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Using Robot Animal Companions in the Academic Library to Mitigate Student Stress

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Abstract

Purpose: The purpose of this paper is to interrogate the relationship between self-reported levels of acute stress, perceived social support, and interactions with robot animals in an academic library. The authors hypothesized: 1. participants would report lower stress and higher positive affect after their interaction with a robot support animal; 2. perceived supportiveness of the robot support animal would positively predict the amount of stress reduction the participants reported.

Design/methodology/approach: The authors hosted a robot petting zoo in the main library at a large Midwestern university during finals week. Participants were asked to rate their stress level prior to interacting with the robot pets (T1) and then after their interaction they were asked about their current stress level and the perceived supportiveness of the robot animal (T2). Data were analyzed using paired samples *t* tests for the pretest and posttest scores.

Findings: The results showed a significant decrease in acute stress between T1 to T2, as well as a significant increase in happiness and relaxation. Participants reported feeling less bored and less tired after their interactions with the robot support animals. The findings also reveal that the degree to which individuals experienced a reduction in stress was influenced by their perceptions of the robot animal's supportiveness. Libraries could consider using robot pet therapy.

Originality: This study reveals the benefit of robot support animals to reduce stress and increase happiness of those experiencing acute stress in a library setting. The authors also introduce the concept of socially supportive contact as a type of unidirectional social support.

Using Robot Animal Companions in the

Academic Library to Mitigate Student Stress

Introduction

Final exam periods are a significant source of stress for college students (Barker et al., 2016) and many students make use of university library resources during this time (e.g., space, technology access, textual materials, and support services). The purpose of this study is to determine whether and how much an interaction with a robot companion animal in the university library would reduce students' stress levels and boost their moods. Libraries are a logical location for showcasing new technology to serve student needs on campus. The introduction of makerspaces, fab labs, augmented and virtual reality labs, and endeavors such as experimenting with social robots, have become visible in recent years (Guth and Vander Meer, 2017). Advantages of using library space for this purpose includes centrality, long hours, and accessibility for a wide range of patrons (Little, 2014). This practice also reflects an overall trend of greater collaboration by academic libraries within higher education (ACRL Research Planning and Review Committee, 2016). Additionally, libraries 1) are open and well-staffed during the evening and weekend hours, 2) offer both a serious and casual atmosphere to students since they often contain designated areas for each (i.e., technology labs, quiet study spaces, cafes, popular reading areas) and 3) serve students from multiple disciplines and seek to create an inclusive and safe space for students across identity groups, increasing the availability of a heterogeneous group of participants.

At the same time, many academic libraries offer targeted services that address student needs at different times in the semester, particularly final exams week. Often these final exams week events are designed to offset some of the pressure of exams, provide snacks and social time, or offer a place to relax. It is during this time that college students experience higher levels of stress. To combat these higher levels of stress, some libraries have experimented with the introduction of live animals such as dogs and cats (Haggerty & Mueller, 2017). However, live animals provide unique challenges in regards to an academic setting due to health issues, safety of the animals, and general liability of the institution. Because social robots have long been examined for potential use in a college education setting (Authors, et al., 2019, Authors et al., 2018, Authors, et al., 2016), we sought to use robot animals for a similar purpose in a library setting. Ling and Björling (2020) note, "With the prevalence of mental health problems today, designing human-robot interaction for mental health intervention is not only possible, but critical" (p. 133). This field experiment examined the impact of using animal companion robots in the academic library to help reduce college student stress. In the following sections, we will discuss college student stress, socially supportive contact, and the impact of companion animals to reduce stress and provide support. Finally, we will examine the use of robot animals in various contexts and offer the study's hypotheses.

Review of Literature

College Student Stress

The prevalence of stress during a college student's life is an important consideration to understand their well-being and life satisfaction (Delgado et al., 2018). Previous studies have shown that the vast majority of college students are moderately stressed (Pierceall & Keim, 2007). Often this stress is due partially to this time of transition in a student's life (Coccia and Darling, 2016). Emerging adulthood may play an important part in the prevalence of stress during these times (Arnett, 2000). It is during emerging adulthood that students learn to be separated from their families of origin, develop romantic and friend relationships, and consider their future careers.

