Designing for engagement: Using participatory design to develop a social robot to measure teen stress

Emma J. Rose
University of Washington Tacoma
Tacoma, WA
USA
ejrose@uw.edu

Elin A. Björling
University of Washington
Seattlee, WA
USA
bjorling@uw.edu

ABSTRACT

While scholars in technical communication have examined on theoretical concerns of post humanism, less work has focused on designing for engaging experiences between humans and non-human agents like robots. In this research article, we present findings from a project investigating the possibility of designing a social robot to help measure teen stress. To explore design possibilities, we conducted a series of participatory design sessions with teens to envision the design of a social robot to measures stress. The findings from the study include how teens react to existing robots, how teens conceptualize robots that might live in their schools through storyboarding and group discussion, and reactions to an emerging design of a low fidelity robot. In our discussion, we reflect on implications for designing social robots for and with teens, considerations for studying engaging relationships, and reflections on methodological choices of participatory design.

CCS CONCEPTS

• **Human Centered Computing → Interaction design;** *Interaction design process and methods;* Participatory design
• **Computer systems organization → External interfaces for robotics**

KEYWORDS

Participatory design, social robots, stress, adolescents

ACM Reference format:

1 INTRODUCTION

Historically, usability and user experience methods have been narrowly concerned with measuring efficiency, effectiveness, and satisfaction in online experiences and workplace tools [57, 72]. As technologies continue to move into all aspects of daily life, including conversational agents [43] and wearable technologies [51, 75, 81], researchers and designers need to consider how to design for engagement between people and things [5]. As such, the methods, tools and approaches of UX researchers and professionals need to take into account a wider variety of factors and actors to attend to in the design process [61].

Although the SIGDOC community has focused on designing communication across a variety of domains, little work has specifically ventured into how to design interactions with social robots. Studying how to design the interactions between humans and robots is seen as qualitatively different from the field of human-computer interaction and therefore has spawned the sub field of human-robot interaction [26]. Scholars in technical communication have considered the impact of theoretical approaches of new materialism and post humanism to design [44, 46, 61]; however, there is a lack of empirical work in our field that examines the interactions between human and non-human agents, in the form of social robots, and how to design an engaging relationship between the two.

In this research article, we present findings from a project investigating the possibility of designing a social robot to help measure teen stress. Teens experience stress at higher rates than any other age group [41, 85]. However, there is a lack of accurate data to help researchers and schools assess how, when, and why stress occurs. As a result, our interdisciplinary team embarked on project EMAR (Ecological Momentary Assessment Robot), to consider the design for a robot that would interact and engage with teens at school to collect self-reported stress and mood data. In order to design an engaging experience between teens and robots, we used a human-centered approach and participatory design methods to engage teens throughout the design process.

In this research paper, we report the results of three design sessions early in the project that engaged teens in the conceptualization of a social robot. We detail the research questions and the participatory design methods used to gather information from three groups of socially connected teens (n=40). In each session, we asked teens to (1) design a robot that would live in their school, (2) respond and discuss images of existing robots, and (3) interact with a physically present, low fidelity, robot prototype. The findings of this research inform design considerations for our ongoing project and also can inform other scholars interested in considering designing experiences for teens and robots. We conclude the article by focusing on the implications for designing for engaging

SIGDOC '17, August 11-13, 2017, Halifax, NS, Canada

ACM 978-1-4503-5160-7/17/08$15.00
https://doi.org/10.1145/3121113.3121212

relationships between humans and robots and the considerations for the use and expansion of participatory design methods in this context.

2. BACKGROUND

In this section, we situate our research by providing background on the issue of teens and stress, the challenges of accurately measuring stress, and an overview of applications and approaches for designing social robots and issues of engagement.

2.1 Teen stress

Although a great deal of research has been conducted in the field of human-robot interaction (HRI) among children [32, 33, 37, 59], adults [15, 66] and seniors [63, 79], very little is known about the relationship between teens and robots. Adolescents are a unique and vulnerable population, negatively affected by stress and mental health issues [2, 3, 22, 27, 40, 45, 62, 73, 77, 83]. Today's adolescents experience more stress than any other age group [3, 42]. The adolescent brain is extremely vulnerable to the negative impacts of stress [2, 22] which have been shown to increase both mental and physical illness [27, 45, 73, 83] and decrease learning [77]. Stress negatively affects teens at school. Eighty-three percent of teens report that school is a significant source of stress, and 34% predict that the next school year will be even more stressful than the last [3]. Stress has been shown to impair memory retrieval and associated learning of new material and reduce cognitive flexibility and problem solving [77], thus dramatically affecting learning and retention. Increased academic stress in high school students is also linked to substance abuse and risk-taking behavior [42].

2.2 The challenges of accurately measuring stress with teens

Due to the concern about the negative impact of stress on teens, many schools are interested in implementing programs and interventions to address the issue of stress [17, 21, 54, 71]. However, measuring the effects of these programs on stress is challenging and limited, often relying on anecdotal assessment of interventions. Typical stress measurement tools are often pencil and paper, retrospective instruments [6] and, therefore, subject to evaluation burden and recall bias, thus limiting their validity. Understanding stress in teens requires longitudinal data which has been found difficult to collect from adolescents due to attrition [6, 8]. Recent research supports the validity and feasibility of capturing momentary, within-day data to measure stress and moods in teens to eliminate recall bias and increase reporting [36].

Although there are numerous interventions for stress [24, 35, 58] measuring the effect of these interventions is difficult as gathering accurate data from teens is often problematic [48]. Unlike adults, research has found that teens can be uncomfortable in face to face interviews [76] and prefer an automated phone to a written diary for sensitive information [47]. Teens are already connecting to others via electronic media and messaging [69], thus using a digital format to gather data from them may increase the ecological validity of that data while reducing their response burden. Importantly, school based data collection regarding mental health in teens has been shown more effective and accurate than home based data collection [34].

Ecological momentary assessment and experience sampling have been shown to be extremely successful in capturing data from adolescents [20, 36, 68, 74]. However, capturing data repeatedly in a busy school setting requires both novelty and engagement that moves beyond current research tools found in static, ordinary smart phones and tablets. Therefore, the challenge for accurately gathering data from teens in a school setting requires an approach that moves beyond just designing for individual use. The challenge is to consider how to design an engaging experience for users in order to collect data longitudinally.

