Perceived Robot Threat Reduces Prosocial Tendencies

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Abstract

The integration of robots into society may pose psychological threats to humans, which can challenge interpersonal relationships. Through eight studies combining archival database analysis, questionnaires, scenario experiments, and offline surveys, this article examines the impact of perceived robot threat on prosocial tendencies, as well as its underlying mechanisms and boundary conditions. The results indicate that perceived robot threat reduces individuals' prosocial tendencies (Studies 1–7); the mechanism involves the mediating role of collective anxiety, whereby perceived robot threat increases collective anxiety, thereby decreasing prosocial tendencies (Studies 2–4). This effect is moderated by ingroup-outgroup distinctions, such that perceived robot threat primarily reduces prosocial tendencies toward outgroup members (Study 5). Additionally, this effect is moderated by moral comparison orientation, such that perceived robot threat mainly reduces prosocial tendencies among individuals with downward moral comparison orientation (Study 6). The findings reveal the negative impact of perceived robot threat on interpersonal relationships and extend existing research on the social impact of robots.

Full Text

Perceived Robot Threat Reduces Prosocial Tendencies

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Abstract

As robots enter society, they may pose psychological threats to humans, and such threats could challenge interpersonal relationships. Through eight studies combining archival database analysis, questionnaire surveys, scenario experiments, and field investigations, this paper examines the impact of perceived

robot threat on prosocial tendencies, as well as its underlying mechanisms and boundary conditions. The results show that: (1) Perceived robot threat reduces people's prosocial tendencies (Studies 1–7); (2) The mechanism is mediated by collective anxiety—perceived robot threat increases collective anxiety, which in turn reduces prosocial tendencies (Studies 2–4); (3) This effect is moderated by ingroup/outgroup distinction, such that perceived robot threat primarily reduces prosocial tendencies toward outgroup members (Study 5); (4) This effect is also moderated by moral comparison orientation, such that perceived robot threat mainly reduces prosocial tendencies among those who engage in downward moral comparisons (Study 6). These findings reveal the negative impact of perceived robot threat on interpersonal relationships and extend existing research on the social effects of robots.

Keywords: prosocial tendencies, perceived robot threat, collective anxiety, outgroup, moral comparison
Classification Code: B849: C91

Introduction

Concerns about technological unemployment have persisted since the Industrial Revolution. From early machines to today's AI-powered robots, people have consistently worried that technology would acquire human skills and replace human labor (Susskind & Susskind, 2015). Current AI technology has an even greater impact on routine task-based jobs (Neufeind et al., 2018). Looking at the data alone, AI already poses a serious threat to humans in the job market. Some predictions suggest that 47% of existing jobs in the United States will be replaced by AI, with that figure reaching as high as 54% in European studies (Frey & Osborne, 2017). The labor transformation brought by AI will make simple, repetitive work without cognitive demands the ideal scenario for robot application, potentially turning most workers into a "useless class" (Harari, 2017).

Discussions about the degree to which AI will replace different occupations continue unabated, with some scholars even calculating the specific percentage of jobs that will be replaced by AI in various industries as a reference for job seekers (Frey & Osborne, 2017). However, the threats that robots may pose to humans extend beyond this. In addition to realistic threats such as seizing human jobs, increasingly humanoid robots in appearance and capability may also pose identity threats—that is, blurring the boundaries between humans and machines, thereby threatening human identity and the uniqueness of being human (Yogeeswaran et al., 2016).

Although robot technology is profoundly transforming the global economy (Agrawal et al., 2019; Ford, 2009), people's perception of robot threats may have important social consequences, particularly in affecting interpersonal relationships—similar to the social disruption caused by early industrial

development. Realistic group conflict theory suggests that increasing automation will intensify intergroup tensions because it increases competition between groups for resources (Bobo, 1983; Jackson, 1993). For example, the Industrial Revolution amplified racial and class-based hostility in Europe and the United States (Mathias, 2013). Against these historical and theoretical backgrounds, recent research has begun to examine the impact of robot threats on interpersonal society. For instance, increased contact with robots enhances support for anti-immigration policies (Frey et al., 2018); perceived threat from automation increases support for restrictive immigration policies and leads to more discriminatory behavior toward immigrants (Gamez-Djokic & Waytz, 2020). Recent research has also found negative interpersonal effects of robots in the workplace. For example, increased workplace robots cause stronger job insecurity, which is significantly positively correlated with job burnout and workplace incivility (Yam et al., 2023); AI deployment increases unethical behavior among workplace employees (Bai et al., in press); perceived robot threat increases workplace objectification (Xu et al., 2024). These findings reflect that robot technology not only affects interpersonal society but may also bring negative consequences.

In this context, examining the impact of robot threats on people's prosocial tendencies becomes particularly important. Prosocial behavior refers to actions that individuals voluntarily take to benefit others, groups, or society, aimed at promoting others' rather than one's own interests (Batson & Powell, 2003). Prosocial behavior has received widespread attention due to its significance for interpersonal relationships and overall social well-being (Penner et al., 2005). Existing literature has explored the influence of internal factors (such as personality, emotions, motivations, and preferences) and external factors (such as norms, reputation, and relationships) on prosocial behavior (Simpson & Willer, 2015). However, with the rapid development and popularization of AI technology, robots are gradually appearing in various environments such as workplaces, homes, and service settings. The threat perception they generate may become a new external factor affecting prosocial behavior, leading to deteriorating interpersonal relationships and social indifference. Based on this, the present research aims to explore the impact of perceived robot threat on prosocial tendencies and attempts to reveal its underlying mechanisms and boundary conditions. This will help us better understand and address the challenges that robots pose to interpersonal relationships in the context of increasingly prevalent robot technology.

