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Help please! Deriving social support from Geminoid DK, Pepper, and AIBO as companion robots

Abstract

Rooted in the Computers Are Social Actors (CASA) paradigm, this study explored the possibility of robots to serve as companions. Two research questions were investigated: (1) How do people's perceptions of companion robots help them obtain social support from the robots? (2) To what extent does robot appearance affect the relationship between people's perceptions of companion robots and social support? Three different robots were considered: Geminoid DK (a human-like robot), Pepper (a human/machine-like playful robot), and AIBO (a zoomorphic robot). A scenario-based online experiment (N=306) was conducted with robot appearance as a between-participants factor. Perceived anthropomorphism of robots had a negative curvilinear relationship with social support. Perceived safety was a significant mediator that explained the effects of perceived anthropomorphism on social support for all three robot types. The study further revealed how perceptions of a robot vary as a function of its appearance. Perceived likeability mediated the effect of perceived anthropomorphism on social support for Pepper but not for Geminoid DK or AIBO. The study adds to the human-robot interaction literature by revealing the underlying mechanism of how robots' perceived anthropomorphism predicts the extent to which they can offer social support as companions.

Keywords: companion robot; human-centered artificial intelligence; human-robot interaction; perceived social support; robot appearance; robot safety; social robot.

1. Introduction

Social support refers to individuals' experiences of being cared for and being responded to (Cobb, 1976). It is a major protective device against pressing public health problems such as depression, loneliness, and stress (Loveys et al., 2021). Traditionally, people sought social support from partners, family, and friends. However, technological advancements now enable people to leverage technology to obtain social support.

To this end, the role of online communities and chatbots is well-documented (Billedo et al., 2019; Park and Noh, 2018). Building on existing works, this study explores how people could leverage companion robots, another form of customer-facing technology, to obtain social support. Companion robots, as the name suggests, are artificially intelligent robots that offer companionship and emotional support to humans, especially when the scope for human-human interactions is limited (Caddy, 2019; Yu and Fan, 2024).

Understanding how companion robots engender social support is important now. Artificially intelligent agents and autonomous systems are becoming increasingly popular and are expected to capture a market of US$87 billion by 2025 (Boston Consulting Group, 2017). Companion robots are already in use in several contexts such as hospitality, healthcare, and education. By mimicking human-like interactions, they cost-effectively perform the task of offering social support (Belanche et al., 2021; Edwards et al., 2022; Tuisku et al., 2019; Zafrani et al., 2023). These robots come in various shapes (Davis et al., 2023; Pütten and Krämer, 2014). Alongside the constant growth in the humanoid robot market (Markets and Markets, 2025), non-humanoid robots are now growing in popularity with robotic pet dogs predicted to witness a yearly growth rate of over 16% in its market size (Technavio, 2025).

As robotisation continues to make rapid inroads into everyday life, two gaps in the literature need to be plugged. First, the underlying mechanism of how individuals' perceptions of companion robots predict social support remains unexplored. Companion robots have been reported to support older people needing care (Tuisku et al., 2019) and mitigate stress among university students (Edwards et al., 2022). Recent works such as Yu and Fan (2024), however, argue that user perceptions of companion robots, and the complex factors shaping positive or negative responses, are still not well understood.

Second, although the physical shape of robots determines human perceptions (Belanche et al., 2021; Fukawa et al. 2024; Li et al., 2025), little is known about how the underlying mechanism of obtaining social support manifests for robots with different appearance designs. While some companion robots such as Geminoid DK are human-like, others such as Pepper are human/machine-like, yet others such as AIBO are zoomorphic (Barco et al., 2020; Edwards et al., 2022; Pütten and Krämer, 2014; Konok et al., 2018). However, research on how robot appearance affects human perceptions is still limited, as highlighted in recent works (Barco et al., 2020; Grazzini et al., 2023; Neef et al., 2023; Zhang et al., 2021).

Therefore, this study addresses two research questions:

RQ1: How do people's perceptions of companion robots help them obtain social support from the robots?

RQ2: To what extent does robot appearance affect the relationship between people's perceptions of companion robots and social support?

International relocation was chosen as the study context. International relocation causes anxiety, culture shock, depression, fear, homesickness, and loneliness (Berry et al., 2006; Park and Noh, 2018). Yet, it is common for people to relocate internationally for education and work. International relocation agencies such as Brookfield Global Relocation Services manage an average annual volume of 50,000 relocations across more than 180 countries (Brookfield Global Relocation Services, 2022). Such large segments of the relocating population would require social support to ward off their acculturative stress

(Cobb, 1976; Loveys et al., 2021). This is especially pertinent for students moving countries for education. They are usually younger and less mature than those who relocate for employment (Park and Noh, 2018). After moving abroad, international students suffer from the pangs of not only culture shock and language shock but also academic shock (Ryan, 2005). Therefore, this study specifically investigates how students relocating internationally could derive social support from various companion robots. It is a novel context that has not been explored hitherto.

The study contributes in the following ways. First, rooted in the Computers Are Social Actors (CASA) paradigm (Nass et al., 1994), it is one of the earliest empirical attempts to investigate the potential of companion robots to offer social support to sojourners. A large body of literature has examined how social media and chatbots can offer social support (Billedo et al., 2019; Park and Noh, 2018). An emerging strand of the literature has started to reveal how robots could serve as social actors and companions (Edwards et al., 2022; Yu and Fan, 2024). Building on the nascent trend, this study advances the human-robot interaction literature by shedding light on the underlying mechanism of how individuals' perceptions of companion robots predict perceived social support.

Second, the study compares how social support derived from companion robots differs across Geminoid DK (Figure 1a), Pepper (Figure 1b), and AIBO (Figure 1c). While each of the three stands a good chance of being accepted as companion robots (Edwards et al., 2022; Pütten and Krämer, 2014; Zhang et al., 2019), differences in people's perceptions across these robots have not been previously examined. By revealing how robot appearance determines perceptions and elicits social support, the study has practical implications for roboticists in general and companion robot marketers in particular.

