to what extent the social engagement we observe in the results differ from object attachment. We will discuss these possible factors below and make recommendations on how to address them in future work.

**Framing effect** One aspect that potentially influences the results is the possibility that the deployment narrative of the BlockBot already frames participants to perceive it in a certain manner. The BlockBot is presented as an entity that wants to travel the world, stay with people and has parents that people can report to. This narrative mainly functions as a forward-propelling mechanism for the BlockBot in order to increase the number of participants and subsequently to increase the amount of data that we receive. However, does this narrative also function as a framing device that influences the participants perception of the BlockBot from the start?

The exact mechanisms and effect of framing on robot perception are not yet fully understood. While some studies have shown how (anthropomorphic) framing can affect how people perceive robots, for example, participants were more hesitant to strike a robotic bug toy after it had been framed with a personality and backstory [78,40], other studies found that anthropomorphic framing had no effect on the human-like perception of the robot [79]. Other times, effects are subtle. One study found subtle differences in children's gaze behavior between a robot that was framed as a social agent or a machine-like being [80], but this difference in perception was not present in the children's evaluations pre-test and post-test [81] Another study, showed that while framing does affect participants mind perception of a robot in a laboratory setting, this effect is hard to replicate in real-world studies [82]. In summary, some studies indicate a clear effect of (anthropomorphic) framing on how robots are perceived, but results are inconclusive.

It is important to point out that participants are not explicitly encouraged or discouraged to anthropomorphically frame the robotic artifact. Furthermore, the majority of attributions made on the BlockBot are unrelated to its deployment narrative. For example, the narrative does not provide the BlockBot with a gender, name or any preferences. However, one can argue that - even if the attributions are unrelated - because BlockBot is presented as robotic artifact with a goal, that this lowers the threshold for participants to make attributions compared to a situation in which there was no 'framing' to begin with. Hence, we acknowledge the possibility that the deployment narrative of the BlockBot frames how participants view the robotic artifact. In future studies, we could, for example, compare different narratives with which we deploy the BlockBot. This could mean different narratives on the back of the BlockBot or different narratives told to the initial participants.

**Face** As stated, the three factors in the ABC-framework that facilitate a robot passing the social threshold are not mutually exclusive but can strengthen the experience of a robot as a social actor. Due to the open-ended nature of this study, which did not isolate single aspects of the BlockBot, the question arises as to whether the BlockBot passes this social threshold based on the common locus or that its arbitrarily low realism in appearance or behavior was 'high enough' for it to pass the social threshold based on those qualities (or a combination of them). Critics could, for example, point to the fact that the BlockBot displays a 'face' as the main factor as to why we observe participants ascribing identity, mind and agency attributions to the robotic artifact.

A similar argument as with the framing effect can be made here. While there are attributions made that seem to be more related to the BlockBot's face (the ability to observe, for example), there are also other examples that seem unrelated to this feature, such as having certain preferences. But the possibility exists that the presence of the face could potentially lower the threshold for participants to make attributions that are unrelated to its appearance alone.

However, this does imply that the same BlockBot would be able to pass a social threshold if participants interact with it in a laboratory setting. Or that the same BlockBot without a face would not be able to pass a social threshold in a common locus setting, which our hypothesis states it would. Due to the nature of our study we can't exclude this possibility with certainty. This establishes the need for a future study in which we deploy a BlockBot without a face on its display and see whether it would be possible to generate similar results that indicate that the BlockBot has passed a social threshold.

**Novelty Effect** The observed results could potentially be influenced by a certain novelty effect of having an unfamiliar, ambiguous robotic artifact in the social setting of the home. A novelty effect would cause participants to initially be very disposed to engage with a robot and lose interest after its novelty has 'worn off'. This type of effect has been observed in previous studies [83]. One study which aims to provide a formal model of anthropomorphism considers anthropomorphism as a dynamic concept that evolves over time. This model theorizes that at the start of a human-robot interaction, anthropomorphism spikes due to a novelty effect, before familiarization stabilizes this tendency, only to spike up again due to disruptive and surprising robot behavior [84]. In future work, we could aim to measure this novelty effect by testing if the frequency of reporting goes down over time.