1.1 How Perceived Robot Threat Affects Prosocial Tendencies The development of robot technology has brought profound changes to society (Agrawal et al., 2019; Ford, 2009), but it has also triggered deep anxiety about robot threats. Regarding robot threats, people often paint a bleak picture of the future. For example, people worry that robots will replace their jobs or lead to an uncertain and crisis-filled future for humanity (Asimov, 1950; Gray et al., 2023). These concerns exist not only at the individual level but also

generate widespread anxiety at the collective level.

Individual-level anxiety typically refers to uncertainty about personal life and future (Mann et al., 2020; Miloyan et al., 2018), such as concerns about career and economic security (Li et al., 2019). Collective-level anxiety involves a broad sense of crisis about the entire group's future (Wohl & Branscombe, 2008). Previous research has extensively studied individual anxiety caused by robot threats and its impact on interpersonal relationships (Frey et al., 2017; Im et al., 2019; Wu et al., in press; Yam et al., 2023). For example, contact with robots in the workplace triggers job insecurity and leads to incivility toward colleagues (Yam et al., 2023). The threat of automation to future employment increases people's material insecurity and increases their support for anti-immigration policies (Frey et al., 2017; Im et al., 2019). Currently, research on individual-related anxiety triggered by robot threats and its negative interpersonal consequences is relatively clear (Frey et al., 2017; Im et al., 2019; Wu et al., in press; Yam et al., 2023). However, similar to other threat sources (Kahn et al., 2022), robot threats may also trigger collective anxiety. Collective angst is a concern about the group's future fate, reflecting group members' unease about the future (Wohl & Branscombe, 2008).

Collective anxiety has two sources: threats to group distinctiveness and extinction threats (Wohl et al., 2012), which are similar to the identity threats and realistic threats that robots pose to humans (Yogeeswaran et al., 2016). First, according to social identity theory, group members have a motivation to maintain their group's distinctiveness (Brewer, 2001; Tajfel & Turner, 1986). When people believe their group may lose its distinctiveness compared to another group in the future, they experience collective anxiety. This is evident in concerns that celebrating other ethnic groups' festivals and adopting their rituals and terminology will lead to loss of tradition, that intermarriage with other ethnic groups will cause cultural extinction among ethnic minorities, and that Canadians worry about becoming too Americanized amid globalization (Lalonde, 2002; Roccas & Amit, 2011; Wohl et al., 2011). This distinctiveness threat is similar to the identity threat caused by robots, as people experience collective anxiety due to concerns that the boundary between machines and humans will blur in the future. Second, group extinction is not unprecedented in history. When people imagine that natural disasters could cause their group's extinction, or even just symbolically cause their group's identity to disappear permanently, they fall into group anxiety (Wohl et al., 2010). Regarding the rapid development of robots, people also have concerns about extinction threats. For example, some scholars and experts believe that transformative technologies such as machine intelligence pose unprecedented risks to humanity, potentially leading to human extinction or destroying Earth's potential to nurture intelligent life (Bostrom, 2002; Khasawneh, 2018; Li & Huang, 2020; Yudkowsky, 2008). Science fiction novels often depict robots' cruel harm to humans, and this year, as large language models like ChatGPT began to exhibit possible human-like behaviors, various tech leaders called for a pause in related research to avoid humanity falling into an irreversible situation (Kahn, 2023). These are almost real-world

versions of collective anxiety caused by robot threats. More direct evidence shows that economic inequality generates collective anxiety, particularly among low-income populations (Jetten et al., 2017); and national inequality as reflected by the Gini coefficient is significantly positively correlated with people's perception that AI or robots pose a threat of widespread unemployment (Shoss & Ciarlante, 2022). Based on this, we can speculate that perceived robot threat increases collective anxiety.

Unlike the negative interpersonal consequences typically produced by individual anxiety, the interpersonal consequences of collective anxiety may be either constructive (i.e., prosocial) or destructive (i.e., antisocial) (Wohl et al., 2012). Human society has always been filled with global crises such as pandemics, earthquakes, climate change, and terrorism (Kahn et al., 2022). These crises have generated anxiety and worry about the entire group's future. On the one hand, this collective anxiety promotes intergroup cooperation, such as collaborative problem-solving, investment in public facilities, or providing help to other groups (Fuesting et al., 2019; Kung et al., 2018; Römpke et al., 2019). On the other hand, this group anxiety is also believed to lead to the dissolution of social bonds (Drury, 2018), instead exacerbating individualism and selfish behavior. For example, global pandemics increase perceptions of competition between whites and blacks, and subsequent discrimination against outgroups, behavioral avoidance, intergroup anxiety, and interracial distrust (Gordils et al., 2021). After natural disasters, people show significantly less trusting behavior (Fleming et al., 2014). As a new source of collective anxiety accompanying technological progress, the impact of robot threats on human prosocial behavior has not yet been empirically tested.