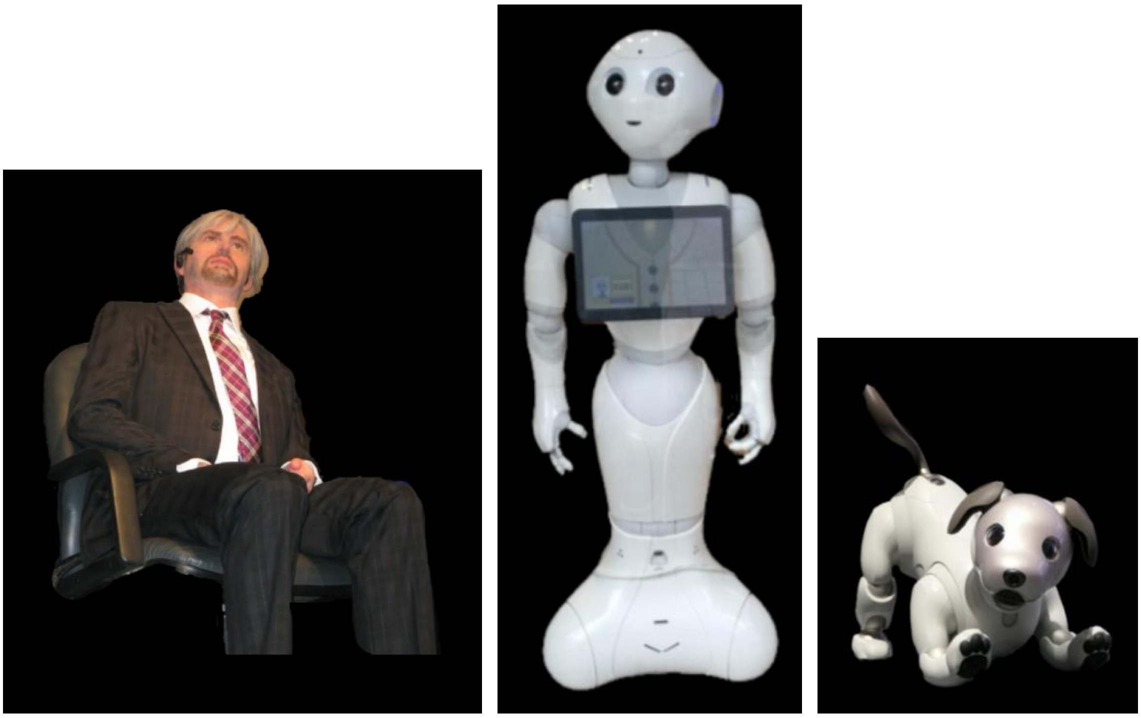

Figure 1: (a) Geminoid DK, (b) Pepper, and (c) AIBO.

Note. One of the authors took the picture of Pepper. Those of AIBO (ETC-USC, 2018) and Geminoid DK (pressgirlk, 2012) were obtained from Flickr. Their licenses allow sharing and adapting.

2. Literature Review and Hypotheses

2.1. Theoretical background

This study is rooted in the CASA paradigm, which posits that humans treat gadgets, including robots, as if these were real people (Nass et al., 1994). When engaging with robots, humans mindlessly evaluate the interactions by applying social rules. Over the years, the CASA paradigm has been widely leveraged by the growing body of literature that investigates how findings from interpersonal relationships are applicable to human-computer and human-robot interactions (de Kervenoael et al., 2024; Edwards et al., 2022; Lei and Rau, 2023; Tay et al., 2014).

In the context of this study, the CASA paradigm suggests that individuals can derive social support from a companion robot by treating it as a social actor. Companion robots are now able to mimic human-like social interactions (Edwards et al., 2022; Gonzalez-Jimenez, 2018). They can support school children with autism (Zhang et al., 2019), individuals suffering from loneliness (Yu and Fan, 2024), and wellbeing in later life (Tuisku et al., 2019; Zafrani et al., 2023). While studies such as Zhang et al. (2019) used playful robots such as Nao to play with children, Tuisku et al. (2019) explored the possibility of humanoid robots such as Zora in elderly-care services. Edwards et al. (2022) showed that zoomorphic robots could also help mitigate stress among university students. These works have thus started to reveal how robots with different appearances could be effective as companion robots.

However, there is still a knowledge lacuna in explaining the underlying mechanism of how humans' robot perceptions translate to social support from companion robots of varying appearances. Guided by the CASA paradigm, this study argues that people's interaction with companion robots to derive social support can be explained as a two-step process. In the first step, robots trigger fundamental robot-specific perceptions such as anthropomorphism. These are evoked mindlessly by merely recognising a robot (Boch and Thomas, 2025; Gambino et al., 2020; Tay et al., 2014). In the next step, upon acknowledging robot-specific perceptions (Grazzini et al., 2023), a deeper level of general psychosocial perceptions such as likeability and safety is eventually triggered to reflect subtler and more complex changes in attitudes (Boch and Thomas, 2025; Gambino et al., 2020; Nass et al., 1994). These in turn determine the extent to which social support could be obtained from the robots.

2.2. Human perceptions of companion robots

For this study's purposes, people's perceptions of companion robots are conceptualised in terms of three commonly studied constructs: perceived anthropomorphism (Mara and Appel, 2015), perceived likeability (Bartneck et al., 2009), and perceived safety (Pütten and Krämer, 2014). Perceived anthropomorphism is a robot-specific perception automatically triggered by robots (Boch and Thomas, 2025; Grazzini et al., 2023). It is conceptually different from perceived likeability and perceived safety, which are general psychosocial factors that are anticipated to be predictors of social support seeking from a companion, regardless of whether the companion is a robot or a human. This is consistent with the CASA paradigm (Nass et al., 1994; Tay et al., 2014).

Perceived anthropomorphism refers to the attribution of uniquely human characteristics to nonhuman creatures, objects, and even abstract concepts such as brands (Bartneck et al., 2009). Anthropomorphised entities can mitigate the negative effects of loneliness and stress by providing emotional support. Robots can be made anthropomorphic by emulating the shape, size, and structure of humans. For example, a robot like Geminoid DK is structurally more anthropomorphic compared with AIBO. When it comes to a companion robot, an increase in its degree of perceived humanness is anticipated to improve the quality of human-robot interactions (Belanche et al., 2021; Kim et al., 2019). Thus, considering the CASA paradigm, perceived anthropomorphism of a companion robot should have a positive relationship with social support (Gambino et al., 2020).

However, according to the uncanny valley theory (Mori, 1970), this positive effect should only be evident up to a certain degree of anthropomorphism (Ho and MacDorman, 2017). When a robot becomes too human-like, it can be perceived as creepy, eerie, unnerving, and weird (Burleigh et al., 2013; Neef et al., 2023). This decrease in comfort levels is attributed to the robot's appearance, which produce an approximation of human likeness and subsequently induce cognitive dissonance (Destephe et al., 2014; Kim et al., 2019; Stein and Ohler, 2017).

The uncanny valley theory has been effective in explaining attitudes towards digital entities, including virtual influencers (Jhawar, in press), virtual animals (Schwind et al., 2018), and robots (Shum et al., 2024). It is, therefore, anticipated to shape the relationship between a companion robot's perceived anthropomorphism and social support. Negative responses engendered by an overly human-like companion robot would hinder feelings of closeness and rapport (Mori, 1970). Without rapport, a robotic companion cannot effectively serve as a source of social support (Alabed et al., 2024; Loveys et al., 2021). Hence, the following is posited:

H1: Perceived anthropomorphism has a negative curvilinear (i.e., concave or ∩-shaped) relationship with social support.

The direct relationship hypothesised in H1 could be mediated by the general psychosocial perception constructs of perceived likeability and perceived safety. Perceived likeability refers to a user's view of a robot in terms of how nice, friendly, and pleasant it appears (Bartneck et al., 2009). Perceived safety is the user's impression of the risk involved in dealing with a robot (Bartneck et al., 2009). Following the CASA paradigm, humans must first mindlessly process a robot's anthropomorphic appearance cues before responding to it as a social being (Boch and Thomas, 2025; Tay et al., 2014). Therefore, the perception of anthropomorphism should precede the impressions of likeability and safety.