Students face multiple stressors during college. For instance, final exams are a significantly stressful time period for college students (Barker et al., 2016). There has been a reported increase in depression and tension during stressful times in a college (Gilbert et al., 2009). To help alleviate stress among students, universities are seeking ways to provide support services. Some universities are using yoga (Malathi and Damodaran, 1999) and mindfulness training (Byrne, et al., 2013, Shapiro, et al., 1998) to help reduce stress and anxiety among students. Byrne et al. (2013) reported large effect sizes for interventions involving mindfulness training to reduce anxiety and depression in college students. However, these techniques require skilled instructors. As such, institutions have been seeking out alternative means that are easier and more cost-effective to help influence student wellness by reducing stress. Recently, universities have been using pet therapy as a strategy to increase student well-being during stressful times in a college experience. In the following sections, we will discuss how pet therapy has been utilized to provide social support. We will then explore the use of therapy robots for similar outcomes.

Socially Supportive Contact

In this study, we define social support as an interpersonal resource that is appraised and delivered through interactions with others (see Albrecht et al., 1992). Socially supportive interactions offer a host of benefits to college students that include buffering against stress (Zaleski et al., 1998), boosting performance (Nicpon et al., 2006), and decreasing loneliness (Mattanah et al., 2010). In fact, research in this area suggests that receiving stress-reducing support can influence psychological well-being (Moore, 2018) and even physical health

(Brashers et al., 2004). Researchers have also found that the perceived availability of support (i.e., am I able to get support if I need it) can be influential and offer similar psychological benefits to those who actually receive support (Collins and Feeney, 2004). Studies show that the availability of social support can reduce the physical symptoms of anxiety (Lepore et al., 1993), allow a person to recover from stress more quickly (Priem and Solomon, 2018), and attenuate the damage of traumatic experiences (Pietrzak et al., 2009). The feeling that support is accessible through one's network offers a range of tangible, interpersonal benefits.

People are not always able to be physically present to offer support. To address that issue, individuals may employ surrogates to stand in for the lack of physical presence they feel from their conversational partner. For example, Sumioka et al. (2013) asked two groups of people to have a conversation with a stranger over the phone. One group simply chatted with the person while holding their phone and the other group was asked to hug a "human-shaped cushion" (p. 2) during the phone call. They found those in the pillow group showed a significant decrease in hormones related to stress (i.e., cortisol). The study suggests that mitigating stress is more than the availability of support, but may require some form of contact as well.

Providing social support can be labor intensive. Additionally, offering unidirectional, or unreciprocated support, is taxing for people (Gottlieb and Bergen, 2010). Engaging in *socially supportive contact*, interactions that include a reasonable expectation of support but may include limited or even one-way communication, may, however, offer some relief. Nonhuman actors such as animals or robots require less structured involvement, but still offer physical and psychological benefits (e.g., Pu et al., 2020). Interactive alternatives may offer people a genuine feeling of support while limiting the burden of unidirectional support from others. For example, animal therapies have been one alternative explored by researchers and practitioners.

Pet Therapies

There has always been a bond between people and their animals. Using this evolved bond, clinicians, therapists, and medical doctors have used animals to provide a means for aid which is loosely labeled pet therapy (Serpell, 2010). Pet therapy is the use of animals to aid in the physiological and psychological issues people face (Kamioka et al, 2014). For physiological uses, previous research has found therapeutic uses for companion animals when seeking to complement medical treatments such as cancer (Larson, et al., 2010), heart issues (Cole, et al., 2007), and palliative care (Harmon, 2019). For psychological issues, research has demonstrated that a human-animal bond can reduce anxiety, loneliness, and stress (Delgado et al., 2018; Krause-Parello, et al., 2012). In a large meta-analysis of 28 published studies, Ein et al., (2018) found that pet therapy can be used effectively at reducing stress reactivity.

Pet therapy can help alleviate college student stress and increase well-being (Delgado et al., 2018). Barker et al., (2016) demonstrated a reduction in perceived student stress during final exam time when students interacted with a therapy dog. This study demonstrated large effect sizes for decreased stress levels of participants after interaction with therapy dogs. Similarly, in a college counseling center context, students report having stress reduction after interacting with therapy dogs (Daltry and Mehr, 2015). Kurdek (2009) argues that college students will sometimes turn to their companion animals for comfort during stressful times. Because students are often separated from their companion animals during college, pet therapy sessions that are hosted by the university are often thought of as a way to assist students. Adamle, et al., (2009) reported that 96% of participants in their sample of college students reported being interested in pet therapy programs on campus. The data in this area have led many academic libraries, in particular, to begin actively hosting live pet therapy activities (Christensen, 2013; Haggerty and Mueller, 2017).