2.3 Designing for engagement

Early research in UX focused on evaluating a narrowly conceived notion of usability [72] and early conceptions of usability were primarily concerned with issues of effectiveness, efficiency, and satisfaction [28, 30]. However, as technologies have grown into further areas of daily life, engaging for longer term relationships between people and products require different considerations and approaches. In their work on investigating long time interactions with relational agents, Bickmore and Picard identify how relationships are "incrementally built and maintained over a series of interactions that can potentially span a lifetime" [6, p.294] and what impact a relationship can have when designing between computers and people. They identify three components of personal relationship management that are implicated during long term relationships (1) relational communication, (2) relational dynamics, and (3) relational nonverbal behavior. Relational communication is made up of both propositional information and also social dialogue, which is lacking in specific task-oriented language. Social dialogue, for example, what is often referred to as "small talk" is integral to establishing rapport or maintaining relationships and therefore "simply engaging a user and keeping them engaged—even when not performing a task—will help to establish a bond with the system." [6, p. 295]. Relational dynamics includes elements such as "meta-relational communication" in other words talking about the relationship, which is important, especially early on to set a foundation for communication. Further, empathy, "the process of attending to, understanding, and responding to another person's expressions of emotion" [6, p. 296] is key to relational dynamics. Finally, Bickmore & Picard discuss the importance of relational nonverbal behaviors according to [1], these include "close conversational distance, direct body and facial orientation, forward lean, increased and direct gaze, smiling, pleasant facial expressions and facial animation in general, nodding, frequent gesturing and postural openness" [1, p. 297]. Considering the need to design for long term engagement inspired our team to think about how to make data collection a more engaging and relational experience.

2.4 Social robots as data collectors

Within the field of human-robot interaction, social robotics is a subfield focusing on the design of robots that will interact socially with humans. As Brezeal notes, a social robot should be able to interact and communicate in “a personal way” and is “socially intelligent in a human-like way, and interacting with it is like interacting with another person”[10]. Social robots have shown many benefits to humans such as increasing human-human social interactions in both children and adults [37, 79], providing comfort [15] and reducing stress [78]. However, social robots may also be a unique tool that is well situated to collect data from humans to inform a variety of applications. The use of robots to gather information from and about people has been somewhat limited with some notable exceptions including using social robots to diagnose autism spectrum disorders [64] and deploying robots in hotels and airports to survey customers about their satisfaction [14, 29]. Although social robots that have been part of long-term deployments that may gather information about their users [23, 39], the information is often processed to inform the robot’s actions or to understand a user’s interaction with a robot. In this project, the data being collected by a social robot would be used to understand the environment and state by a particular population, namely teens, to collect data about the health of that population, in the form of mood and stress data.

Preliminary research on undergraduate students and physical robots provides evidence that compared to flat screen images, physical robots greatly increase compliance [4]. Although no adolescent studies were found, one long-term field test of a peer robot in an elementary school proved successful in maintaining engagement over a two-month period [32]. In 2013, Leite, et al. reviewed investigations of physical robots deployed over longer periods of time [39]. None of these studies included adolescents, however, with both adults and children, long-term engagement was limited and often surprised the developers. In order to design a social robot that teens will engage with over time, we plan to use the guidelines proposed by Leite, et al. for maintaining or increasing long-term engagement with physical robots. The four guidelines (1) appearance, (2) continuity and incremental behaviors, (3) affective interactions, and (4) memory and adaptation, have directly informed our research areas.

Finally, Wood, et al. [82] found using a social robot in interviewing children was significantly more successful in maintaining overall engagement and interview duration than a human. Although there is little, previous research on teen-robot social interactions, drawing from evidence regarding social robots with children and adults, we wondered how teens might interact with a robot designed specifically for and with them.

3 METHODS

To investigate teens’ impressions and opinions of social robots, we conducted a series of design sessions with three groups of teens in different social settings. Participants were asked to take part in participatory design activities to explore the idea of a social robot to measure teen stress. Parents consented to teens participating in the educational design sessions. University IRB approval was obtained to analyze and disseminate the data as research. In this section, we provide details about the participants, recruiting, activities and analysis.

3.1 Participants and recruiting

A total of 40 students participated in one of three design sessions between February and May in 2016. To engage students with a shared social experience, we recruited participants in three groups through convenience sampling from connections with local teens, an informal learning program and a high school robotics program. We did not collect detailed demographic data as part of the study. Details about the number of participants and their ages are shown below in Table 1.

Table 1. Overview of participants

Group	Description	Participants	Ages
1	Socially connected group of teens	6	12-14
2	Pre-teens and teens at a meet up for a summer STEM program	15	12-17
3	High school robotics club	19	14-18

3.2 Participatory Design Sessions

Each group of teens engaged in a participatory design session to explore the idea of a robot who would exist in their school environment. Participatory design, originating in Scandinavia, is an approach that advocates for the full participation of representative users in the design of a product or service [52]. The roots of participatory design have a political commitment to democratic decision making and starts from the “simple standpoint that those affected by a design should have a say in the design process [8, p. 103]. In participatory design the line between design and research is blurred and, according to Spinuzzi, the results of research are “co-interpreted by the designer-researchers and the participants who will use the design” [70]. For this project, we chose participatory design as the guiding methodology for the study due to a recognition and philosophical commitment that recognizes young people as experts in their own lives. We knew that preconceived assumptions about the needs and wants of this population could easily sway the design in a way that would undermine its goal. Therefore, the team was careful to watch, listen and co-interpret the data we gathered from our participants, rather than dictate the design. Each of the three participatory design sessions lasted between 60-90 minutes and included a variety of activities to elicit design ideas and requirements about social robots. Each activity is described in more detail below.

3.2.1 Ideation. To explore possible ideas for a robot design, we engaged participants in a drawing activity that acted as a modified form of a future workshop [31], a method from participatory design. The goal of the activity was to have students envision what a robot, that was designed specifically for their school, might look like. Participants were given a blank piece of paper and asked to draw an image of a robot. After drawing the image, participants were then asked to share their drawing with the rest of the group and describe their robot. The drawings and articulated rationale for the design were then collected and analyzed.

3.3.2 Storyboarding and discussion. Participants were then asked, using paper to draw a story of a robot living in your school. In user experience design, professionals use a variety of visual tools and techniques for storytelling [56] including sketching and using storyboards [11] and comics [13]. These techniques are ways to envision and communicate designs and ideas for a broader audience. After participants completed their drawings they were asked to articulate what the robot was doing and why. This exercise was designed to have students consider the specific context and constraints of their own schools and how an imagined robot might live or exist in this specific space.