The literature supports the notion that perceived anthropomorphism is associated with perceived likability (Castro-González et al., 2016; Sasaki et al., 2017) and safety (Bartneck et al., 2009; Burleigh et al., 2013; Pütten and Krämer, 2014). Meanwhile, both likeability and safety are integral for establishing effective relationships with companions, whether humans or robots, in line with the CASA paradigm (Nass et al., 1994). Likeability is positively associated with support perceptions in not only offline (Shah et al., 2024) but also technology-mediated (Pütten et al., 2019) interactions. The relevance of safety has also been demonstrated in human-human (Yano et al., 2021) and human-technology (Szymkowiak et al., 2025) interactions. Recent research has highlighted the importance of perceived likeability (Finkel and Krämer, 2023; Moriuchi and Murdy, 2024) and perceived safety (Choi et al., 2023; Rubagotti et al., 2022) for the acceptance of robots. Considering the important role of effective, positive, and reciprocal relationships in social support (Billedo et al., 2019), both likeability and safety could explain the underlying process of how anthropomorphism affects social support (Nass et al., 1994; Wirtz et al., 2018). Hence, the following mediation hypotheses are proposed:

H2(a): The relationship between perceived anthropomorphism and social support is mediated by perceived likeability.

H2(b): The relationship between perceived anthropomorphism and social support is mediated by perceived safety.

While reviewing the human-robot interaction literature, the authors also came across other constructs such as perceived animacy (Bartneck et al., 2009), perceived eeriness (Destephe et al., 2014), perceived attractiveness (Ho and MacDorman, 2017; Mara and Appel, 2015), perceived warmth (Belanche et al., 2021), perceived agency (Müller et al., 2021), perceived competence (Belanche et al., 2021), and perceived intelligence (Bartneck et al., 2009). However, these were excluded for the sake of parsimony.

Specifically, perceived animacy was excluded because it is strongly correlated with perceived anthropomorphism (Ho and MacDorman, 2017), which is already included. Perceived eeriness was ignored as it is also conceptually similar to the notion of anthropomorphism (Burleigh et al., 2013; Destephe et al., 2014). Perceptions of attractiveness and warmth were excluded because these overlap with likeability, which is anyway considered. Perceptions of agency, competence and intelligence were excluded because these traits are particularly critical when a robot must actively perform a task or solve a problem. To obtain social support from a companion robot—the focus of the current study—however, people might not be too concerned about its agency, competence, and intelligence (Castro-González et al., 2016; Pütten and Krämer, 2014; Tuisku et al., 2019). Instead, they need to find the companion robot safe to derive emotional support amid stress (Loveys et al., 2021).

A context that is objectively safe—obtaining social support in this case—but not perceived as such can trigger negative attitudes (Neef et al., 2023). This justifies the inclusion of perceived safety.

2.3. Robot appearance

Robot appearance has to do with the shape, size, and structure of a robot. One classification scheme organises robot appearance as anthropomorphic, zoomorphic, caricatured, and functional (Barco et al., 2020; Fong et al., 2003; Grazzini et al., 2023). Anthropomorphic robots (e.g., Geminoid DK) are human-like and their embodiment makes them suitable for social interactions (Belanche et al., 2021; Gonzalez-Jimenez, 2018). Zoomorphic robots (e.g., AIBO) are animal-like and resemble pet companions (Konok et al., 2018). Caricatured robots (e.g., Cozmo) are cartoon-like that do not necessarily appear realistic (Fong et al., 2003). In functional robots, the morphology is a direct consequence of its intended functionality. For example, a healthcare robot meant to support disabled patients could include sturdy handlebars (Pineau et al., 2003). In addition, zoomorphic and caricatured features are often combined to develop cute, playful, mascot-like robots (Zhang et al., 2021).

A more granular classification scheme identifies six robot types (Pütten and Krämer, 2014): (1) likeable human-like androids such as Geminoid DK, (2) playful robots such as Pepper that are perceived as submissive and likeable, (3) unusually shaped mechanical robots such as Wakamuru, (4) futuristic robots such as Twendyone, (5) threatening human-like androids such as Geminoid HI-1, and (6) threatening mechanical robots such as Robonova. Of these, the first two groups of robots are usually received favourably for social interactions and hence might work well as companion robots.

Additionally, Konok et al. (2018) suggested that companion robots do not necessarily need to be bipedal. Since pet dogs are usually able to engage in meaningful social interactions with humans, robots could instead be quadrupedal, incorporating the liked qualities of pet dogs. Moreover, animal behaviour is simpler than human behaviour, making it easier to incorporate into robots.

Guided by these works on robot appearance, this study examines three possible companion robots: the human-like robot Geminoid DK, the human/machine-like playful robot Pepper, and the zoomorphic dog-like robot AIBO (Figure 1). Geminoid DK was included because people might favour robots that resemble humans to obtain social support (Belanche et al., 2021). Integrating human-like appearance cues in robots enhance user preferences and affective experiences (Li et al., 2025). However, in line with the uncanny valley theory, robots that are too human-like undermine human-robot distinctiveness and can lead to discomfort (Destephe et al., 2014; Kim et al., 2019; Müller et al., 2021; Shum et al., 2024).

Pepper was included because it is a playful robot with both human-like and mechanical characteristics. This mix makes humans feel comfortable because they perceive such robots as non-threatening and cute (Pütten and Krämer, 2014). Human/machine-like playful robots evoke high degrees of social presence, a crucial enabler of meaningful human-robot interactions (Sasser et al., 2024). They are usually seen as safe and trustworthy (Rubagotti et al., 2022). Humans have been shown to enjoy interacting with these robots as shopping assistants (Fukawa et al. 2024).

AIBO was included because research shows the possibility of incorporating the liked qualities of animals into companion robots (Edwards et al., 2022). Zoomorphic robots mimic animal behaviours to foster relationships akin to owner-pet bonds (Konok et al., 2018). These robots are easily adopted as companions and within healthcare scenarios due to their stress-relieving capabilities (Blaurock et al., 2022; Klüber and Onnasch, 2022).

In contrast, the other robot types identified by Pütten and Krämer (2014) were excluded because they would not be functional as providers of social support. For example, neither unusually shaped mechanical robots nor futuristic robots were deemed appropriate because they would be perceived as being too unfamiliar. Threatening human-like androids and threatening mechanical robots were also excluded. After all, unfamiliarity and threat are not ideal traits for a companion. Instead of offering emotional support, robots with such traits would have triggered disgust and avoidance (Belanche et al., 2021).

All the three selected robots—Geminoid DK, Pepper, and AIBO—share sociable characteristics (Barco et al., 2020; Konok, 2018; Pütten and Krämer, 2014). In other words, these are anticipated to provide similar levels of social support. However, given their inherent differences in appearances, there can be nuances in how people perceive each of these robots (Belanche et al., 2021; Pütten and Krämer, 2014). Therefore, the following moderated-mediation hypotheses are worth testing:

H3(a): Robot appearance moderates the mediating role of perceived likeability between perceived anthropomorphism and social support.

H3(b): Robot appearance moderates the mediating role of perceived safety between perceived anthropomorphism and social support.

Figure 2 presents the conceptual model of the study. It encompasses three hypotheses. While the first two cater to RQ1, the next one addresses RQ2.