Based on the unique characteristics that distinguish robot threats from other threats, this research argues that collective anxiety triggered by robot threats should reduce prosocial behavior among humans rather than promote it. First, perceived resource scarcity creates different focuses on threats (Miao et al., 2023). When people believe resources are sufficient to address threats, they develop a sense of shared fate across groups and promote intergroup cooperation to jointly address threats (Cortland et al., 2017; Dovidio et al., 2004). However, when existing resources are believed to be insufficient to jointly address threats, this destroys the sense of common purpose under collective anxiety (Bavel et al., 2020) and hinders interpersonal and intergroup reciprocity (Butz & Yogeeswaran, 2011; Frankenberg et al., 2012; Gamez-Djokic & Waytz, 2020; Uenal et al., 2021). Robot threats possess the latter characteristics. For example, panel data from 33 OECD countries found that robots and AI have led to insufficient job positions and increased unemployment rates (Bordot, 2022). Therefore, although robots trigger collective anxiety—people view robots as a common threat to humanity and worry about the future of the human group—the objective reality or subjective belief that robots seize resources makes people more inclined to find "scapegoats" when facing this common threat and collective anxiety, i.e., reducing prosocial tendencies. Second, one prerequisite for cooperation and reciprocity among people under collective anxiety is view-

ing each other as a single, common group, i.e., different social groups become equal targets of the common threat, thereby generating a sense of "we suffer together" (Drury, 2018). However, in situations of obvious inequality, even when facing the same threat, people are unwilling to view everyone as a single group, whether they are advantaged or disadvantaged groups (Drury, 2018; Vezzali et al., 2017). Robot development may exacerbate social inequality (Howard & Borenstein, 2018). For example, robots may have racial and gender biases (Howard & Borenstein, 2018), are more likely to first replace low- and medium-skill positions (Goyal & Aneja, 2020), and increase economic inequality (Goyal & Aneja, 2020). This makes it difficult for collective anxiety caused by robots to prompt people to view each other as a single group; instead, it is more likely to trigger hostility and reduce prosociality.

Based on the above perspectives, collective anxiety caused by perceived robot threats may negatively impact interpersonal relationships, leading to reduced prosocial tendencies. That is, robot threats increase people's collective anxiety—concerns about humanity's future—but do not unite humanity, so collective anxiety instead reduces people's prosocial tendencies. Previous research on collective anxiety and interpersonal effects has mostly used pandemics, natural disasters, terrorism, or outgroup threats as sources of collective anxiety (e.g., Jetten et al., 2021; Wohl et al., 2011). With technological development, the realistic and identity threats that robots and AI may pose to humans have received increasing attention (Yogeeswaran et al., 2016; Złotowski et al., 2017), becoming one source of collective anxiety. However, the subsequent interpersonal effects of this threat-induced collective anxiety have not yet been confirmed. Will people increasingly view humanity as a whole ingroup and become more united, or will they find scapegoats under collective anxiety and become more alienated? This research focuses on this question, attempting to explore the potential impact of perceived robot threat on prosocial tendencies through collective anxiety.

1.2 Boundary Conditions of How Perceived Robot Threat Affects Prosocial Tendencies The impact of perceived robot threat on prosocial behavior varies depending on ingroup/outgroup relationships. According to intergroup threat theory, in the absence of conflict, neither strong ingroup attachment nor outgroup hostility emerges (Brewer, 1999, p. 431; Sherif, 1966; Sumner, 1906). Threat is an important factor that highlights and strengthens outgroup categorization (Stephan et al., 2015) and further triggers hostility toward outgroups (Riek et al., 2006). Even threats faced together with outgroups lead to negative attitudes (Gordils et al., 2021; Miao et al., 2023). For example, global pandemics increase perceived competition between whites and blacks, and subsequent discrimination against outgroups, behavioral avoidance, intergroup anxiety, and interracial distrust (Gordils et al., 2021); anti-immigrant sentiment increases after natural disasters (Andrighetto et al., 2016); macroeconomic threats only increase prejudice against Asian Americans (Butz & Yogeeswaran, 2011). Collective anxiety increases prejudice against Muslims (Tabri et al., 2018), opposition to and prejudice against immigrants, and intolerance

of interethnic marriage (Jetten et al., 2021; Jetten & Wohl, 2012; Lucas et al., 2014; Roccas & Amit, 2011). Therefore, similar to other threats, robot threats may strengthen boundaries and opposition between ingroups and outgroups in interpersonal relationships. Some studies provide preliminary evidence. For example, concerns about automation increase opposition to and discrimination against outgroups (Gamez-Djokic & Waytz, 2020). Automation threat makes people oppose immigration and support policies restricting immigration and foreign goods (Wu, 2022a, 2022b). Based on this, we hypothesize that ingroup/outgroup distinction moderates the effect of perceived robot threat on prosocial tendencies, i.e., the effect of perceived robot threat reducing prosocial tendencies is stronger for outgroup members and weaker for ingroup members.