3.3.3 Responses to existing robots and prototypes. Students were also asked to suggest and discuss social robots from popular culture and provide feedback on four unknown existing social robots. Images of these existing robots were shared in photographs with space for teens to comment on post-it notes. While a considerable amount of work in social robotics has examined the relationships between robots and age groups like children, adults, and seniors very little is known about how teens engage and interact with robots. Therefore, we shared images of these existing robots and asked participants to react to them. Robots included Jibo (MIT), and Dragonbot (MIT), Pepper (Softbank, Japan), and Boxie (MIT). Participants were asked to write down their likes and dislikes to each robot and then their reactions were discussed as a group. Images of these robots are shown in Figure 1.

In the second and third design sessions, the research team included a low-fidelity prototype of a robot our team had been developing named EMAR (Ecological Momentary Assessment Robot). The design of EMAR had been informed based on a literature review and the results of the first design session. Students were asked to engage with the robot. After interacting with the prototype, students were asked in small groups to articulate what they liked or disliked about the prototype as well as how they felt during their interacting with EMAR.

3.3 Collecting and capturing data

In an effort to collect as much data as possible, the design sessions were captured by digital video (Go Pro cameras) and photographs (DSLR), to document the design sessions and teens interactions with the prototype (during design sessions 2 and 3). In addition, participants' robot drawings, storyboard drawings, and written responses to existing robots were all collected and scanned for analysis. The research team also took field notes, made voice memos, and participated in structured debriefs after each data collection session. After each session, artifacts were analyzed for the study including field notes, photographs, and drawings. Each design session yielded designs and insights that informed the following iteration of the design as well as the thematic analysis of the data.

3.4 Analysis

To analyze the data from the three design sessions, our team took a qualitative, iterative approach informed by the concept of bricolage, conceptualized by Denzin & Lincoln [18] and further expanded by Kincheloe [38]. Bricolage is "critical, multi-perspectival, multi-theoretical and multi-methodological approach to inquiry" and examines "phenomena from multiple, and sometimes competing, theoretical and methodological perspectives" [60, p. 1]. The team consisted of a multi-disciplinary team with expertise in health sciences, experience design and engineering. Upon final analysis, the authors revisited the study data in its entirety and began open coding of main themes and outliers. Individual codes were discussed and further analyzed until consensus was reached about the most salient concepts that were evidenced by the data.

4 FINDINGS

In the following section, we present a series of key findings from the study with emblematic quotes, pictures or commentary. The study focused on conceptualizing both the embodied form of a stress robot for teens and the kinds of interactions teen could imagine engaging in with a robot.

4.1 Reactions to Existing Robots

Participants were presented with images of existing robots (see Figure 1) and expressed strong reactions to these robots.

Figure 1. Images of existing robots used to elicit reactions from participants (Clockwise from upper left: Jibo, Dragonbot, Pepper, Boxie)

When participants discussed social robots from popular culture (BB-8, Baymax, Wally) they described unanimous likability, cuteness, and good hearted-ness. In these discussions, most participants articulated an emotional connection to social robots from movies in particular and the desire to have such robots in real life. However, when asked to review images of four existing and typically unknown social robots that exist in the real world (see Figure 1) participants were much more critical, and typically suspicious. They found simple, small robot designs (e.g. Boxie and Jibo) typically to be "friendly" and "cute." Both Boxie and Jibo were described as "simple" and one teen articulated, "simplicity is really good." A few participants described Jibo's eye-like design as "creepy," but for the most part, teens really resonated with Jibo's simple and "clean" design, and its futuristic look, "HAL9000/Glados-esque." Surprisingly they liked the idea that Jibo looks "like it doesn't move" and is "stationary." One participant even suggested that Jibo "looks like it cares about you." Boxie was equally liked for it's "cute" and simple design although one teen did comment that it "looked cheap," and another that it might be "too short to interface with." A few participants suggested that Boxie had a pet-like characteristic and would make people happy to interact with it, similar to a dog or cat. Participants suggested that Boxie likely didn't do much, but one teen wrote, "I want it to talk to me" and they liked its "friendly eyes" and "smile."

Figure 2. Examples of participants' responses to existing robots (each comment maps to the robot examples shown in Figure 1)

To our surprise, almost all participants expressed their feelings that Pepper and Dragonbot were disturbing. When the images of these robots appeared, in all three design sessions, participants were united in vocalizing fear and disgust. Although customer service robots are well-liked by adults [16], participants used strong and vivid language to describe Pepper as "a scary mannequin," having a "death stare," and "more like a peeper." Dragonbot was equally disliked and described as "nightmare fuel" and one participant responded by writing "no, God, no" on the image. A few outliers were participants who found Dragonbot to be "fuzzy, like a stuffed animal," or a couple of comments that Pepper looked "futuristic" or "clean," but overall Pepper and Dragonbot were perceived as threatening and suspicious. Several participants commented that Peppers "dot" or "bindi" in the middle of its head was likely a camera making it very "creepy."

4.2 Characteristics of Social Robots

When reviewing the data from our three design sessions, four main themes emerged in regards to participants' expectations of social robots. Each is discussed in more detail below.

4.2.1 Clean and Simple

Although the participants expressed wanting the robot to have a multitude of human-like interactions, they did not want the design to be complex or resemble a humanoid. In terms of design, the participants leaned heavily toward a simple design and demonstrated this fact in their own drawings (see Figure 3) and in their reactions to existing robots.