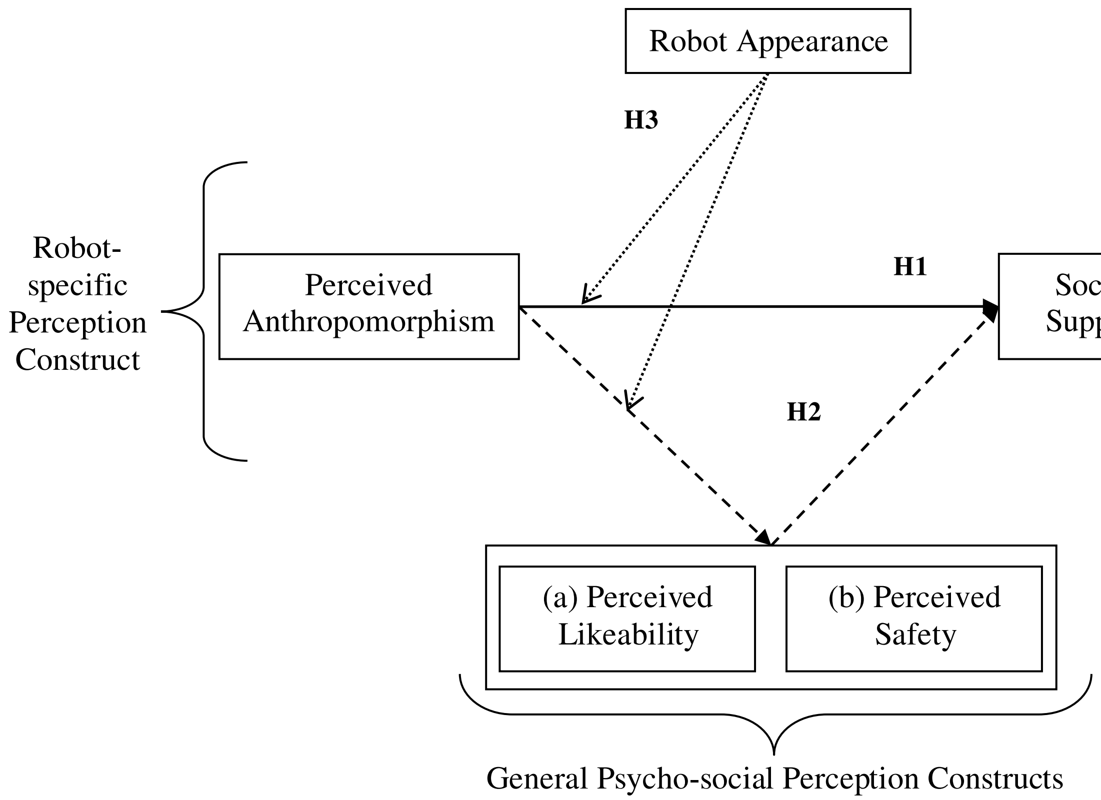

Figure 2: Conceptual model.

Note. The solid line represents the direct relationship (H1). The dashed lines represent the mediation (H2). The dotted lines represent the moderation (H3).

3. Methods

3.1. Research design

A scenario-based online experiment was conducted with companion robot appearance as a between-participants factor. The scenario was designed such that participants would imagine receiving a companion robot upon their arrival in a new country for studies. The robot was intended to provide emotional support, companionship, pleasure, and entertainment, easing their transition. Five international postgraduate students pre-tested the description of the scenario. Their feedback was leveraged to ensure its clarity.

The between-participants experimental stimulus was a picture of either Geminoid DK, Pepper or AIBO (Figure 1). As a robot's physical appearance is an objective difference, no manipulation check question was used (O'Keefe, 2003; Walther et al., 2018). Its effects are revealed through the results that follow. Nonetheless, a pre-test was conducted involving 12 final year international undergraduate students. They were asked to map the three robot pictures (Figure 1) into the categories of human-like robot, human/machine-like playful robot, and zoomorphic robot. There was full agreement that Figure 1a, Figure 1b, and Figure 1c represent a human-like robot, a human/machine-like playful robot, and a zoomorphic robot, respectively.

3.2. Experimental procedure

Participants included international postgraduate students from five European universities the authors had access to; four of these were in the UK and the fifth was in Spain. The students had relocated internationally for their studies within the previous year and were therefore deemed appropriate for the study. Specifically, postgraduate students were chosen rather than undergraduate students. This is because there are proportionately more overseas students pursuing postgraduate degrees vis-à-vis undergraduate degrees (Bell et al., 2022; Bolton, 2025).

The URL to participate in the online experiment was emailed to international students in various postgraduate programmes at the five universities. After providing electronic consent, the participants were presented with the scenario that they had a robot as a companion during the initial days after their relocation. The purpose of the robot was to ease their transition in the new country by offering emotional support, companionship, pleasure, and entertainment. The participants were then randomly exposed to a picture of either Geminoid DK, Pepper, or AIBO (Figure 1), after which they had to reflect on the robot as a companion and respond to a questionnaire. The picture of the robot was repeated on each webpage of the questionnaire to maximise the respondents' likelihood to bear the robot appearance in mind while answering the questions (Müller et al., 2021).

A total of 306 students (173 or 56.54% females and 133 males) participated in the experiment. The sample size compares favourably with those in related studies (Burleigh et al., 2013; Loveys et al., 2021; Müller et al., 2021). Age ranged from 18 to 41 years (M = 23.25, SD = 2.88, Mdn = 23), and more than 30 nationalities were represented in the sample. Ninety-six students (31.37%) had prior experience using some form of robots and 195 (63.72%) had pet ownership experience.

3.3. Operational definitions

Scales for all the study constructs were first derived from the literature. Thereafter, 12 final year undergraduate students were recruited to help assess the face validity of the questionnaire items. Their suggestions were discussed jointly by the authors to make modifications, where needed. For example, to measure social support, items such as "I can count on my friends when things go wrong," and "I have friends with whom I can share my joys and sorrows" from the original scale were deemed inappropriate in the context of robots. These were changed to "I would have been able to count on the robot after my relocation," and "The robot would have been a great companion for me after my relocation" respectively. Items highlighted as inappropriate in the context of this study or those considered difficult to understand were dropped.

Social support (dependent variable). On a scale of 1 (Strongly Disagree) to 7 (Strongly Agree), participants indicated their degree of agreement with the following three statements: "The robot would have helped me adjust to the new environment after my relocation," "I would have been able to count on the robot after my relocation," and "The robot would have been a great companion for me after my relocation." The items were adapted from Park and Noh (2018). Responses to these items were averaged to create a composite index, with higher scores indicating greater social support (M = 3.48, SD = 1.75, Mdn = 3.67, Cronbach's α = 0.94).

Perceived anthropomorphism (independent variable). On a seven-point semantic differential scale, participants indicated whether the robot was fake/natural, machine-like/human-like, and unconscious/conscious. The items were adapted from Bartneck et al. (2009). Responses to these three items were averaged to create a composite index, with higher scores indicating greater perceived anthropomorphism (M = 3.62, SD = 1.74, Mdn = 3.67, Cronbach's α = 0.87).