While the previous research is positive for the use of pet therapy, it does have some issues with liability and the well-being of the animals for the use in a college setting (Parshall, 2003). Individuals might have adverse health reactions to the animals ranging from allergies to previous negative interactions with animals (Perkins, 2020). As a result of potential problems, Daltry and Mehr (2015) recommend the use of certified therapy dogs because of the training these animals undergo for this type of support and context. Concerns that have been expressed in utilizing therapy animals in libraries have included behavior, health conditions of the animals, and accidents, many of which are issues to be addressed before considering a program and when gauging the trustworthiness of the animal providers (Jalongo and McDevitt, 2015). Because of these issues, we sought to conduct a field experiment using robot companion animals in a library setting to achieve positive outcomes.

Robot Companion Animals

The Computers are Social Actors (CASA) paradigm argues that people will mindlessly interact and treat computers as another social actor in analogous ways to how they treat another person (Nass and Moon, 2000; Reeves and Nass, 1996). Furthermore, CASA demonstrates that people apply social scripts in similar ways to computers as they do people (Gambino et al., 2020). While CASA was initially developed for interactions between humans and computers, recent research has been extended to human-robot interaction (HRI). Many studies have demonstrated that CASA can be applied to HRI and achieve parallel results (Authors, 2016a; Park, et al., 2011; Authors, 2018b; Authors, 2016b). Within the current study, the CASA paradigm would suggest that if pet therapy produces positive outcomes in the form of social support and stress reduction for college students, robot companion animals are likely to achieve similar results. In other words, if pet therapy can provide socially supportive contact, we predict that robot pet therapy will too.

Much research in HRI has focused on the verbal aspects of social robots; however, nonverbal communication can provide a crucial interface between humans and robots (Sidner et al., 2005). As part of nonverbal communication, the study of affective haptics (or touch) has been an important source of HRI in understanding how emotions can influence interaction (Bianchi et al., 2016). Social robots that can express emotions through haptics have been increasing in use. For example, Yohanan and MacLean (2012) created a social robot that simulates breathing movement, warmth, and purring for user touch. Sefidgar et al. (2015) even demonstrated a "calming effect" with this type of affective haptics. Other studies have used a stuffed teddy bear with vibration motors to create a purring effect. These robots were rated by participants as lively (Yoshida et al., 2016). While affective haptics is still an emerging field in HRI, there is evidence that touching a companion robot can be useful for some therapeutic uses. These robots can range from simple to complex, and research has demonstrated that simple robots can produce therapeutic advantages (Bucci et al., 2017).

Capitalizing on familiar zoomorphic designs, robot animals have been utilized as robot-assistants in therapies with older populations (Lazar et al., 2016). Melson et al., (2009) found that while people treat robot animals, which simulate live companion animals, as a piece of technology, they give them mental states as a social "other" in the interaction. Robot companion animals for therapeutic effects have been shown to reduce stress and pain and increase relaxation (Takayanagi et al., 2014). Sabanovic et al. (2013), using an in-home study with Paro the Seal, found that the positive impacts of a robot animal for nursing home patients were not due to short-term novelty effects but rather sustained interaction. Heerink et al., (2010) suggest that the use of robot-assisted therapy in the form of robot animals might be an alternative to older adults living with dementia. Banks et al. (2008) demonstrated that loneliness could be decreased through the use of robot dogs. Geva et al., (2020) found that touching a Paro Seal robot reduced pain perception in healthy young adults. While none of the current literature examined highlights the use of robot animals and college students for social support and general stress reduction, we can make general assumptions that robot animals would likely provide some positive contact as it does with real animals. The paradigm of the CASA backs this notion. Using a field experiment, we are investigating if short term interactions with robot companion animals can aid in reducing reported stress and provide socially supportive contact. To that end, we offer the following hypotheses:

H1: Participants will report lower stress and higher positive affect following interaction with robot companion animals.

H2: Perceived supportiveness of the robot companion animals will positively predict the amount of stress reduction.