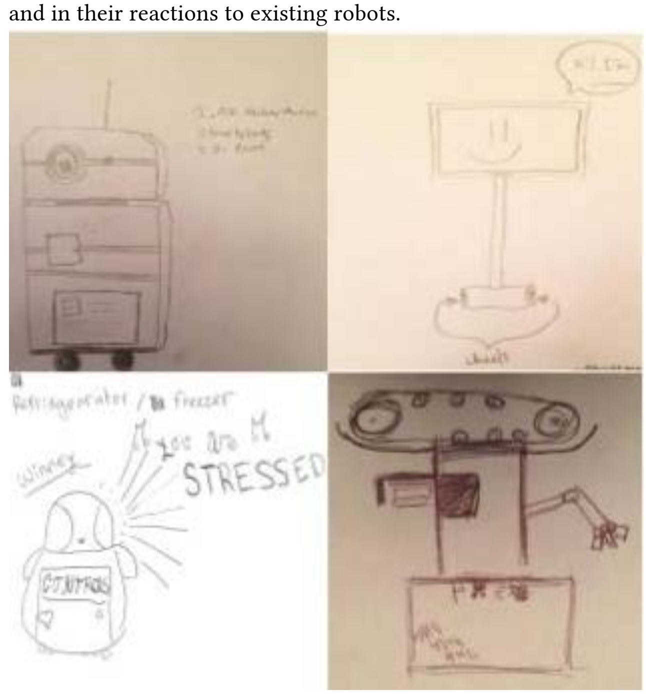

Figure 3. Drawings of robots generated by participants

4.2.2 The Helper

During the design sessions, we gathered data regarding what participants thought a robot that lived in their school should do and how it should behave. We saw in the participants' designs and heard during discussions a very strong theme from most of the participants that the robot's function should be to "help others" (see Figure 4). Almost all of the participants' storyboards of robots at school featured some aspect of helping either by asking the students how they are doing (Figure 4), carrying their books, or helping them with academics. In the participants' illustrations, they included details that demonstrated the concept of helping. In Figure 4a, the participant noted that the robot's function includes "friendly communication/navigation, different moods, help others, and movement (wheels or tread). In Figure 4b, the participant illustrated a story of the school being introduced to the robot, groups of students socializing with the robot, and sharing how they are feeling. In Figure 4c, the participant illustrated an individual interaction with the robot, again sharing their feelings, and then closing with the robot offering to help the student.

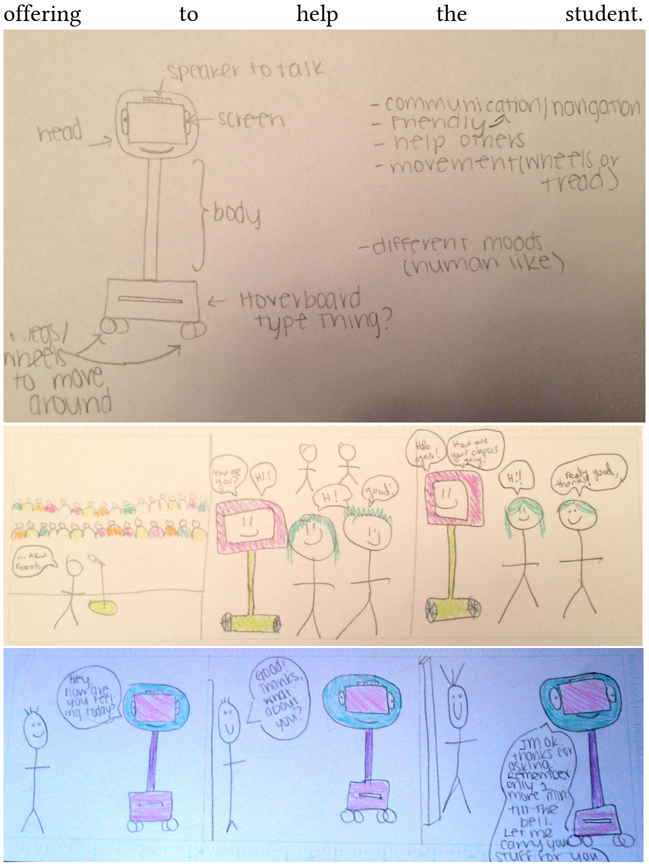

Figure 4. (a. b. c.) Storyboards drawn by participants

One of the areas identified by participants as a potential design challenge was how the robot would move around the school. The teens in our design sessions described the busy and crowded environment of a large urban high school would be a challenge for a robot. The initial EMAR prototype we shared with teens was small, approximately 2 feet and sat on a table. Students wondered how it might withstand a school environment.

4.2.3 Interactive and Emotive

In addition, participants articulated a desire for the robot to have different moods and a variety of conversational responses. As one participant stated, "[EMAR] needs to have a variety of ways of interacting…and a variety of responses". They desired a large response range that was similar to that of a human. A few participants suggested that EMAR should move or even sing in response to its interactions. Participants also suggested that EMAR should be mobile and perhaps approach and recognize students: "If it could come up to you and recognize you…like how people get really excited to have their puppy run up to you at the end of the day, what if it could be a domestic robot?"

Teens were also very interested in EMAR being able to use voice recognition. One student suggested that the touchscreen could be used in public places, but in more private areas, you could just naturally convers with the robot about how you're doing. Several participants mentioned that they would prefer EMAR to approach them and initiate conversation with them, rather than them having to seek out EMAR for an interaction.

4.3 Responding a low-fidelity prototype

We saw strong engagement from participants interacting with our simple, low fidelity, prototype. Although we expected participants to desire a sophisticated, high fidelity social robot, they were immediately engaged with our low-fidelity prototype. As groups of teens rotated through the design session stations, they were clearly most excited to arrive at the prototype station. Even before the first participant began an interaction, the excitement from the teens was notable. Most participants spent 5-10 minutes interacting and witnessing others interacting with the prototype. Across all age groups we captured participants' expressions of satisfaction, happiness, and surprise as they engaged with the prototype. Participants smiled, laughed, and were curious about interacting with EMAR. They interacted with the touchscreen by touching and responding to the robot. Several also tried out all the possible interactions contained in the simple script. They repeatedly emphatically used the word "cute" to describe EMAR's voice, eyes and appearance. When the teens had completed their turn, they often stayed to witness a peer's interaction and expressed sadness and disappointment when their turn was over. Interacting with EMAR increased the teen's engagement during the teen-robot-interaction. However, we also witnessed an increase in peer-to-peer interactions as well. Teens smiled and laughed with one another while witnessing a peer's interaction. Often the interacting teen would look to other peers for their reaction or as a form of social referencing.

4.4 Impressions of Gender and Race

While we did not collect demographic data as part of the study, we did informally note that make up of gender and racial diversity of our participants. While most groups seemed to include an even split between different genders, the racial diversity varied from group to group. Both groups of students in Groups 1 & 3 appeared to be primarily white, whereas Group 2 had a great deal of racial diversity. For these design sessions, the three people who conducted the research and/or designed the prototype, were also white. We note these details to contextualize results related to students' assessment of the robot's gender and race.

Many participants, after interacting with the EMAR prototype referred to the robot as "he" even though the design team had intentionally designed the voice to be mid-range, childlike, robotic and not explicitly performing a specific gender. While many participants referred to EMAR as "he," others used neutral pronouns, or cycled through a variety of pronouns before using "it."

In addition to notions of gender, we also saw students responding to impressions of race. The prototype of EMAR was housed in a black box. This design decision was an opportunistic one due to the convenience of having this particular box on hand. No participants in Group 1 or 3, who appeared to be primarily white, made any direct comments about EMARs race but a few noted how Pepper, in the example robot image, was white. One teen commented that this was a positive attribute: "it's white so it doesn't stand out to [sic] much." Another teen suggested that a robot "...should be clean and simple...but not medical white, like Pepper."