Ingroup/outgroup distinction allows individuals to adjust their attitudes toward helping others in horizontal group comparisons. As a morally relevant behavior, the impact of robot threat on prosocial behavior may be influenced by moral comparisons. Previous studies show that common external threats may either promote cooperation and mutual assistance, thereby increasing prosocial behavior (Fuesting et al., 2019; Kung et al., 2018; Römpke et al., 2019), or may foster selfish behavior and reduce prosociality (Fleming et al., 2014; Gordils et al., 2021). This dual effect may stem from motivational differences when people face threats: on the one hand, individuals may be encouraged to transcend self-concern and consider the situation of "others"; on the other hand, individuals may justify maintaining their own and their group's status during crises. This involves upward or downward moral comparison tendencies. First, the traditional realistic group conflict perspective holds that threats increase intergroup prejudice and conflict, while moral superiority can provide justification or legitimation for dominating or actively conquering outgroups when conflicts arise (Sidanius, 1993). Moral superiority also provides defense for who has the right to obtain these resources, who should obtain these resources, and how these resources should be allocated during crises (Hirschberger & Pyszczynski, 2011). Therefore, the sense of superiority produced by downward moral comparisons may lead people to act more selfishly when facing robot threats. Additionally, downward moral comparisons may make individuals feel morally licensed (Lasarov & Hoffmann, 2020; Merritt et al., 2010), allowing them to indulge themselves when responding to robot threats by engaging in some immoral behaviors or reducing prosocial behaviors to protect personal interests. For example, under threat induced by the Holocaust, moral licensing increased people's acceptance of harming civilians (Hirschberger & Pyszczynski, 2011). Based on these perspectives, downward moral comparators prioritize self over others when facing threats, justifying themselves through moral superiority and moral licensing. Based on this, we hypothesize that the effect of perceived robot threat on prosocial tendencies is moderated by moral comparison direction, i.e., the effect of perceived robot threat reducing prosocial tendencies is stronger among downward moral comparators and weaker among upward moral comparators.

1.3 Overview of Studies This paper consists of eight recursive studies (Table 1), with the main research objective being to explore the impact of perceived robot threat on prosocial tendencies, with collective anxiety as the mediating mechanism and ingroup/outgroup distinction and moral comparison orientation as moderators of its effects. Studies 1a and 1b used existing archival databases to identify the basic relationship between perceived robot threat and prosocial behavior. Studies 2 and 3 used questionnaire and experimental research respectively to explore how perceived robot threat affects prosocial tendencies, i.e., to verify the mediating mechanism of collective anxiety. Study 4 excluded the influence of other potential mediators. Studies 5 and 6 respectively explored the boundary conditions of perceived robot threat reducing prosocial tendencies, i.e., verifying the moderating effects of ingroup/outgroup distinction and moral comparison orientation. Study 7 examined the impact of perceived robot threat on actual prosocial behavior.

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2 Study 1a: The Relationship Between Perceived Robot Threat and Prosocial Tendencies (Donation Index)

Study 1a preliminarily established the relationship between perceived robot threat and prosocial behavior using archival data. In this study, the national donation index was used as an indicator of prosocial behavior.

2.1 Sample The data for this study were divided into individual-level and country-level data. Individual-level data came from Eurobarometer 87 .1 (Eurobarometer 87.1, 2017), which included a special topic on "The Impact of Digitalization and Automation on Daily Life" covering content related to perceived robot threat. The Eurobarometer 87.1 data were collected through face-to-face interviews with representative European citizens (aged 15 and above) from March 18 to March 27, 2017. The total sample included responses from 27,901 participants across 28 EU member states.

Table 2 presents country-level demographic information: gender and age.

In this study, we included all 27,901 participants' responses from Eurobarometer 87.1 in the individual-level data for Sample 1 (55.0% female, M age = 51.38, SD = 18.25) for comprehensive and large-scale analysis. Simultaneously, we restricted Sample 2 to 13,294 employed participants (51.5% female, M age = 44.06, SD = 12.20) for separate analysis of the workforce sample, as previous research suggests that robot development poses a greater threat to the labor force (Shoss & Ciarlante, 2022). In both Sample 1 and Sample 2 (see Table 2), we combined West and East German samples as the Germany sample (total N1 = 1,537, total N2 = 650) and combined Northern Ireland and Great Britain samples as the UK sample (total N1 = 1,346, total N2 = 620). Table 2 includes country-level sample sizes and basic demographic data for each country, namely gender, age, and sample size.

2.2.1 Individual-Level Variables Perceived Robot Threat. Eurobarometer items related to perceived robot threat include 6 questions: (1) "Due to the use of robots and artificial intelligence, more jobs will disappear rather than create more new jobs"; (2) "Robots and artificial intelligence are a good thing for society because they help people with work or daily tasks at home"; (3) "Robots and artificial intelligence are technologies that need to be carefully managed"; (4) "Robots are necessary because they can do work that is too difficult or dangerous for humans"; (5) "In terms of industrial digital transformation, the EU is ahead of the rest of the world"; (6) "Robots and artificial intelligence are taking people's jobs" (items 2 and 4 are reverse-scored). Shoss and Ciarlante (2022) argue that robots mainly threaten the labor force, so they restricted their sample to employed individuals and selected the two items most relevant to perceived job threat (items 1 and 6) as indicators of perceived robot threat. Following Shoss and Ciarlante (2022), we averaged these two items' scores as Robot Threat Indicator 1. However, we believe that robot threats are not limited to the workplace, so we additionally selected items 1, 2, 3, 4, and 6 (5 items total) and averaged these 5 items' scores as Robot Threat Indicator 2. All items used a 4-point Likert scale (1 = strongly disagree, 4 = strongly agree), with higher scores indicating higher perceived robot threat.