In our current data we do observe a frequency pattern that could be identified as a novelty effect (see fig. 16). Participants often communicate most about the BlockBot in the early days of having received it or communicate about it on a relatively high frequency at one moment compared to moments later in time. Often participants send one or two messages with photos after which either the frequency drops or they pass it along. Even with participants that are highly frequent communicators, we note a decline in the frequency and quantity of communication over time.

One participant that had a BlockBot for over two weeks, notes that her BlockBot "Jules" slowly lost his "magic robot powers" and became a part of the interior, akin to a plant, lamp or printer. The only difference being that she still felt a certain responsibility to it and a slight feeling of sadness that it was integrating in the interior. It is possible that a novelty effect influences an initial high level of anthropomorphism which in turn affected the type of communication we received from participants.

**Object attachment** A final question worth considering is to what extent does the observed social engagement towards the BlockBot differ from other forms of object attachments? Robots are usually understood as mechanical artifacts that possess a level of autonomy, agency and choice [85]. The BlockBots presented in this study possess neither of these qualities. Hence, why we have refered to the BlockBot as a robotic artifact, as opposed to a robot. Has our methodology taken such a minimal approach that we have left the field of human-robot interaction and have entered human-object relations? While it is not in the scope of this paper to provide a conclusive answer to this, we do provide a brief take on this question below.

In general, objects are argued to function as a "major contributor and reflector of our identities" [86]. In this sense, we relate to objects as an extension of our own identity. It is well observed that people from across different age ranges can form strong attachments to objects. Children, for example, often have a 'transitional object': a favorite stuffed animal, blanket or toy that they form strong and persistent attachments to (however, this is not a universal event in child development) [87]. Adults might possess certain emotional objects - objects whose value is not (primarily) derived from its function, but which we find valuable because of what we attribute to it: the watch of a deceased family member that holds certain memories or a medal that signifies ones competitiveness, physical qualities and persistence. These objects often feel as a part of our identity and some would feel as if they lost a part of themselves when these emotional objects would get lost or destroyed.

One aspect in which attachments made to objects and the attachments made to robots could differ is in which ontological category we place robots compared to other objects and machines; what kind of being we perceive them to be. Damiano and Dumouchel note that people across age groups perceive robots as "ambiguous objects" in relation to traditional ontological categories [12]. Robots seem to inhabit a place on a spectrum between alive and not alive, sentient and not sentient, intelligent and not intelligent [13]. We see this ontological ambiguity back in the results when we analyze how participants associate the BlockBot to other entities (see table 5). Participants do not exclusively place the BlockBot in an ontological category of living or non-living entities, but associate it with humans, animals, plants, toys and inanimate objects. The fact that a robot or robotic artifact is perceived as an ambiguous entity, perhaps supports it passing the social threshold and become a social agent.

In this way robot attachment and object attachments could differ: as an attachment to two different ontological categories. While someone can get attached to an object, this does not imply that this person will regard this object as another entity or subject. Robot attachment could be understood as a relationship with an external entity akin to a human-animal bond; with artifacts that are 'subjectified'. Meanwhile, we could understand object attachment as a projection of a certain self-reflecting quality, memory or state of mind onto an object. You can grow attached to a watch, but this does not mean that you would consider it another entity.

However, this divide seems to be highly person dependent. For example, while some people readily attribute moods and a certain persona to their car, others do not have this tendency whatsoever. For some a car is nothing more than an object, while others grow attached to their cars, give it an identity and attribute emotions to it. Therefore, when considering a difference between robot and object attachment, it is perhaps more useful not to make a distinction between objects, machines and robots, but between those entities that pass a social threshold and those that don't solicit this perception. In other words: those objects that people 'subjectify' and those objects that people 'objectify'.