However, in Group 2, several participants of color enthusiastically noted that the robot was black. In addition, participants from Group 2 made comments about their perceived race of the low fidelity prototype of EMAR. Finally, after interacting with our prototype, one teen wrote, *"He's (or she or it) black! Saying yes, even robots can be a different race too! Racially* [sic] *equality across the board."*

5. DISCUSSION

In this section, we discuss the findings in relation to the challenge of designing a social robot to measure teen stress.

5.1 Mental models and functionality

In this section, we discuss how participants conceptualized robots based on their own designs, drawings, and stories according to their existing mental models [53, 84]. Young explains that a mental model "gives you a deep understanding of people's motivations and thought-processes, along with the emotional and philosophical landscape in which they are operating" [82, p. 3]. In this section, we discuss the findings that yielded insights into the participants' mental models of robots, what they should look like, and how they should behave.

5.1.1 References to popular culture

Both in their drawings and in discussions, participants drew on references from popular culture and media. They spoke positively and enthusiastically about the robots they knew from television, movies and video games. For example, participants made references to Baymax from Big Hero Six, BB8 from Star Wars: The Force Awakens, and GLaDOS from the video game Portal. Perhaps it is not surprising that participants reference robotic characters in the movies and games they consume. It is notable that these references are very much of the participants particular time and current moment (rather than say, R2-D2 from Star Wars, 1976). However, it is helpful for designers to consider how to leverage these existing well known robotic characters, both in terms of considering audience expectations and also being careful not to just duplicate these existing robots that have established personalities and conceptions for participants. Rather, it is helpful to see how these robots in popular culture embody some of the other functional requirements that the participants discussed, as detailed in the remaining sections.

5.1.2 Robot as a helper

The participants in the study conceptualized robots that might live in their schools as "helpers." Almost every design sketch articulated the robot helping the student in some fashion (see Figure 4). Participants illustrated a variety of ways that robots could help them, including in academics, difficult social interactions with teachers or peers, and more menial tasks such as carry a backpack or open a door. While many robots in pop culture often are positioned as companions with fairly advanced abilities, taking on complex tasks, teens in the design sessions articulated fairly simplistic interactions for the robot. Social robots in public spaces is a novel idea for teens to conceive, and thus reinforces the potential for project EMAR and the importance of a human-centered approach that requires prototyping and evaluating interactions with an embodied prototype. It is not surprising that teens invite the idea of a social robot in their school to help them as school has been shown to be an overwhelmingly stressful environment for teens [3].

5.2 Robot appearance and embodiment

In this section, we discuss evidence from the findings related to the robot's appearance and its embodiment. In human-robot interaction, embodiment refers to the physical makeup of a robot: it's size, shape, body, and so on. Research shows that the embodiment of a robot is an important factor on how it is perceived by others and that users prefer an embodied interaction to a virtual one, such as a virtual agent [80].

5.2.1 Cuteness, simplicity, and avoiding the uncanny valley

In their drawings, stories, and in comparison with existing robots, participants articulated that the design of a robot should be "cute" and simple and referred to the EMAR prototype as cute. This is the word participants used repeatedly to refer to robots in the pictures and our prototype. Delving further into the concept of cuteness, we draw from the field of aesthetics, specifically in relation to what makes infants cute, which include characteristics such as a large head proportional to the body, protruding forehead, large eyes, large cheeks, and soft bodies, coupled with a clumsy and helpless demeanor that instills the desire to cuddle or care for them [50]. Further, we took from our participants conversations and observations about robots and cuteness, we took this description to mean: small, nonthreatening, having characteristics of wanting to take care of or befriend the robot. Surprisingly, participants expressed strong dislike for animal looking robots that are popular with young children, such as Dragonbot, which was described as "nightmare fuel." And they universally showed extreme dislike for humanoid robots such as Pepper. Participants described Pepper as "creepy" and "soulless" echoing earlier findings related to the concept of the uncanny valley [25, 49]. Findings from preliminary design and interaction sessions also illuminated the complexity of the teen-robot interaction and the necessity to create an engaging robot that shows empathy in response to participants sharing information. Finally, our preliminary research showed that teens are engaged and interested in interacting even with very simple and low-fidelity prototypes. Our design challenge will remain for how to create a robot that evokes feelings of cuteness that is resonates with teens.

5.1.3. Initial engagement and potential for data collection

We witnessed strong individual interaction with the EMAR, but also strong peer-to-peer interactions as a result of the prototype. This phenomenon of increasing social interactions when in the presence of robots has been well documented [10] and is the basis for the powerful impact social robots have on children with autism [37, 64, 65]. Based on observing participants' initial engagement with the low fidelity prototype, there is evidence to suggest that even a simple, low fidelity version of a robot is a novel and engaging way to potentially collect stress data. Participants as a whole were eager and interested in the EMAR group. In each group, we observed both individuals and groups of students enthusiastically interacting, laughing, and following the touch screen prompts. Initially, we had wondered if teens would think the robot was not interesting, boring or even a silly idea. However, we found no evidence that this was the case. They consistently had positive comments about EMAR and mentioned its "cuteness." We acknowledge that issues of novelty might be in play that these results may be attributed to first time use. Therefore, it will be important to investigate how these impressions and interactions change over time after extended interactions with the robot.

5.1.4. Challenges for embodiment: durability in school settings

Teens in the design session mentioned the challenges of a small robot in a busy school setting. While they had also reacted to the prototype positively and referred to it as cute, it brings up a future design challenge for our team. How do we create a robot that is durable for a school environment and one that teens can interact with in a way that is physically comfortable way, without too much stooping or bending? Simultaneously, how do we keep the positive cute factor of the initial prototype as we scale up to a more substantial and therefore durable size?

5.2 Race and gender

A variety of studies have looked at the impact of gender on the design, interaction and expectations of humanoid robots [12, 55, 67] and have found that gender cues in the design of robots, such as ones that are performed via voice and embodiment have an impact on human-robot interaction. In this study, we noted that participants did not provide explicitly gendered cues in their own robot drawings or storyboards. Therefore, in the design of the prototype, the design team intentionally tried to create a robot that was gender neutral using a higher pitch, but robotic voices and a boxy, simple body to attempt to not conform to particular gender expectations. However, in interacting with the robot, participants tended to use a variety of pronouns, most commonly "he" or "it."