Individual-Level Control Variables. This study considered several individual-level demographic and technology-related variables that may predict people's perceived robot threat. Demographic variables included education, gender, age, community size, and political beliefs (McClure, 2018). Regarding technology-related variables, Eurobarometer surveyed people's experience and knowledge of advanced technology, including participants' digital technology skills (i.e., "whether these skills are sufficient to support current or future work"), participants' knowledge of AI (i.e., "whether they have read or seen anything about AI in the past year"), and robot use at work (i.e., "whether they currently use or have ever used robots at work"). Previous research shows that such variables may also affect people's perception of robot threat (Vu & Lim, 2021). Moreover, previous analyses of Eurobarometer datasets found these variables related to people's views on and acceptance of technology impacts (Carradore, 2022; Rughiniş et al., 2018). Finally, individuals' views on whether AI or robots could perform their current jobs in the future were also controlled, as the threat of advanced technology replacing one's job may affect personal views on the general threat of this technology (Shoss & Ciarlante, 2022). Including these control variables can reduce the impact of systematic differences between countries in these factors on the results.

2.2.2 Country-Level Variables Individual-level data (including robot threat and other control variables) all came from Eurobarometer 87.1. Since this data were collected by March 2017, country-level data (including prosocial behavior and other control variables) from 2016 were more temporally consistent with Eurobarometer 87.1 data.

Prosocial Behavior. Prosocial data came from the Charities Aid Foundation (CAF) World Giving Index 2017, which reflects the 2016 World Giving Index. The World Giving Index focuses on charitable giving worldwide and includes three different types of giving behaviors: helping strangers ("Have you helped a stranger or someone you didn't know but who needed help?"), monetary donation ("Have you donated money to charity?"), and time contribution ("Have you volunteered for an organization?"). These three different giving behaviors form the Helping Strangers Index, Monetary Donation Index, and Time Contribution Index respectively. Averaging these three indices yields the Donation Index, with higher scores indicating more prosocial behavior. This report collected data from 139 countries; we used data from the 28 EU countries corresponding to Eurobarometer 87.1 for analysis.

Country-Level Control Variables. Since prosocial behavior may be affected by economic development level, we controlled for each country's 2016 per capita gross domestic product (GDP per capita), i.e., a country's economic output divided by its population annual estimate. This data came from World Development Indicators (World Bank, 2016). To ensure normality, we used the natural logarithm of per capita GDP (lnGDP) in all analyses. Since prosocial behavior is also related to equity, we also controlled for each country's 2016 Gini index. This study's country-level economic indicators came from the World Bank's World Development Indicators (WDI; World Bank, 2016). Country-level prosocial behavior data and control variable indices are shown in Table 3 .

2.2.3 Analytical Method This study used prosocial tendency (donation index) as the dependent variable, perceived robot threat as the independent variable, and gender, age, community, education, political orientation, technology skills, robot-related knowledge, robot use, social class, national Gini coefficient, and national GDP as control variables. Hierarchical linear regression analysis was conducted using SPSS 25. The regression formula was as follows:

$$y_{j(i)} = \beta_{1x} i + Control_i + Control_j + \varepsilon_i$$

where i represents the individual, j represents the country, *j(i)* represents the country where individual i is located, $y_{j(i)}$ is the 2016 donation index, x_i is the robot threat indicator, $Control_i$ represents individual-level control variables, $Control_j$ represents country-level control variables, and ε_i represents random error.

2.3.1 Full Sample Table 4 provides descriptive statistics and correlations for the full sample. As shown in Table 4, Robot Threat Indicator 1 (composed of 2 items) was significantly negatively correlated with the Helping Strangers Index ($r = -.065$, $p < 0.001$), Monetary Donation Index ($r = -.151$, $p < 0.001$), Time Contribution Index ($r = -.083$, $p < 0.001$), and total Donation Index ($r = -.125$, $p < 0.001$). Robot Threat Indicator 2 (composed of 5 items) was also

significantly negatively correlated with the Helping Strangers Index (r = –.014, p = 0.017), Monetary Donation Index (r = –.102, p < 0.001), Time Contribution Index (r = –.017, p < 0.001), and total Donation Index (r = –.063, p < 0.001).

Since many control variables were correlated with the donation index, we conducted hierarchical linear regression analysis with the donation index as the dependent variable, Robot Threat Indicator 1 (2 items) as the independent variable, and control variables included in the model. Results showed that after controlling for demographic variables (i.e., gender, age, community, education, and political orientation), technology-related variables (i.e., technology skills, related knowledge, and robot use), and country-level variables (Gini coefficient and national GDP), Robot Threat Indicator 1 still negatively affected prosocial behavior, $B = –.51$, $p < 0.001$ (see Table 5).

Similarly, hierarchical linear regression analysis with the donation index as the dependent variable and Robot Threat Indicator 2 (5 items) as the independent variable, with control variables included, found that after controlling for demographic variables, technology-related variables, and country-level variables, Robot Threat Indicator 2 still negatively affected prosocial behavior, $B = –.60$, $p < 0.001$ (see Table 5).

2.3.2 Workforce Sample Table 6 provides descriptive statistics and correlations for the workforce sample. As shown in Table 6, Robot Threat Indicator 1 (2 items) was significantly negatively correlated with the Helping Strangers Index (r = –.069, p < 0.001), Monetary Donation Index (r = –.172, p < 0.001), Time Contribution Index (r = –.098, p < 0.001), and total Donation Index (r = –.141, p < 0.001). Robot Threat Indicator 2 (5 items) was only significantly negatively correlated with the Monetary Donation Index (r = –.096, p < 0.001) and total Donation Index (r = –.057, p < 0.001).