This raises the question: does a mechanical artifact need to possess certain qualities in order to earn the moniker of 'robot' or is it sufficient that a human merely believes or performs that it has those qualities? One could argue that if a human believes an entity has the capacities of a robot, it is irrelevant (when studying their engagements) if the entity they engage with actually possess them. Perhaps the BlockBot can function as a starting point to discuss the boundaries of the concept of a robot, one not defined necessarily by its inner workings, but how humans perceive its presence.

## 8 Conclusion

Science fiction has provided us with an image of a future cohabited by humans and robots. While robots are far from the autonomous entities they are portrayed to be in various media, robotic technologies are increasingly present in our daily lives and the spaces we frequent and inhabit. The presence of robots in a human-inhabited environment provides an exciting new frontier in the research of human-robot interaction. While there is ample research done in a laboratory setting, the way in which humans make sense cohabiting with these ontological ambiguous creatures is not yet fully understood.

In this paper, we have provided an exploration of this novel frontier. Specifically, we were interested in which factors allow a robot to pass a 'social threshold', after which it is perceived not as a machine, but as a social agent. We theorized that, aside from its realism in appearance and behavior, the presence of a robot in close proximity to a person's daily life, space and experiences could be a relevant factor for a robot passing the social threshold. We call this factor the common locus.

The central aim of this study is to research the relevance of the common locus. We designed a robotic artifact called the BlockBot that does not make a strong claim on realism of appearance or behavior, but is aimed to facilitate a common locus with a participant. We released four BlockBots into 'the field' to be hosted and passed on by people in an unsupervised, open-ended experiment to study what kind human engagement would arise based on the robotic artifact presence in the participants domestic setting. We theorized that, regardless of its lack of realism in appearance or behavior, the BlockBot would still be able to pass a social threshold after which participants would perceive it as a social agent.

Although initial data is inconclusive, the results indicate that the BlockBot successfully establishes a common locus with participants whom are prone to engage with the BlockBot. Participants keep the robotic artifact in close proximity and anthropomorphize it. The BlockBot evokes identity, mind and agency attributions and is frequently taken on social activities outside the home, even long trips. These observed engagements could suggest that the BlockBot has passed a social threshold whereby they consider the BlockBot- to a certain degree - a social actor. Given the fact that we minimized its realism in appearance and behavior, the results could suggest that its common locus was a relevant factor in passing the social threshold. However, we also identified and discussed several alternative explanations that might have influenced the observed engagements: a framing effect, a novelty effect, its appearance and object attachment.

The concept of common locus implies that the presence of robots and robotic artifacts in our daily lives will impact how we perceive these robots. It is important to consider this dynamic because these attributions can be harmless and even useful in case they are leveled towards activities such as therapy or education. However, if the perception of a robot as a social agent and any possible social engagement is undesirable, the common locus implies that certain robots should be present in a limited capacity and proximity of certain people. Merely removing anthropomorphic qualities could in some cases not be sufficient.

Currently, three BlockBots are still operating as figurative 'probes' into human-inhabited environments. We are excited to follow their journey, what data they will generate, where they will go, what activities they will be part of and what attributions will be made along the way. Our in-the-field approach turned out to be an exciting methodology for studying human-robot interaction. We have received an interesting variety of messages, photos, videos and feedback. The positive reactions to the BlockBot point to the strength of its design and its viability as a research tool for human-robot interaction. Due to the fact that the BlockBot can be programmed with a different appearance or behavior, future studies could use the BlockBot not only to study the relevance of the common locus but as a research platform in a wide variety of other human-robot interaction research. We hope this study will contribute to the growing understanding of human-robot interaction in human-inhabited environments.

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# A Image Data BlockBot


**Fig. 16.** BlockBot Prototype in the field

**Fig. 17.** Second Generation BlockBot in the field


**Fig. 18.** Second Generation BlockBot in the field

**Fig. 19.** Second Generation BlockBot in the field