Further, the findings related to notions of race were striking. While the participants of the groups were primarily white, they did not comment about the robot's "race" per se, instead, there were several comments about the robot Pepper, who is a glossy, technical white, was described as "high-tech" or "medical". In contrast, group number 2, which was a group of teens from a variety of racial and ethnic groups, made comments that specifically commented on EMAR's "race". These students read a robot encased in a black body was, racially, black and they responded positively to this perception.

While there are a variety of scholars discussing gender and robots, research related to race and robots is sparse outside of the idea that robots may be conceptualized as belonging to their own race [19] or discussions in science fiction studies about robots as a metaphor for a post-racial society [9]. However, this study suggests that robots may be perceived as being part of a racial or ethnic group. While the data is limited, this area of inquiry is one that will be fruitful to examine in further detail. Specially, how do certain groups perceive the race of a robot and what is the impact of that perception on first time and long-term interaction and engagement.

6. Implications and limitations

In this section, we discuss the implications for the results of this study and in regards to design and methods of considering engagement between robots and teens. We also reflect on the limitations of the study and share areas for future work.

In terms of design, the results of this study suggest that teens are a unique population and have opinions and impressions of existing robots that differ from children and adults. Therefore, as with other unique populations, their needs should be taken into account throughout the design process. Several valuable findings from the study are directly informing the design of EMAR, the robot our team is designing namely, the specific need to design for cute and avoid the uncanny valley by designing a relatively small robot that is more mechanical than humanoid. In addition, findings related to race and gender point to the need to be sensitized and make thoughtful choices about how the robot is perceived and received by a particular group.

In terms of methods, the study demonstrates that participatory design, used with groups of socially connected teens, is an effective and engaging way to elicit design input from this population. Within a relatively short amount of time, our team gathered a host of valuable data from teens by engaging them in hands on activities like the robot sketches, storyboards, and the interactive sessions with the robots. We conclude from this experience that design research with teens needs to work in two ways. It is both helpful to gather input from teens, but also in a way that provides them an opportunity to be co-creators and co-meaning makers.

The study had several limitations. While this project is in its nascent stages, it is clear that participatory design sessions are the first step in the process of designing for long term engagement between teens and robots. In the study, we conducting design sessions with three different groups of socially connected teens. While there were common themes across the three groups, there was also a great deal of diversity in terms of thoughts about how the robot would inhabit a particular school space. There were also limitations in the robot prototype that we presented in the second and third groups. While low fidelity prototypes are helpful in early design stages, the robot will need additional fidelity and functionality to gather meaningful feedback. Finally, the study focused primarily on existing conceptions of robots and initial interactions with a robot prototype. To truly understand long term engagement with robots, it will be necessary to investigate a longer-term engagement to see how a group of teens engages with a robot over time.

In terms of future work, the next step in this study is to continue to develop a higher fidelity version of the prototype and investigate its use and engagement longitudinally through a year-long pilot in a public urban high school. In addition, research areas for investigation include how to design long term, engaging interactions with a social robot for teens and how to gather and reflect back aggregate stress data for teens and schools.

8. CONCLUSIONS

In conclusion, the paper contributes to the growing fields of social robotics, human robot interaction, and provides preliminary and much needed adolescent impressions of social robots and their design. By utilizing human-centered design to develop a better understanding of the responses and the views of teens we can ensure development or appropriate and likable robots for this specific population.

ACKNOWLEDGEMENTS

We would like to thank all the participants, their parents, and teachers for participating in this research project and taking times out of their busy lives to share their thoughts and opinions with us. We would also like to thank the lead engineer on the first iteration of EMAR, Kristine Kohlhepp, who took an amorphous set of design requirements and brought EMAR to life. We would also like to thank Andrew Davidson and the Human Centered Design & Engineering Department at the University of Washington Seattle for their ongoing support of this project.

REFERENCES

[1] Argyle, M. 1988. *Bodily communication.*

[2] Arnsten, A.F. and Shansky, R.M. 2004. Adolescence: Vulnerable Period for Stress- Induced Prefrontal Cortical Function? Introduction to Part IV. *Annals of the New York Academy of Sciences.* 147, 1021 (2004), 143–147.

[3] Association, A.P. 2013. *Stress in America 2013 Highlights: Are Teens Adopting Adults' Stress Habits.*

[4] Bainbridge, W.A. et al. 2011. The Benefits of Interactions with Physically Present Robots over Video-Displayed Agents. *International Journal of Social Robotics.* 3, 1 (Jan. 2011), 41–52.

[5] Bickmore, T.W. and Picard, R.W. 2005. Establishing and maintaining long-term human-computer relationships. *ACM Transactions on Computer-Human Interaction.* 12, 2 (2005), 293–327.

[6] Bjertness, E. et al. 2010. Response rates and selection problems, with emphasis on mental health variables and DNA sampling, in large population-based, cross-sectional and longitudinal studies of adolescents in Norway. *BMC Public Health.* 10, 1 (Dec. 2010), 602.

[7] Bjögvinsson, E. et al. 2012. Design Things and Design Thinking: Contemporary Participatory Design Challenges. *Design Issues.* 28, 3 (2012), 101–116.

[8] Boys, A. et al. 2003. Minimizing respondent attrition in longitudinal research: Practical implications from a cohort study of adolescent drinking. *Journal of Adolescence.* 26, 3 (Jun. 2003), 363–373.

[9] Brayton, S. 2008. The Post-White Imaginary in Alex Proyas's "I, Robot." *Science Fiction Studies.* 35, 1 (2008), 72–87.

[10] Breazeal, C.L. 2002. *Designing sociable robots.* MIT Press.

[11] Buxton, B. 2007. *Sketching User Experiences.*

[12] Carpenter, J. et al. 2009. Gender representation and humanoid robots designed for domestic use. *International Journal of Social Robotics.* 1, 3 (2009), 261–265.

[13] Cheng, K. 2012. *See What I Mean: How to Use Comics to Communicate Ideas.* Rosenfeld Media.

[14] Chung, M. et al. 2015. Exploring the Potential of Information Gathering Robots. *Proceedings of the Tenth Annual ACM/IEEE International Conference on Human-Robot Interaction Extended Abstracts* (New York, New York, USA, 2015), 29–30.

[15] Collins, C. et al. 2015. Therabot™. *Proceedings of the Tenth Annual ACM/IEEE International Conference on Human-Robot Interaction Extended Abstracts - HRI'15 Extended Abstracts* (New York, New York, USA, 2015), 307–307.

[16] Comito, C. et al. 2016. Psychological and symbolic determinants relating to the first meeting with a humanoid robot. *Annals of physical and rehabilitation medicine.* 59S, (Sep. 2016), e87.