Methods

Participants

The sample included 103 college students at a large, midwestern U.S. research university. The majority were women (*n* = 61, 59.2%), with fewer men (*n* = 26, 25.2%), nonbinary/gender fluid people (n = 3, 2.9%), and those who preferred to not indicate their gender (*n* = 13, 12.6%). In terms of ethnicity, a majority identified as White or Caucasian (*n* = 54, 52.4%), followed by Black or African-American (*n* = 14, 13.6%), Hispanic or Latinx (*n* = 10, 9.7%), Asian or Pacific Islander (*n* = 4, 3.9%), bi- or multi-racial (*n* = 8, 7.8%), and those who opted to not answer (*n* =

13, 12.6%). Student participants were relatively equally dispersed among first-year (*n* = 23, 22.3%), sophomore (*n* = 25, 24.3%), junior (*n* = 24, 23.3%), and senior (*n* = 16, 15.5%) status, with fewer graduate students (*n* = 2, 1.9%), "others" (*n* = 1, 1.0%), and those who did not indicate (*n* = 12, 11.7%).

Most participants (76.7%) reported spending 1-10 minutes interacting with the robot animals, with fewer spending 11-20 minutes (20.4%) or longer (2%). Some participants opted to interact only with a robot cat (*n* = 8, 7.8%) or a robot dog (*n* = 18, 17.5%), but most participants interacted with both robot cats and dogs (*n* = 76, 73.8%). These percentages were in rough alignment with participants' reported liking of real animal cats (4.9%), dogs (26.2%), both (65%), and neither (3.9%). Table 1 displays participants' mean impressions of the robot animals, as evaluated on 7-point semantic differentials. Generally, participants rated the robot animals as comforting and caring, but also as strange. Their perceptions of life-likeness and supportiveness were near the scale mid-points. See Table 1.

{See Table 1}

Experimental Setting

This field experiment took place in the main library of a U.S. midwestern research university that serves a student body of around 21,000 students. We planned a "robot petting zoo" on the entry floor to be held for two hours on each of two subsequent evenings during the beginning of final exams week in the fall 2019 academic term. The event was intended to serve as a fun diversion for students but also as a means of exploring the effects of interacting with the robot animals through an optional research study.

Procedures

Upon securing institutional review board approval, we conducted a pretest/posttest quasi-experiment in which we exposed volunteer student participants to the "robot petting zoo" experience, measuring their self-reported stress and affect at Time 1 (T1), prior to the interaction, and Time (T2), following the interaction. The research design was a field experiment in the sense that we manipulated an independent variable (exposure to human-robot interaction), but did so in a natural setting that did not allow full control of all extraneous variables that may have influenced results. It was a quasi-experiment in the sense that participants were not randomly assigned to the treatment and compared against a control group; rather, they volunteered to take part in the interaction.

{insert Figure 1 about here}

Because this study occurred in the public setting of a university main library, we aimed to control as much of the environment as possible. The university library prepared a small area for students to interact with the robot cats and dogs. This area was on the main floor near the entrance to the library. In this area, we arranged couches, chairs, and small tables and placed nine robot cats and dogs around the area for interaction. The entire area was roped off to create a space separate from the other student areas, concessions, and resources located on that floor. At the entrance to the interaction area, approaching students were given a consent form and the option to choose to participate in the study or to simply enter the space and interact with the robot animals.

After providing informed consent, those students who opted to participate in the study (almost all approaching students chose to participate) were seated in a make-shift waiting area and given a brief T1/pretest questionnaire to report their current levels of stress, subjective feelings, and anticipated comfort interacting with the robot animals. Afterward, they entered the interaction area and could choose to interact with a robot cat or dog (or both). They were informed that they could spend as little or as much time in the space as they liked. They were not given any instructions on how to interact with the robot animals, but rather were free to engage however they chose.

After the interaction, as participants left the area, they were given T2/posttest measures and were thanked for their time in the study. The posttest questionnaire requested (a) T2 assessments of stress, subjective feelings and comfort, (b) information about their interaction choices (time spent in area, choice of robot, liking of live dogs and cats), (c) impressions of the robot animal(s) with which they interacted and the experience itself (d) demographic information for sample description purposes, and (e) library assessment information (e.g., "What other types of events would you like the library to hold during final exams week?"). The assessment information was not analyzed as part of this study, but appears, alongside commentary on the working partnership between the social robots lab and university library in (Authors et al., 2020a) and (Authors et al., 2020b).

Apparatus

Nine of Hasbro's Joy For All Companion Pets (5 cats and 4 dogs) were utilized in the study. These life-size animal simulations are battery-operated and have built-in sensor technology enabling them to respond to petting, movement, and voice. They mimic the look and feel of live animals, including realistic fur, motion, and periodic vocalizations.