Perceived likeability (mediating variable). On a seven-point semantic differential scale, participants indicated whether the robot was awful/nice, unfriendly/friendly, and unpleasant/pleasant. The items were adapted from Bartneck et al. (2009). Responses to these three items were averaged to create a composite index, with higher scores indicating greater perceived likeability (M = 4.55, SD = 1.49, Mdn = 4.67, Cronbach's α = 0.90).

Perceived safety (mediating variable). On a seven-point semantic differential scale, participants indicated whether the robot would have made them anxious/relaxed, agitated/calm, and tense/secure. The items were adapted from Bartneck et al. (2009). Responses to these three items were averaged to create a composite index, with higher scores indicating greater perceived safety (M = 3.87, SD = 1.48, Mdn = 4, Cronbach's α = 0.92).

Post-relocation acculturative stress (control variable). Given the context of the study, it was important to control for the extent of acculturative stress experienced by the participants after their relocation. On a scale of 1 (Strongly Disagree) to 7 (Strongly Agree), they indicated their degree of agreement with the following nine statements: "I felt uncomfortable to adjust to new eating style," "I felt intimidated to participate in social activities," "Multiple pressures were placed upon me after my relocation," "People did not seem to understand my cultural values," "I felt low because of my cultural background," "I missed the people and country of my origin," "I felt uncomfortable to adjust to new cultural values," "I felt that my people are discriminated against," and "I felt some people don't associate with me because of my ethnicity." These items were adapted from Park and Noh (2018). Responses to these items were averaged to create a composite index, with higher scores indicating greater acculturative stress (M = 3.24, SD = 1.42, Mdn = 3.11, Cronbach's $\alpha = 0.91$).

Technology readiness (control variable). As the study is about the use of new technology, it was important to control for the individual difference of technology readiness. It includes four dimensions: optimism, innovativeness, discomfort and insecurity. Given that technology readiness is not the key construct of interest, the study used only one item for each dimension instead of the entire 16-item scale from Parasuram and Colby (2015). This was necessary to manage the overall length of the questionnaire and prevent participant fatigue. On a scale of 1 (Strongly Disagree) to 7 (Strongly Agree), participants indicated their degree of agreement with the following statements: "New technologies contribute to a better quality of life" (optimism dimension: M = 5.2, SD = 1.45, Mdn = 5), "In general, I am among the first in my circle of friends to acquire new technology" (innovativeness dimension: M = 3.81, SD = 1.59, Mdn = 4), "Sometimes, I think that technology systems are not designed for use by ordinary people" (discomfort dimension: M = 3.8, SD = 1.68, Mdn = 4), and "Too much technology distracts people to a point that is harmful" (insecurity dimension: M = 4.79, SD = 1.58, Mdn = 5).

3.4. Data analyses

The data were first analysed using analysis of variance (ANOVA) to explore differences across the three robots: Geminoid DK, Pepper, and AIBO. To delve into significant differences, Tukey's post hoc tests were used.

Multiple regression was employed next to test for the curvilinear effect of perceived anthropomorphism (H1). The quadratic term was computed using standardised components to reduce multicollinearity (Aiken and West, 1991). The linear effect of perceived anthropomorphism was treated as a covariate. Not doing so is equivalent to assuming that the negative curvilinear (i.e., concave or ∩-shaped) relationship reaches its peak at perceived anthropomorphism = 0 (Aiken and West, 1991). Such an assumption would not have been meaningful.

Thereafter, a parallel mediation model with bias-correction was employed to test the mediating effects hypothesised in H2 (Hayes, 2013; model 4; 5,000 bootstrap). Finally, to test H3, a moderated parallel mediation model with bias-correction was employed with robot appearance as the moderator (Hayes, 2013; model 8; 5,000 bootstrap).

To lend robustness to the analyses, several control variables were added such as the participants' country of relocation (Spain or the UK), age in years, gender, prior robot usage, prior pet ownership, acculturative stresses levels, and technology readiness scores across the four dimensions. Considering all the hypothesised constructs and the control variables, all tolerance values were well over 0.25, confirming no multicollinearity.

4. Results

4.1. Exploratory analysis of differences as a function of robot appearance

Table 1 presents the descriptive statistics of the constructs studied as a function of robot appearance. ANOVA tests were used to identify differences in perceptions across the three robots: Geminoid DK, Pepper, and AIBO. There was no significant difference in terms of perceived social support, confirming the literature-informed assumption that all the three are suitable as companion robots (Edwards et al., 2022; Fukawa et al., 2024; Pütten and Krämer, 2014; Zhang et al., 2019).

This similarity notwithstanding, differences arose in the other three perception constructs. First, perceived anthropomorphism was the highest for Geminoid DK ($F(2, 303) = 67.49$; $p < 0.001$; partial $\eta^2 = 0.31$). Tukey's post hoc test confirmed that perceived anthropomorphism of Geminoid DK was significantly higher than that of both Pepper ($p < 0.001$) and AIBO ($p < 0.001$). Perceived anthropomorphism of Pepper and AIBO were, however, not significantly different from each other.

Second, a marginally significant difference emerged in terms of perceived likeability ($F(2, 303) = 2.73$; $p = 0.07$; partial $\eta^2 = 0.02$). Tukey's post hoc test revealed that AIBO was perceived as being equally likeable as Pepper but more likeable than Geminoid DK ($p = 0.07$).

Finally, perceived safety varied significantly as a function of robot appearance ($F(2, 303) = 6.26$; $p = 0.002$; partial $\eta^2 = 0.04$). Tukey's post hoc test revealed that AIBO was perceived as being equally safe as Pepper but safer than Geminoid DK ($p = 0.001$). Such nuances support the argument forwarded earlier that the underlying mechanism of obtaining social support is unlikely to be identical for different robots. This sets the stage for testing the proposed hypotheses.

Table 1: Means ± standard deviations as a function of robot appearance.

Constructs	**Geminoid DK (N=108)**	**Pepper (N=99)**	**AIBO (N=99)**
Social support	3.24 ± 1.51	3.56 ± 1.79	3.66 ± 1.93
Perceived anthropomorphism	4.92 ± 1.49	2.96 ± 1.49	2.85 ± 1.37
Perceived likeability	4.29 ± 1.48	4.65 ± 1.42	4.74 ± 1.52
Perceived safety	3.53 ± 1.40	3.86 ± 1.58	4.25 ± 1.39

4.2. The role of anthropomorphism on social support (H1)

While the linear effect of perceived anthropomorphism was positive (β = 0.27, $p < 0.001$), the square of perceived anthropomorphism was negatively related to social support (β = -0.22, $p < 0.001$). This indicates that social support obtained from the companion robots increased with perceived anthropomorphism but peaked at moderate levels. Social support was lower when the robots were seen as extremely anthropomorphic, indicating a negative curvilinear (concave or ∩-shaped) relationship. Hence, H1 was supported. The curvilinear effect of perceived anthropomorphism on social support is depicted in the scatter plot, fitted with a quadratic equation, shown in Figure 3. The final model R^2 was 22.80%.