[17] Cornwell, P. 2016. Schools create moments of calm for stressed-out students. *Seattle Times.*

[18] Denzin, N.K. and Lincoln, Y.S. 2011. *The Sage handbook of qualitative research.* Sage.

[19] Duffy, B.R. 2003. Anthropomorphism and the social robot. *Robotics and Autonomous Systems.* 42, 3–4 (2003), 177–190.

[20] Dunton, G. et al. 2016. Momentary Assessment of Psychosocial Stressors, Context, and Asthma Symptoms in Hispanic Adolescents. *Behavior modification.* 40, 1–2 (Jan. 2016), 257–80.

[21] Dwyer, L. When Anxiety Hits at School. *The Atlantic.*

[22] Eiland, L. and Romeo, R.D. 2013. Stress and the developing adolescent brain. *Neuroscience.* 249, 212 (2013), 162–71.

[23] Fong, T. et al. 2003. A survey of socially interactive robots. *Robotics and Autonomous Systems.* 42, 3 (2003), 143–166.

[24] Freedenberg, V. a. et al. 2015. A Pilot Study of a Mindfulness Based Stress Reduction Program in Adolescents with Implantable Cardioverter Defibrillators or Pacemakers. *Pediatric Cardiology.* 36, 4 (2015), 786–795.

[25] Gee, F.C. et al. 2005. Uncanny valley revisited. *Proceedings - IEEE International Workshop on Robot and Human Interactive Communication* (2005), 151–157.

[26] Goodrich, M.A. and Schultz, A.C. 2007. Human-Robot Interaction: A Survey. *Foundations and Trends® in Human-Computer Interaction.* 1, 3 (2007), 203–275.

[27] Hamilton, J.L. et al. 2015. Stress and the Development of Cognitive Vulnerabilities to Depression Explain Sex Differences in Depressive Symptoms during Adolescence. *Clinical psychological science : a journal of the Association for Psychological Science.* 3, 5 (2015), 702–714.

[28] Hornbæk, K. 2006. Current practice in measuring usability: Challenges to usability studies and research. *International Journal of Human Computer Studies.* 64, 2 (2006), 79–102.

[29] Huang, J. and Lau, T. 2016. Design and Evaluation of a Rapid Programming System for Service Robots. *Proceedings of the 11th ACM/IEEE International Conference on Human Robot Interaction.* (2016), 295–302.

[30] Jokela, T. et al. 2003. The standard of user-centered design and the standard definition of usability: Analyzing ISO 13407 against ISO 9241-11 - University of Washington. *ACM International Conference Proceeding Series* (2003), 53–60.

[31] Jungk, R. and Muller, N. 1987. *Future Workshops: How to Create Desirable Futures.* Institute for Social Interventions.

[32] Kanda, T. et al. 2007. A two-month field trial in an elementary school for long-term human-robot interaction. *IEEE Transactions on Robotics* (Oct. 2007), 962–971.

[33] Kanda, T. et al. 2004. Interactive Robots as Social Partners and Peer Tutors for Children: A Field Trial. *Human-Computer Interaction.* 19, 1 (Jun. 2004), 61–84.

[34] Kann, L. et al. 2002. An assessment of the effect of data collection setting on the prevalence of health risk behaviors among adolescents. *J.Adolesc.Health.* 31, 4 (2002), 327–335.

[35] Kauts, A. and Sharma, N. 2009. Effect of yoga on academic performance in relation to stress. *International journal of yoga.* 2, 1 (Jan. 2009), 39–43.

[36] Khor, A.S. et al. 2014. Feasibility and validity of ecological momentary assessment in adolescents with high-functioning autism and Asperger's disorder. *Journal of adolescence.* 37, 1 (Jan. 2014), 37–46.

[37] Kim, E.S. et al. 2013. Social robots as embedded reinforcers of social behavior in children with autism. *Journal of Autism and Developmental Disorders*. 43, 5 (May 2013), 1038–1049.

[38] Kincheloe, J.L. 2001. Describing the Bricolage: Conceptualizing a New Rigor in Qualitative Research. *Qualitative Inquiry*. 7, 6 (2001), 679–692.

[39] Leite, I. 2013. Long-term Interactions with Empathic Social Robots. 1, 3 (2013), 1–228.

[40] Leonard, N.R. et al. 2015. A multi-method exploratory study of stress, coping, and substance use among high school youth in private schools. *Frontiers in Psychology*. 6, (Jul. 2015), 1028.

[41] Leonard, N.R. et al. 2015. A multi-method exploratory study of stress, coping, and substance use among high school youth in private schools. *Frontiers in psychology*. 6, (2015), 1028.

[42] Leonard, N.R. et al. 2015. A multi-method exploratory study of stress, coping, and substance use among high school youth in private schools. *Frontiers in psychology*. 6, (2015), 1028.

[43] Luger, E. and Sellen, A. 2016. "Like Having a Really Bad PA": The Gulf between User Expectation and Experience of Conversational Agents. *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems - CHI '16*. (2016), 5286–5297.

[44] Mara, A. and Hawk, B. 2009. Posthuman Rhetorics and Technical Communication. *Technical Communication Quarterly*. 19, 1 (Dec. 2009), 1–10.

[45] McEwen, B. and Dhabhar, F. 2002. Stress in Adolescent Females: Relationship to Autoimmune Diseases. *Journal of Adolescent Health*. 30S, 1 (2002), 30–36.

[46] McNely, B.J. and Rivers, N.A. 2014. All of the things: Engaging complex assemblages in communication design. *Proceedings of the 32nd ACM International Conference on The Design of Communication CD-ROM* (ACM, Jan. 2014), 7.

[47] Minnis, A.M. and Padian, N.S. 2001. Reliability of adolescents' self-reported sexual behavior: A comparison of two diary methodologies. *Journal of Adolescent Health*. 28, 5 (2001), 394–403.

[48] Moore, G.F. et al. 2015. Process evaluation of complex interventions: Medical Research Council guidance. *BMJ*. 350, mar19 6 (Mar. 2015), h1258–h1258.

[49] Mori, M. 1970. The uncanny valley. *Energy*. 7, 4 (1970), 33–35.

[50] Morreall, J. 1991. Cuteness. *The British Journal of Aesthetics*. 31, 1 (1991), 39–47.

[51] Motti, V.G. and Caine, K. 2016. Smart Wearables or Dumb Wearables?: Understanding How Context Impacts the UX in Wrist Worn Interaction. *Proceedings of the 34th ACM International Conference on the Design of Communication* (New York, NY, USA, 2016), 10:1--10:10.