Similarly, we conducted hierarchical linear regression analysis with the donation index as the dependent variable, Robot Threat Indicator 1 (2 items) as the independent variable, and control variables included. Results showed that after controlling for demographic variables (i.e., gender, community, political orientation, and social class), technology-related variables (i.e., technology skills, related knowledge, and robot use), and country-level variables (Gini coefficient and national GDP), Robot Threat Indicator 1 still negatively affected prosocial behavior, $B = –.60$, $p < 0.001$ (see Table 7).

Similarly, hierarchical linear regression analysis with the donation index as the dependent variable and Robot Threat Indicator 2 (5 items) as the independent variable, with control variables included, found that after controlling for demographic variables, technology-related variables, and country-level variables, Robot Threat Indicator 2 still negatively affected prosocial behavior, $B = –.63$, $p < 0.001$ (see Table 7).

2.4 Discussion Study 1a preliminarily identified a negative relationship between perceived robot threat and prosocial behavior through archival database analysis. However, Study 1a has some limitations. Analyzing country-level donation indices with individual-level perceived robot threat may overlook individual differences, causing biased results or ecological fallacy. Additionally, using country-level data for prosocial behavior (donation index) may cause the dependent variable to be heavily influenced by national economy, customs, and values. Therefore, Study 1b will use individual-level data for archival database analysis and control for country fixed effects to reduce the influence of unobservable factors between countries.

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3 Study 1b: Perceived Robot Threat and Prosocial Tendencies (Support for Humanitarian Aid)

To improve the robustness of the archival analysis findings, Study 1b improved upon Study 1a in several ways. First, Study 1b used individual-level perceived robot threat and prosocial tendencies for analysis to reduce result bias caused by cross-level analysis in Study 1a. Second, Study 1b used support for humanitarian aid as an indicator of prosocial tendency to increase diversity in the dependent variable. Third, Study 1b controlled for country fixed effects to reduce the influence of unobservable factors between countries (such as customs and values). Finally, Study 1b used data from a different time point than Study 1a to verify the temporal stability of the findings.

3.1 Sample This study's data came from Eurobarometer 77 .1 (Eurobarometer 77.1, 2012), whose special topics "Public Attitudes Toward Robots" covered perceived robot threat content and "Humanitarian Aid" covered prosocial tendency content. Eurobarometer 77.1 data were collected through face-to-face interviews with representative European citizens (aged 15 and above) from February 25 to March 12, 2012. The total sample included responses from 26,751 participants across 27 EU member states.

Like Study 1a, we combined West and East German samples as the Germany sample and combined Northern Ireland and Great Britain samples as the UK sample. Table 8 includes country-level sample sizes and basic demographic data for each country, namely gender, age, and sample size.

3.2.1 Perceived Robot Threat Eurobarometer 77.1 items related to perceived robot threat include 5 questions: (1) "Robots are a good thing for society because they help people"; (2) "Robots are taking people's jobs"; (3) "Robots are necessary because they can do work that is too difficult or dangerous for humans"; (4) "Robots are a technology that needs to be carefully managed"; (5) "The widespread use of robots can increase job opportunities in the EU." We averaged the scores of these 5 items as perceived robot threat. All items used

a 4-point Likert scale (1 = strongly disagree, 4 = strongly agree), with items 1, 3, and 5 reverse-scored. Higher scores indicated higher perceived robot threat.

3.2.2 Prosocial Tendencies Eurobarometer 77.1 items related to prosocial tendencies include 4 questions: "Humanitarian aid is assistance provided to people in need in countries outside the EU during crises and emergencies. The main goal is to save lives and alleviate the suffering of affected people: (1) How important do you think it is for the EU to fund these humanitarian aid activities?; (2) Europe is in an economic crisis with great pressure on public finances. Nevertheless, the EU continues to fund humanitarian aid to help people in urgent need around the world. How supportive are you of this?; (3) How much do you know about the EU's humanitarian aid activities?; (4) The European Commission is establishing a 'European Voluntary Humanitarian Aid Corps.' Volunteers from EU countries will be selected, trained, and deployed to other parts of the world for humanitarian aid activities. How supportive are you of this?" All items used a 4-point Likert scale. Averaging the four items yielded a prosocial index, with higher scores indicating higher prosocial tendencies.

3.2.3 Individual-Level Control Variables This study considered several individual-level demographic and technology-related variables that may predict people's perceived robot threat. Demographic variables included gender, age, education, community size, political beliefs, and social class (McClure, 2018). Regarding technology-related variables, Eurobarometer surveyed people's experience and knowledge of advanced technology, including participants' interest in science and technology (i.e., "How interested are you in scientific discoveries and technological developments"), robot use (i.e., "Have you ever used a robot at home or at work, such as a household cleaning robot or an industrial robot at work"), and participants' general attitudes toward robots (i.e., "In general, what is your attitude toward robots?"). Previous research shows that such variables may also affect people's perception of robot threat (Carradore, 2022; Rughiniş et al., 2018; Vu & Lim, 2021). All individual-level control variable data came from Eurobarometer 77.1. Including these control variables can reduce the impact of systematic differences between countries in these factors on the results.