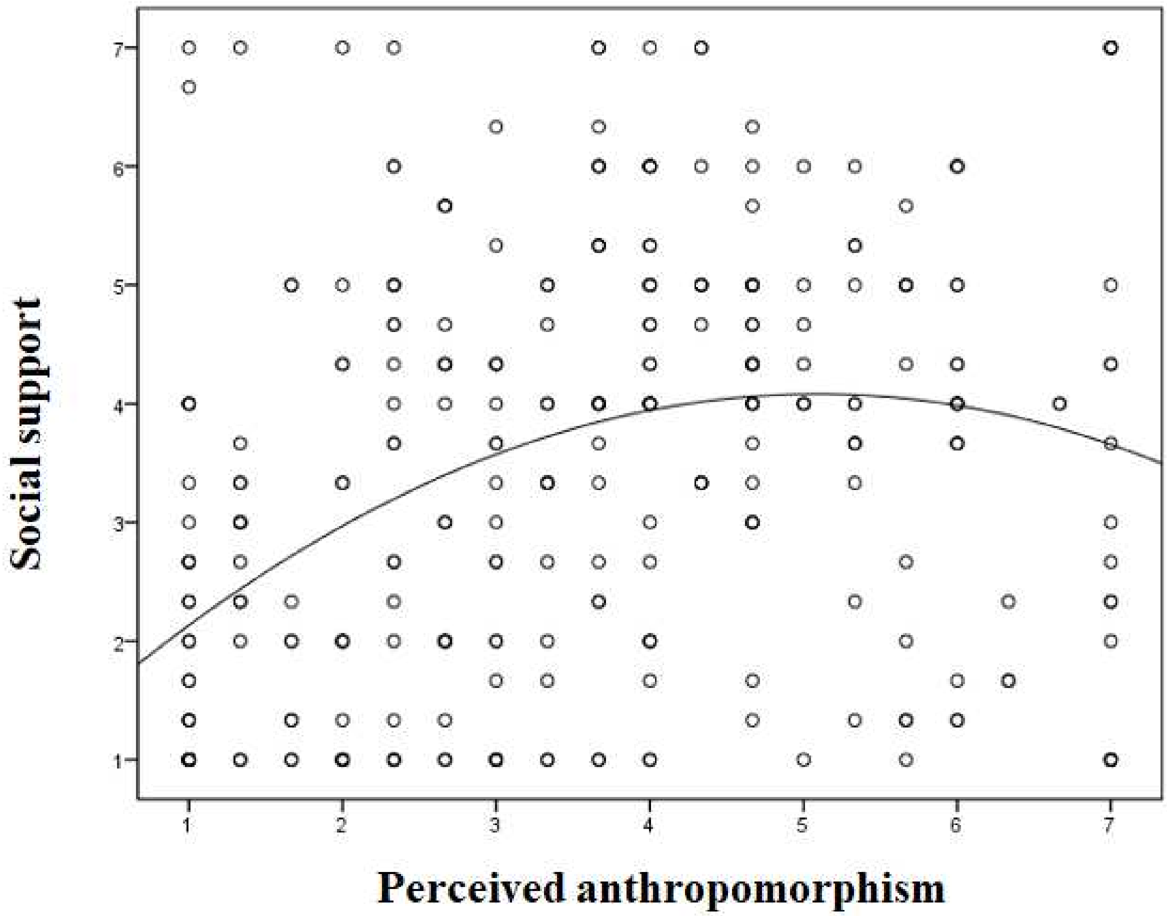

Figure 3: Curvilinear effect of perceived anthropomorphism on social support.

4.3. The mediating roles of likeability and safety (H2)

Figure 4 depicts the mediation between squared perceived anthropomorphism and social support. Perceived likeability did not mediate the relationship. However, perceived safety emerged as a significant mediator [a path: B= -0.22, SE = 0.08, 95% CI = (-0.37, -0.07); b path: B = 0.70, SE=0.06, 95% CI = (0.59, 0.82); ab: B = -0.15, SE = 0.07, 95% CI = (-0.30, -0.02)]. The curvilinear effect of perceived anthropomorphism on perceived safety is depicted in the scatter plot, fitted with a quadratic equation, shown in Figure 5. The direct relationship between squared perceived anthropomorphism and social support was non-significant. Overall, the result confirms that the curvilinear relationship between perceived anthropomorphism and social support is mediated by perceived safety but not by perceived likeability. Thus, H2(a) was not supported but H2(b) was supported.

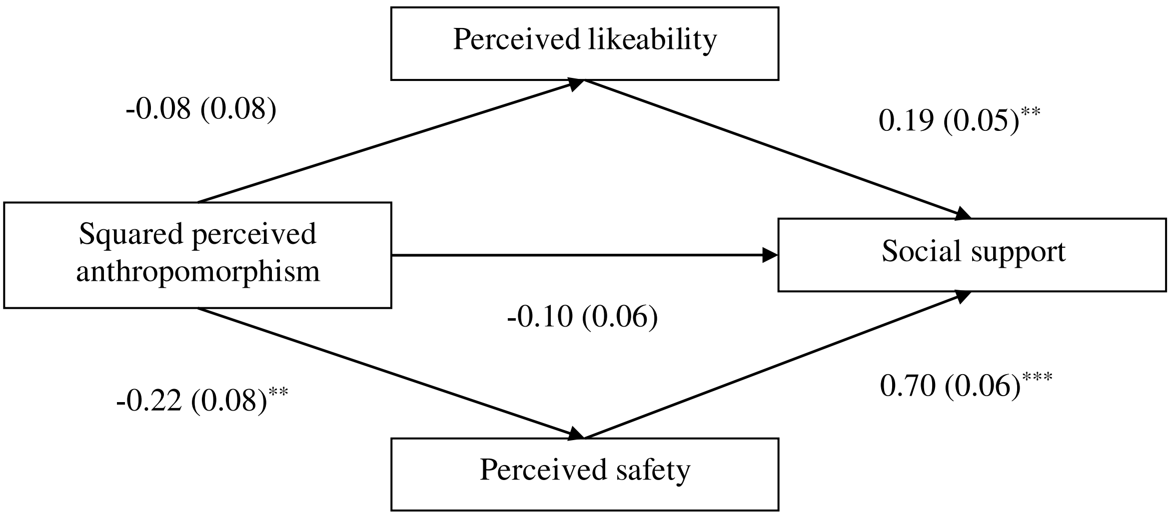

Figure 4: Mediation between squared perceived anthropomorphism and social support.