{insert Figure 2 about here}

Instruments

At T1/pretest and T2/posttest, self-report ratings of stress, subjective feelings, and comfort with the human-robot interaction were collected. Stress was measured with a Likertstyle item asking participants to rate how they currently felt from 1 (*Not At All Stressed*) to 5 (*Very Stressed*). Subjective feelings were assessed with 5 semantic differential items asking participants to indicate their present states on 7-point scales (*Happy/Sad*, *Relaxed/Stressed*, *Bored/Overwhelmed*, *Supported/Alone*, *Rested/Exhausted*). Anticipated (T1/pretest) and actual (T2/posttest) comfort ratings ranged from 1 (*Not At All Comfortable*) to 5 (*Very Comfortable*) in response to the question "How comfortable do you think you'll be [were you] when interacting with the robot animals?"

Impressions of the robots were measured (at T2/posttest) with five semantic differential items rated along 7-point scales: The robot animal was (*Not Comforting/Comforting*, *Strange/Normal, Not Life-like/Life-like*, *Unsupportive/Supportive*, *Uncaring/Caring*). Two open-ended questions asked participants to (1) reflect on and describe their experience and to (b) describe the units with which they interacted.

Results

To determine whether participants' reported levels of stress and affect changed significantly after their interactions with the robot animals (H1), we conducted a series of paired samples *t* tests on the dependent variables to compare T1/pretest versus T2/posttest scores. For all dependent variables, participants' T1 and T2 scores were significantly correlated. See Table 2.

{See Table 2}

Results of the paired samples *t* tests demonstrated that there was a significant change in stress and affect following interaction with the robot animals. See Table 3. Reported stress was significantly lower at T2 than at T1. In addition, participants at T2 rated themselves as significantly happier, more relaxed, less exhausted, and less bored than at T1. In addition, their actual comfort level interacting with the robot animals was significantly higher than what they anticipated. The effect sizes ranged from small (.20) to large (.70), with the greatest effects on levels of stress and relaxation. See Table 3.

{See Table 3}

To determine whether participants' perceptions of the social supportiveness of the robot animals predicted their degree of stress reduction (H2), we conducted a bivariate regression analysis. The predictor variable, perceptions of social supportiveness, was the mean of the three single-item ratings of the robots' perceived supportiveness, caring, and comforting. These three variables were significantly correlated (.37-.56), demonstrated a unidimensional factor structure (based upon visual inspection of the scree plot and Eigenvalues; 1.92, 63.98% variance), and had internal consistency, $\alpha = .72$ (scale $M = 4.60$, $SD = 6.24$). The criterion variable was change in stress, a gain score calculated by T1 stress - T2 stress scores. As predicted, perceptions of the robots' social supportiveness was a significant positive predictor of stress reduction, $\beta = .34$, t (92) = 4.441, $p < .001$, such that the more supportive the robot animals were perceived to be, the greater the reduction in stress following interaction. Perceived supportiveness explained a significant proportion of variance in stress reduction, $r^2 = .18$, F (1, 93) = 23.659, $p < .001$. Perceptions of social supportiveness also predicted gains in relaxation (T2 relaxed - T1 relaxed), $\beta = .496$, t (93) = 3.764, $p < .001$. The more supportive the robot animals were perceived, the greater the increase in reported relaxation [$r^2 = .13$, F (1, 94) = 14.164, $p < .001$].

Discussion

This field quasi-experiment investigated the effects of a brief human-robot animal interaction on college students' stress during an acute situation (final exams week). Building on previous research documenting the benefits of sustained contact with companion animals (both live and robotic) for clinical populations in times of chronic stress, long-term disability, and health conditions, we predicted that student participants' would report lower stress and higher affect after interacting with robot animals (H1), and that the more socially supportive the robot animals were perceived to be, the stronger the effects would be (H2).

Both hypotheses received support. After students engaged in a short interaction with animals in the "robot petting zoo," their reported stress, exhaustion, and boredom were significantly reduced, and their happiness and relaxation improved. The largest effects of the interaction were on stress and relaxation; both are key mood states to target during times of acute life pressure. These effect sizes are comparable to studies that have used live animals or other stress reduction techniques such as mindfulness. Additionally, these robot animals avoid liability and safety issues of using trained therapy dogs for limited exposure to help alleviate college student stress during exam weeks. In other words, this experiment demonstrates the practicality of utilizing robot animals to achieve similar impacts as real animals in this setting.