3.2.4 Country-Level Control Variables Since prosocial behavior may be affected by economic development level, we controlled for each country's 2011 per capita gross domestic product (GDP per capita). This data came from World Development Indicators (World Bank, 2011). To ensure normality, we used the natural logarithm of per capita GDP (lnGDP) in all analyses (see Table 8).

3.2.5 Analytical Method This study used prosocial tendency (support for humanitarian aid) as the dependent variable, perceived robot threat as the independent variable, and gender, age, community, education, social class, science interest, robot use, general attitude toward robots, and national GDP as

control variables. HDFE (High Dimensional Fixed Effects) linear regression analysis was conducted using STATA, controlling for country fixed effects. The regression formula was as follows:

$$y_i = \beta_{1x} i + Control_i + Control_j + \alpha_j + \varepsilon_i$$

where i represents the individual, j represents the country, y_i is the prosocial indicator, x_i is the robot threat indicator, $Control_i$ represents individual-level control variables, $Control_j$ represents country-level control variables, α_j represents country fixed effects, and ε_i represents random error.

3.3 Results Table 9 provides descriptive statistics and correlations. As shown in Table 9, perceived robot threat was negatively correlated with prosocial tendencies ($r = -.154$, $p < 0.001$).

Since many control variables were correlated with perceived robot threat or prosocial tendencies, and country fixed effects may also affect both, we conducted HDFE linear regression analysis with prosocial tendencies as the dependent variable, perceived robot threat as the independent variable, and control variables and country fixed effects included in the model.

Results showed that after controlling for demographic variables (i.e., gender, age, community, education, and social class), technology-related variables (i.e., interest in science and technology, robot use, and general attitude toward robots), country-level variables (national GDP), and country fixed effects, perceived robot threat still negatively affected prosocial tendencies, $B = -0.093$, $p < 0.001$ (see Table 10).

3.4 Discussion Study 1b again supported the negative relationship between perceived robot threat and prosocial behavior using the archival method. However, like most archival studies, it has some limitations (Barnes et al., 2018). First, archival analysis cannot reveal causal relationships between variables. Second, data used for archival analysis are susceptible to interference from other factors, such as economic conditions. Third, individual data containing both perceived robot threat and prosocial tendencies are limited, and findings may differ if more recent data were available (Yam et al., 2023). Fourth, the database we used was limited to a single time point. However, obtaining data containing more time periods would help improve the temporal robustness of the findings.

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4 Study 2: The Mediating Role of Collective Anxiety (Correlational)

Study 2 used a questionnaire method (cross-sectional study) to explore the relationship between perceived robot threat and prosocial tendencies and the mediating role of collective anxiety.

4.1 Participants This study used G*Power 3.1 software (Faul et al., 2007) to determine the required sample size. For the correlational analysis applicable to this experiment, referring to Study 1's correlation analysis results, we used a medium effect size of* $p^* = 0.30$, significance level $\alpha = 0.05$, requiring at least 134 participants to achieve 95% statistical power. Considering possible participant dropout or failure to pass attention checks, we recruited 150 participants on the Credamo platform. Two participants failed the attention check, resulting in a final sample of 148 participants. The mean age was 30.11 years (SD = 5.71), with 84 females (56.8%).

4.2 Materials Perceived Robot Threat. We used the Perceived Robot Threat Scale developed by Yogeeswaran et al. (2016). The scale has two dimensions: perceived realistic robot threat and perceived identity robot threat, each containing 5 items. Perceived realistic robot threat items include: (1) "The increasing use of robots in our daily lives is causing human unemployment"; (2) "Robots cannot replace people's jobs"; (3) "In the long run, robots pose a direct threat to human safety and well-being"; (4) "The development of robot technology will threaten human employment and opportunities"; (5) "The increasing popularity of robots in daily life poses a threat to human safety" (item 2 is reverse-scored). Perceived identity robot threat items include: (1) "The widespread application of robots in daily life bothers me because it blurs the boundary between humans and machines"; (2) "Robots that appear lifelike are disturbing because they are almost indistinguishable from humans"; (3) "Recent technological advances challenge the essence of humanity"; (4) "Technological advances in robotics are threatening human uniqueness"; (5) "Robots are beginning to blur the boundary between humans and machines." The scale used a 7-point Likert scale (1 = strongly disagree, 7 = strongly agree). In this study, Cronbach's α for the realistic threat dimension was 0.87, for the identity threat dimension was 0.93, and for all items was 0.95.

Prosocial Tendencies. Prosocial tendencies were measured using the Prosocial Tendencies Questionnaire by Osgood and Muraven (2015). The questionnaire includes 6 items: (1) "It is important to help people in need"; (2) "I want to help others"; (3) "The happiness and well-being of others is important"; (4) "It is important to make others happy"; (5) "It is important to make everyone happy"; (6) "The needs of others are important." The questionnaire used a 7-point Likert scale (1 = strongly disagree, 7 = strongly agree), with higher scores indicating stronger prosocial tendencies. In this study, Cronbach's α was 0.79.

Collective Anxiety. Collective anxiety was measured using the Collective Anxiety Scale by Wohl et al. (2010). The scale includes 5 items: (1) "I am confident in the survival of humanity"; (2) "I am confident in the future of humanity"; (3) "I am worried about the future of humanity"; (4) "I believe humanity will prosper forever"; (5) "I am concerned that the future vitality of humanity is in jeopardy" (items 1, 2, and 4 are reverse-scored). The scale used a 7-point Likert scale (1 = strongly disagree, 7 = strongly agree), with higher

scores indicating stronger collective anxiety. In this study, Cronbach's α for all items was 0.92.