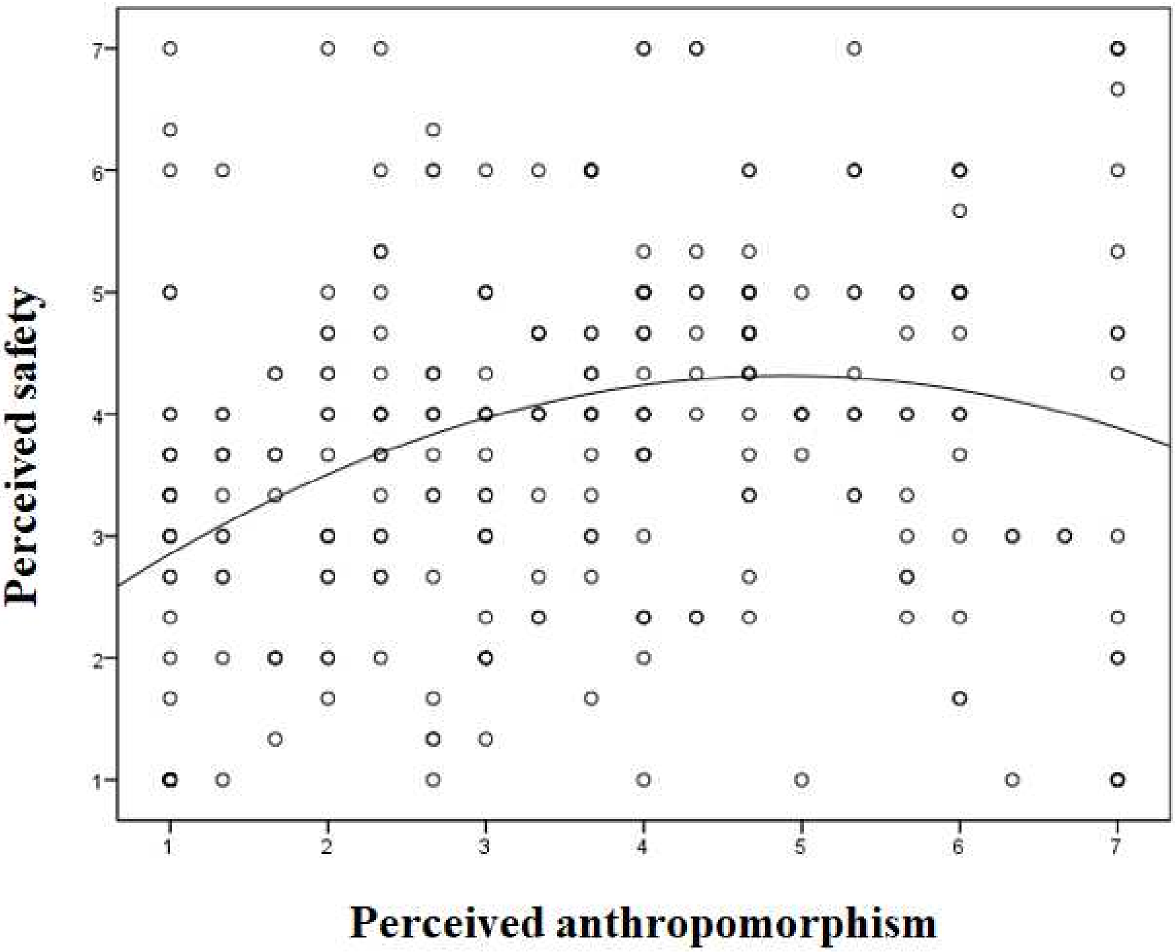

Figure 5: Curvilinear effect of perceived anthropomorphism on perceived safety.

4.4. The moderating role of robot appearance (H3)

Four observations emerged. First, robot appearance moderated the curvilinear effect of perceived anthropomorphism on perceived likeability [B = 0.25, SE = 0.1, 95% CI = (0.06, 0.44)]. The effect was significant only for Pepper [B = -0.38, SE = 0.15, 95% CI = (-0.68, -0.09)] but non-significant for Geminoid DK and AIBO.

Second, robot appearance did not moderate the curvilinear effect of perceived anthropomorphism on perceived safety. In other words, the significant curvilinear relationship—revealed through the earlier mediation analysis (Figure 4)—remained stable regardless of robot appearance.

Third, the indirect effect of the square of perceived anthropomorphism on social support via perceived likeability was conditional on robot appearance [moderated mediation index = 0.04, SE = 0.03, 95% CI = (0.002, 0.11)]. The mediation was significant for Pepper [B = -0.07, SE = 0.04, 95% CI = (-0.17, -0.005)] but non-significant for Geminoid DK and AIBO.

Fourth, the indirect effect via perceived safety was not conditional on robot appearance. In other words, the significant indirect effect of squared perceived anthropomorphism on social support via perceived safety—revealed earlier through the mediation analysis (Figure 4)—was valid for all the three chosen robots.

In sum, robot appearance seemed to moderate the indirect effect via perceived likeability but not that via perceived safety. Thus, with respect to the curvilinear relationship of perceived anthropomorphism, H3(a) was supported but H3(b) was not supported. Table 2 summarises the results of the hypotheses testing in relation to the two research questions.

Table 2: Results of the hypotheses testing.

Research Question	**Hypothesis**	**Test Result**
RQ1: How do people's perceptions of companion robots help them obtain social support from the robots?	H1: Perceived anthropomorphism has a negative curvilinear (i.e., concave or ∩-shaped) relationship with social support.	Supported
	H2(a): The relationship between perceived anthropomorphism and social support is mediated by perceived likeability.	Not supported
	H2(b): The relationship between perceived anthropomorphism and social support is mediated by perceived safety.	Supported
RQ2: To what extent does robot appearance affect the relationship between people's perceptions of companion robots and social support?	H3(a): Robot appearance moderates the mediating role of perceived likeability between perceived anthropomorphism and social support.	Supported
	H3(b): Robot appearance moderates the mediating role of perceived safety between perceived anthropomorphism and social support.	Not supported

5. Discussion and Implications

5.1. Key findings

Rooted in the CASA paradigm, this study proposed a conceptual model to explain the underlying mechanism of how three different companion robots—Geminoid DK (a human-like robot), Pepper (a human/machine-like playful robot) and AIBO (a zoomorphic robot)—could be leveraged to obtain social support in the aftermath of international relocation. The results confirm a negative curvilinear (concave or ∩-shaped) relationship between perceived anthropomorphism and social support. There was an increase in social support with increasing perceived anthropomorphism, but the trend was reversed when the robots were perceived as being overly anthropomorphic. Building on prior studies (Burleigh et al., 2013; Destephe et al., 2014; Kim et al., 2019; Mori, 1970), this finding not only lends support to the uncanny valley theory but also extends the current scholarly understanding of how companion robots' perceived anthropomorphism relates to social support, particularly in the context of international relocation. Beyond the context of international relocation, the finding also aligns with recent research on the impact of robot anthropomorphism on user perceptions (Alabed et al., 2024; Grazzini et al., 2023; Jhawar, in press; Schwind et al., 2018; Shum et al., 2024).

Moreover, the study unravels the underlying mechanism of how perceived anthropomorphism relates to social support from companion robots. The negative curvilinear relationship between perceived anthropomorphism and social support was mediated by perceived safety but not by perceived likeability. Prior research suggests that perceived anthropomorphism is associated with perceived likability (Castro-González et al, 2016; Sasaki et al., 2017) and safety (Bartneck et al., 2009; Pütten and Krämer, 2014). There is also evidence that likeability and safety perceptions are crucial for robot acceptance (Choi et al., 2023; Finkel and Krämer, 2023; Moriuchi and Murdy, 2024; Rubagotti et al., 2022; Wirtz et al., 2018). Extending the literature, this study shows that perceived safety—but not perceived likeability—could explain the curvilinear relationship between perceived anthropomorphism and social support. Companion robots could fail to inspire confidence when perceived as threats to personal safety.