As expected, perceptions of supportiveness (the degree to which the robot animals were seen as supportive, comforting, and caring) could be used to predict the amount of stress reduction and relaxation following the interaction. These findings suggest that robots can provide socially supportive contact that helps mitigate acute stress. Even a brief, initial interaction with an animal companion robot produced a large stress relief and relaxation effect (d = .70 & .67).

The data imply that it was the contact with the robot pets that influenced participants' perceptions of support and contributed to their reports of lower stress levels and greater feelings of relaxation. The focus on this brief encounter as socially supportive contact extends the literature on CASA and HRI by showing that people are able to comingle the experiences of feeling uncomfortable and comforted by machines within the same interaction (e.g., "I was a little uncomfortable with the automated cat but it was also cute to me. It felt to me like I was petting a real cat in the way I felt more relaxed."). Additionally, scholars often conceptualize social support as an interpersonal construct that is understood to be reciprocal (Albrecht et al., 1992). The results in the current study, however, suggest that people were able to receive the benefits of social support from interpersonal contact with an entity that had no need for physical or emotional care from others.

In addition to the quantitative results, many participants also commented about reduced stress and improved mood in their responses to an open-ended request to "describe your feelings about the experience." For instance:

- "It lifted weights off my shoulders and made me happier to interact with them."
- "This small interaction actually improved my mood and decreased my stress and I would do this again given the opportunity."
- "It was relaxing being able to de-stress by petting the animals. It was a productive distraction."
- "Funny, I liked it a lot. I feel like we should have this a lot more on campus during stressful times."
- "Immediately happy. The cats purring was especially soothing and forgot about stresses, animals are amazing."

{insert Figure 3 about here}

Several participants focused on a special relationship with a particular robot animal. For example, one participant said, "I had a great experience. I made a special connection with a certain black and white cat. I named her Floofy. I felt very giddy and happy. I was sad to leave her." Another shared, "As soon as I touched one of the dogs (who I believe was asleep), the dog got super excited. That made me really happy. Just hearing the pets bark & meow relieved a lot of stress." As these comments illustrate, many participants linked positive effects to haptic exchange (petting, stroking, or holding) and interactive affect exchange (positive vocal and movement reactions to affective touch and speech).

Yet, not all participants found the experience pleasant. For a few, interacting with the robot animals was described as negative or unhelpful. In the words of one participant, "Feelings aren't a very useful way to describe my experience. I say I was mostly confused. Students who found themselves smiling and laughing at the toys were pretty annoying to me. I left with more cortisol in my system than when I entered." A second participant wrote, "I did not find the robots emotionally comforting, and really only stopped being uncomfortable when I started trying to analyze the engineering of it." Although the reactions were overwhelmingly positive, this sort of variation helps underscore the importance of perceptions of robot supportiveness to stress reduction and relaxation.

Implications

The results of this experiment are consistent with previous research demonstrating the emotional benefits of human-robot companionship (Lazar et al., 2016; Sefidgar et al.,2015) and human-animal therapy (Barker et al., 2016; Delgado et al., 2018). But, they also extend the literature in several ways. In terms of scholarly research, the results demonstrate that some of the benefits of HRI observed in studies of longer-term, in-home/residence use for chronic conditions may also extend to limited, short-term interactions in public spaces and for populations facing acute stressors. Rightly, many longitudinal HRI support studies are conducted to understand the effects of using socially and emotionally assistive robots over time and in intimate care contexts.

This has been an important step in teasing apart novelty effects of new technologies from the consequences of their sustained use.

Results of this experiment demonstrate that novelty effects may sometimes be productively leveraged rather than viewed as an obstacle preceding “true” interaction (see Smedegaard, 2019), especially when people need support for handling transitory versus chronic stress situations. In such cases, curiosity and novelty may actually facilitate the experience of a productive distraction from worries. Further, there are practical implications for public spaces like libraries, which often support populations undergoing localized stress, but may need to avoid the health and liability risks associated with live animal therapy and the sometimes prohibitive financial costs of autonomous humanoid robots. In fact, our results demonstrate that even minimally-engineered robot animal companions (Joy for All Companion Pets cost US$109.99, are battery operated, and use basic sensor technology, https://joyforall.com/products/companion-cats) afford a haptic and visual experience and sufficient responsiveness/interactivity to accrue social support benefits of HRI.