[52] Muller, M.J. 2003. Participatory design: The third space in HCI. *Human-Computer Interaction Handbook*. 4235, (2003), 1051–1068.

[53] Norman, D.A. 2014. Some Observations on Mental Models. *Mental Models*. 7–14.

[54] Pope, D.C. and Simon, R. 2005. Help for Stressed Out Teens. *Educational Leadership*. 62, 7 (2005), 33–37.

[55] Powers, A. et al. 2005. Eliciting information from people with a gendered humanoid robot. *Proceedings - IEEE International Workshop on Robot and Human Interactive Communication*. 2005, (2005), 158–163.

[56] Quesenbery, W. and Brooks, K. 2010. *Storytelling for User experience: Crafting Stories for Better Design*.

[57] Redish, J. 2010. Technical communication and usability: Intertwined strands and mutual influences. *IEEE Transactions on Professional Communication*. IEEE.

[58] Rew, L. et al. 2014. A Systematic Review of Interventions to Reduce Stress in Adolescence. *Issues in Mental Health Nursing*. 35, 11 (2014), 851–863.

[59] Robins, B. et al. 2005. Robotic assistants in therapy and education of children with autism: can a small humanoid robot help encourage social interaction skills? *Universal Access in the Information Society*. 4, 2 (Dec. 2005), 105–120.

[60] Rogers, M. 2012. Contextualizing Theories and Practices of Bricolage Research Contextualizing Theories and Practices of Bricolage Research. 17, 48 (2012), 1–17.

[61] Rose, E.J. and Walton, R. 2015. Factors to Actors: Implications of Posthumanism for Social Justice Work. *Proceedings of the 33rd Annual International Conference on the Design of Communication*. (2015), 33:1--33:10.

[62] Rosiek, A. et al. 2016. Chronic Stress and Suicidal Thinking Among Medical Students. *International journal of environmental research and public health*. 13, 2 (Jan. 2016).

[63] Sabelli, A.M. et al. 2011. A conversational robot in an elderly care center. *Proceedings of the 6th international conference on Human-robot interaction - HRI '11* (New York, New York, USA, 2011), 37.

[64] Scassellati, B. 2007. How social robots will help us to diagnose, treat, and understand autism. *Robotics research*. M. Kaneko and Y. Nakamura, eds. Springer. 552–563.

[65] Scassellati, B. et al. 2012. Robots for Use in Autism Research. *Annu. Rev. Biomed. Eng*. 14, (2012), 275–94.

[66] Severinson-Eklundh, K. et al. 2003. Social and collaborative aspects of interaction with a service robot. *Robotics and Autonomous Systems*. 42, 3 (2003), 223–234.

[67] Siegel, M. et al. 2013. Persuasive Robotics : the influence of robot gender on human behavior The MIT Faculty has made this article openly available . Please share Citation Accessed Citable Link Detailed Terms Persuasive Robotics : The Influence of Robot Gender on Human Behavior. (2013).

[68] Silk, J.S. et al. 2011. Daily emotional dynamics in depressed youth: a cell phone ecological momentary assessment study. *Journal of experimental child psychology*. 110, 2 (Oct. 2011), 241–57.

[69] Spies Shapiro, L.A. and Margolin, G. 2014. Growing Up Wired: Social Networking Sites and Adolescent Psychosocial Development. *Clinical Child and Family Psychology Review*. 17, 1 (2014), 1–18.

[70] Spinuzzi, C. 2005. The Methodology of Participatory Design. *Technical Communication*. 52, 2 (2005), 163–174.

[71] Stress in Schools: Seeking Solutions: 2007. .

[72] Sullivan, P. 1989. Beyond a Narrow Conception of Usability Testing A RATIONALE FOR BROADENING USABILITY. *IEEE Transactions on Professional Communication*. 32, 4 (Jan. 1989), 256–264.

[73] Szabó M 2010. The short version of the Depression Anxiety Stress Scales (DASS-21): factor structure in a young adolescent sample. *Journal of Adolescence*. 1, 33 (2010).

[74] Tan, P.Z. et al. 2012. Emotional reactivity and regulation in anxious and nonanxious youth: a cell-phone ecological momentary assessment study. *Journal of child psychology and psychiatry, and allied disciplines*. 53, 2 (Feb. 2012), 197–206.

[75] Tham, J.C.K. 2016. Globally Fit: Attending to International Users and Advancing a Sociotechnological Design Agenda for Wearable Technologies. *Proceedings of the 34th ACM International Conference on the Design of Communication* (New York, NY, USA, 2016), 2:1--2:9.

[76] Trapl, E.S. et al. 2005. Use of audio-enhanced personal digital assistants for school-based data collection. *Journal of Adolescent Health*. 37, 4 (2005), 296–305.

[77] Vogel, S. and Schwabe, L. 2016. Learning and memory under stress: implications for the classroom. *npj Science of Learning*. 1, April (Jun. 2016), 16011.

[78] Wada, K. et al. 2005. Psychological and social effects of one year robot assisted activity on elderly people at a health service facility for the aged. *Proceedings - IEEE International Conference on Robotics and Automation* (2005), 2785–2790.

[79] Wada, K.. and Shibata, T.. 2007. Living With Seal Robots—Its Sociopsychological and Physiological Influences on the Elderly at a Care House. *IEEE Transactions on Robotics*. 23, 5 (Oct. 2007), 972–980.

[80] Wainer, J. et al. 2006. The role of physical embodiment in human-robot interaction. *Proceedings - IEEE International Workshop on Robot and Human Interactive Communication* (2006), 117–122.

[81] Ware, J. 2014. Social Norms Influence Student Journalists' Perception of Wearable Technologies. *Proceedings of the 32Nd ACM International Conference on The Design of Communication CD-ROM* (2014), 23:1--23:2.

[82] Wood, L.J. et al. 2013. Robot-mediated interviews--how effective is a humanoid robot as a tool for interviewing young children? *PloS one*. 8, 3 (Mar. 2013), e59448.

[83] Young, C.C. and Dietrich, M.S. 2015. Stressful Life Events, Worry, and Rumination Predict Depressive and Anxiety Symptoms in Young Adolescents. *Journal of Child and Adolescent Psychiatric Nursing*. 28, 1 (2015), 35–42.

[84] Young, I. 2008. *Mental Models: Aligning Design Strategy with Human Behavior*.

[85] 2014. *American Psychological Association Survey Shows Teen Stress Rivals That of Adults*.