Furthermore, the study shows that each of the chosen robots—Geminoid DK, Pepper, and AIBO—could potentially serve as a companion robot, particularly if they are perceived as safe. This lends support to the literature on robot appearance (Belanche et al., 2021; Blaurock et al., 2022; Fukawa et al. 2024; Konok et al., 2018; Li et al., 2025; Pütten and Krämer, 2014). Nonetheless, it was found that the underlying mechanism of deriving social support was not the same for all three, as shown in Table 3.

The indirect relationship between squared perceived anthropomorphism and social support via perceived likeability was moderated by robot type. The curvilinear relationship mediated by perceived likeability was significant only for Pepper. In addition, the indirect relationship between squared perceived anthropomorphism and social support via perceived safety was not moderated by robot type. That is, the effect made its presence felt for all the three robots.

Table 3: Differences in the underlying mechanisms for Geminoid DK, Pepper, and AIBO.

Effect of perceived anthropomorphism^2	Via perceived likeability	Via perceived safety
Geminoid DK	X	✓
Pepper	✓	✓
AIBO	X	✓

Note. ✓ Mediation supported, X Mediation not supported.

5.2. Contributions to theory

The study makes several theoretical contributions. For one, it adds to the literature on the use of new technology for social support. Research has shown how online communities and chatbots can offer social support (e.g., Billedo et al., 2019; Park and Noh, 2018). As a departure from prior works, this study explores the use of three different robots—Geminoid DK, Pepper, and AIBO—for social support in a hitherto-unexplored context. It is the first work to empirically demonstrate the possibility of deriving social support from companion robots by students in the aftermath of international relocation.

More specifically, the study adds to the human-robot interaction literature by finding support for the two-step process of deriving social support from companion robots, as suggested by the CASA paradigm (Boch and Thomas, 2025; Gambino et al., 2020; Nass et al., 1994; Tay et al., 2014). It shows that the robot-specific perception of perceived anthropomorphism directly predicts the level of social support derived from robotic companions. The study further uncovers the underlying mechanisms of the direct relationship by teasing out the mediating roles played by the general psychosocial perceptions of likeability and safety. It additionally identifies boundary conditions by demonstrating how the underlying mechanism differs as a function of robot appearance. The manifestation of the CASA-informed two step process of deriving social support does not seem to be identical for all robots.

The insights gleaned from the study differ from existing research trends in at least two ways. First, while prior works have sought to classify robots based on their differences (Fong et al., 2003; Pütten and Krämer, 2014), this study shows how different types of robots could be leveraged for the same purpose. The non-significant difference in social support across Geminoid DK, Pepper, and AIBO confirms that each of these has the potential to serve as a robotic companion meant to offer social support.

Second, the study represents the earliest attempt to tease out how the underlying mechanism of deriving social support from a companion robot depends on robot appearance. Yu and Fan (2024) showed the effect of loneliness on attitudes toward companion robots as well as perceived robot-human dominance in driving these effects. However, they did not consider the role of different robot appearances as well as its specific influence on social support. Works such as Barco et al. (2020) compared perceptions of various robots but did not explicate the underlying mechanism of obtaining social support from the robots. Edwards et al. (2022) studied how zoomorphic robots could be vehicles of social support. However, no light was shed on the underlying mechanism of obtaining social support. Also, there was no comparison between zoomorphic and other robot types. In contrast, this study first unravels the mediating roles of likeability and safety in explaining the effects of anthropomorphism on social support. Additionally, it accounts for robot appearance by using three distinct robots, namely, Geminoid DK (a human-like robot), Pepper (a human/machine-like playful robot), and AIBO (a zoomorphic robot). In doing so, it offers a more detailed understanding of the phenomenon of deriving social support from companion robots.

Perceived safety turned out to be a consistently significant mediator for all the three robots. It explained the effects of perceived anthropomorphism on social support. In contrast, perceived likeability mediated the effect of perceived anthropomorphism on social support for Pepper but not for Geminoid DK or AIBO. Pepper's playful design might have heightened the importance of perceived likeability (Pütten and Krämer, 2014). Moreover, Pepper has already experienced wide exposure and acceptance in the media and marketplace, thereby potentially increasing its likeability (Fukawa et al., 2024). In contrast, perceived likeablity did not matter for Geminoid DK perhaps because of its overly human-like appearance. The participants might have focused more on how real it looked (Belanche et al., 2021; Li et al., 2025). Furthermore, the participants could have focused more on AIBO's overall pet-like qualities than its likeability, explaining why perceived likeability did not matter (Konok et al., 2018). These nuanced insights across the three robots necessitate further research into the effect of robot appearance on human perceptions.

5.3. Implications for practice

The study offers several implications for practice. For one, the findings imply that the design of future social support companion robots should prioritise likeability and safety. It should incorporate approachable appearance cues. Overly intimidating features should be avoided. Moreover, if a robot appearance feature creates a tension between likeability and safety, roboticists are recommended to err on the side of safety. After all, perceived safety emerged as a significant mediator regardless of robot type. Overall, it appears that enhancing safety perceptions through appearance cues can mitigate the uncanny valley effect in robotic companions.

Furthermore, the observed disparity in perceived safety, with AIBO scoring the highest and Geminoid DK the lowest, suggests that zoomorphic robots currently hold an advantage over human-like robots in providing social support. This suggests that zoomorphic companion robots may achieve broader adoption than their human-like counterparts. Consequently, given the relative ease of replicating animalistic behaviours compared to complex human interactions, roboticists seeking to introduce companion robots may find a more immediate pathway to market through the creation of zoomorphic models.

The study also has implications for robot marketers. Safety concerns seemed to be a particularly strong impediment to adoption of companion robots. Therefore, positive safety statistics (e.g., low failure rates compared to other technologies or even humans) should be mentioned in the marketing communications related to companion robots. Advertisements should include scenarios that show companion robots interacting responsibly with humans, thus contributing to safety perceptions. Overly anthropomorphic robots might need to target those who are confident in using technology and, hence, less likely to be perturbed by safety concerns. In any case, promotional messages about such robots should explicitly highlight that the robots are safe to use as companions. Such marketing efforts may help mitigate the uncanny valley effect.

5.4. Limitations and future research directions

This study has two limitations that offer potential for future research. First, the sample was drawn from international postgraduate students across five European universities. Although it included students from a variety of national backgrounds, caution is advocated in generalising the findings to either international undergraduate students or those who relocate to non-European countries for their postgraduate studies. Future research could collect data from countries that differ in their degree of technology acceptance to evaluate the replicability of the current findings. Beyond the context of students' international relocation, it is also important to explore: How do human responses to companion robots vary across cultures and demographics (e.g., elderly and children)?

Second, conducting an online scenario-based study with static images of robots meant that the participants could not interact with an actual robot in real-time. Hence, how a robot's physical structure, movements, and sounds shape perceptions and social support was not examined. Although the practice of exposing participants to images of robots in an online setting—as followed in this study—is common in human-robot interaction research (e.g., Laakasuo et al., 2021; Müller et al., 2021), more field experiments are recommended going forward. A key area for future investigation is: How do human interactions with companion robots in real-time affect perceptions and the evolution of human-robot relationships over time? Addressing the limitations of this study and exploring the proposed future research questions will not only deepen the scholarly understanding of human-robot interaction in light of the CASA paradigm but also provide further insights for the development of more socially acceptable robotic companions.

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