Limitations

This study has a few limitations that need to be taken into consideration. Namely, because this study took place in the field, typical experimental controls were not always possible. The field experiment took place in the naturalistic setting of a real library with students coming and going around our roped off interaction area. There was no random assignment to the treatment group and a control group was not possible. Any student could enter the space to take part in the study.

Many students took part with one or more of their friends or study group members, rendering this a social human experience, as well as a human-robot experience. Some students chose to lie on the floor amongst the robot animals, to take smiling selfies, or to film the robots. They could see and overhear the interactions occurring between other participants and robot animals. All of these co occurring factors could have influenced stress levels and general mood. Moreover, the mere fact of a distraction or a break from studying for final exams could have influenced results. Field experiments or studies "in the wild" have such threats to internal validity, but can also demonstrate results with higher levels of ecological validity. In other words, these conditions mirrored real-world incorporation of social robots into the lifeworld. Further, our results are similar to other studies with different populations.

Future Research

This field experiment involved determination of the effects of a brief, initial interaction with companion robot dogs and cats on student participants' stress and affect during final exams week. Although stress decreased, relaxation increased, and mood greatly improved immediately following the interaction, future research should seek to determine how long the effects persist. Further, future research should examine the impact of prolonged use of companion animal robots by college students, who face a number of localized stressors (deadlines, career choices, financial strain, interpersonal conflict) and are vulnerable to more persistent mental health conditions (loneliness, anxiety, depression) (Coccia and Darling, 2016). Emerging adulthood may play an important part in the prevalence of stress during these times while often separated from their primary human social support networks (Arnett, 2000). Examining the longer-term student wellness effects of human-robot animal companionship in their homes, residence halls, libraries, and classrooms is a promising line of inquiry, as previous research demonstrates the positive effects of longer exposure in other populations (Šabanović et al., 2013).

Future research might also productively incorporate other measures of stress and wellbeing. Whereas we employed self-report measures, biological markers might shed light on the more precise physiological mechanisms through which socially supportive contact with robot animals mitigates stress. Related, it is important to identify those factors explaining who is most likely to benefit from HRI in social support contexts in terms of their attitudes, cognition, and behavior related to the interaction.

Conclusion

Many academic libraries offer targeted services that address student needs, especially during high-stress periods like final exams week. Some libraries have offered students opportunities for comforting interaction with live animals such as dogs and cats. Despite their effectiveness in alleviating stress, interactions with live animals introduce potential health, safety, and liability issues to the academic setting. Social robots have emerged as accessible technologies with the potential to provide social support. The Computers are Social Actors paradigm posits that people respond to computer-based technologies in fundamentally social ways (Reeves and Nass, 1996). This quasi-experimental/field study examined the effects of robot animal companions on students' levels of stress and subjective wellbeing during final exams week. After student users (n = 103) of a university library engaged in a short interaction with animals in a "robot petting zoo," their reported stress, exhaustion, and boredom were significantly reduced, and their happiness and relaxation improved. The more supportive students perceived the robot animals to be, the greater their reduction in stress and their increase in relaxation. These findings suggest that an initial and short-term interaction with zoomorphic social robots can provide socially supportive contact that helps mitigate acute stress in public and social service spaces. Further research should be conducted on best contexts of use and practices for implementation and user experience.

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Table 1. Impressions of the Robot Animals

Variable	*M*	*SD*	*t* (*df*)	*p*
Not Comforting/Comforting	4.83*	1.72	4.874 (100)	<.001
Strange/Normal	3.44*	1.70	-3.313 (101)	.001
Not Life-like/Life-like	3.73	1.75	-1.536 (100)	.128
Unsupportive/Supportive	4.31	1.83	1.684 (100)	.095
Uncaring/Caring	4.68*	1.84	3.669 (98)	<.001

Note. *indicates mean is significantly different from scale midpoint (4.0 on 1-7 scale).

Table 2. Correlations between T1/Pretest and T2/Posttest Dependent Variable scores

Dependent Variable	Pearson's r
Feeling Stressed	.33**
Stressed/Relaxed	.46**
Sad/Happy	.46**
Bored/Overwhelmed	.25*
Alone/Supported	.48**
Exhausted/Rested	.47**

Note. * $p < .05$; ** $p < .001$

Table 3. Means and Standard Deviations of the Dependent Variables at Time 1 and Time 2

	T1 (pretest)	T2 (posttest)				
Variable	*M* (*SD*)	*M* (*SD*)	*t*	*df*	*p*	Cohen's *d*
Stressed	3.81 (1.04)	2.97 (1.02)	7.045	98	<.001*	.70
Happy	4.38 (1.50)	5.14 (1.74)	-4.396	98	<.001*	.44
Relaxed	4.97 (1.67)	3.85 (1.57)	6.581	97	<.001*	.67
Exhausted	3.30 (1.74)	3.93 (1.59)	-3.673	99	<.001*	.37
Bored	4.88 (1.58)	4.50 (1.28)	2.142	100	.035*	.21
Comfort	3.56 (1.10)	3.81 (1.13)	-2.012	100	.047*	.20

Note. * indicates a statistically significant difference in T1 and T2 scores at $p \leq .05$.

Note. Cohen's *d* $[(M_2 - M_1)/SD_{\text{pooled}}]$ of 0.2, 0.4, and 0.6 are generally interpreted as effect sizes of small, medium, and large magnitude.

Figure 1. Interaction Space

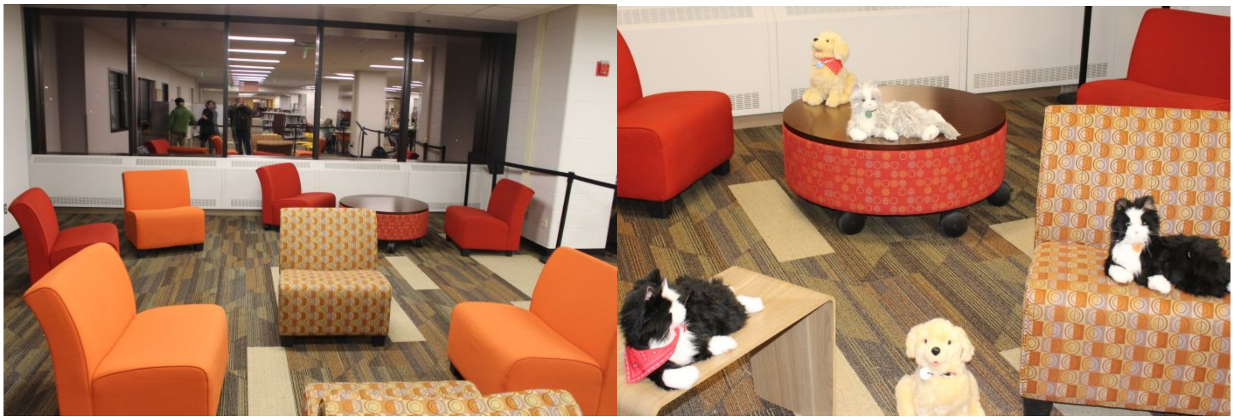

Figure 2. Joy for All™ Cat and Pup

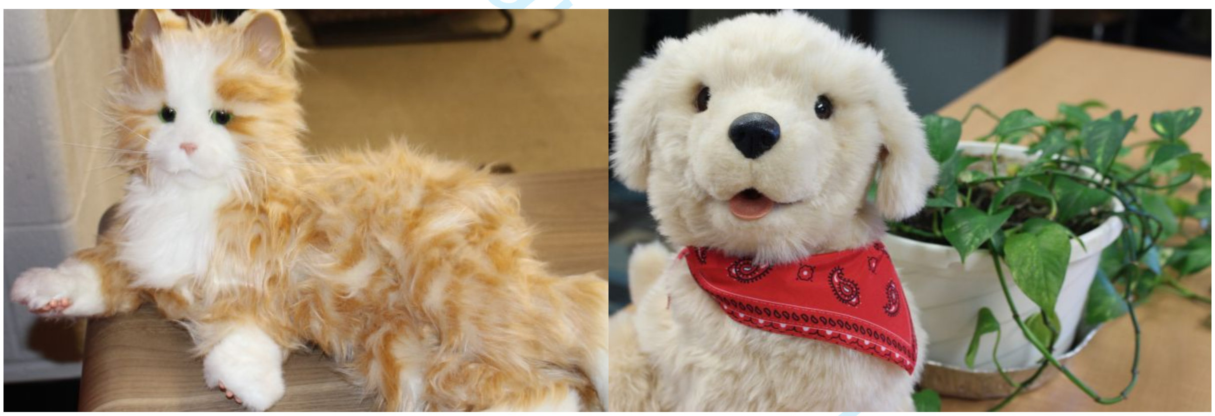

Figure 3. Research Assistant Interacting with Joy for All™ Pup