To further enhance the robustness of the findings, the study also included the following control variables: (1) familiarity with robots (Leo & Huh, 2020): "How familiar are you with AI like robots?" (1 = not familiar at all, 7 = very familiar); (2) liking of robots: "How much do you like AI like robots?" (1 = don't like at all, 7 = like very much); (3) subjective social class (Adler et al., 2000). Additionally, gender and age were included as demographic variables.

4.3 Results Correlation analysis showed that prosocial tendencies were significantly negatively correlated with perceived robot threat and its two dimensions (r threat = –0.41, $p < 0.001$; r realistic = –0.40, $p < 0.001$; r identity = –0.40, $p < 0.001$). Prosocial tendencies were significantly negatively correlated with collective anxiety (r = –0.46, $p < 0.001$). Collective anxiety was significantly positively correlated with perceived robot threat and its two dimensions (r threat = 0.75, $p < 0.001$; r realistic = 0.73, $p < 0.001$; r identity = 0.73, $p < 0.001$). Partial correlation analysis with robot familiarity, liking, subjective social class, and demographic variables as control variables showed that all correlations remained significant: prosocial tendencies were significantly negatively correlated with perceived robot threat and its two dimensions (r threat = –0.23, p = 0.005; r realistic = –0.22, p = 0.008; r identity = –0.23, p = 0.006), and prosocial tendencies were significantly negatively correlated with collective anxiety (r = –0.26, p = 0.002). Collective anxiety was significantly positively correlated with perceived robot threat and its two dimensions (r threat = 0.60, $p < 0.001$; r realistic = 0.59, $p < 0.001$; r identity = 0.57, $p < 0.001$).

To test whether collective anxiety mediates the effect of perceived robot threat on prosocial tendencies, we used the PROCESS macro in SPSS for bias-corrected Bootstrap testing (Hayes et al., 2013), selecting Model 4 with 5,000 resamples. At a 95% confidence interval, with perceived robot threat as the independent variable, prosocial tendencies as the dependent variable, and collective anxiety as the mediator, mediation analysis was conducted. Mediation test results showed that the 95% Bootstrap confidence interval did not include 0, indicating that collective anxiety mediated the effect of perceived robot threat on prosocial tendencies (indirect effect = –0.12, SE = 0.05, 95% CI [–0.218, –0.024]). After controlling for collective anxiety, the direct effect of perceived robot threat on prosocial tendencies was no longer significant (direct effect = –0.06, SE = 0.05, 95% CI [–0.161, 0.034]), indicating full mediation.

4.4 Discussion Study 2 further demonstrated the negative relationship between perceived robot threat and prosocial tendencies using a questionnaire method. Additionally, Study 2 supported the mediating role of collective anxiety in the relationship between perceived robot threat and prosocial tendencies. However, Study 2 also has limitations: questionnaire results may be subject to common method bias that prevents establishing causality. Confirmatory factor

analysis was used to examine common method bias. Results showed that the control model's $^2 = 334.5$, df = 185, and the baseline model's $^2 = 362.5$, df = 186, with a difference of 28.000 (df = 1), reaching significance ($p < 0.05$), indicating some common method bias. Therefore, Study 3 will use an experimental method to test the effect of perceived robot threat on prosocial tendencies and the mediating role of collective anxiety.

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5 Study 3: The Mediating Role of Collective Anxiety (Experimental)

Study 3 used an experimental method to manipulate participants' level of perceived robot threat, on the one hand verifying the causal effect of perceived robot threat on prosocial tendencies, and on the other hand again verifying the mediating role of collective anxiety.

5.1 Participants This study used G*Power 3.1 software to determine the required sample size. Using a medium effect size* f* = 0.2, significance level $\alpha = 0.05$, a single-factor two-level between-subjects design required 266 participants to achieve 90% statistical power. On the Credamo platform, participants who failed attention checks were removed in real-time with rolling recruitment, leaving 270 valid participants. The mean age was 29.01 years (SD = 7.07), with 166 females (61.5%). All participants carefully read the experimental instructions and provided informed consent before the experiment began; participants with valid data received certain compensation after the experiment ended.

5.2 Procedure This study used a single-factor two-level between-subjects design, with participants randomly assigned to high or low perceived robot threat groups. In the final valid sample, there were 135 participants in each group. Perceived robot threat level was manipulated by having participants in both groups watch different robot videos[1] (Yogeeswaran et al., 2016; Złotowski et al., 2017): The high threat group watched a video where robots performed excellently in the real world, with strong locomotion abilities (walking, opening doors, carrying boxes) and interaction abilities (passing objects to humans, conversation), completing various tasks well; the low threat group watched a video where robots performed very poorly in the real world, with low capabilities, unable to complete various tasks well. After watching the videos, participants completed the Perceived Robot Threat Scale (same as Study 2; in this experiment, Cronbach's α for the realistic threat dimension was 0.84, for the identity threat dimension was 0.91, and for all items was 0.93) as a manipulation check.

Since robot videos, especially the low threat group's videos of robot failures, might make participants feel amused and thus affect experimental results, participants next completed the Perceived Video Enjoyment Scale, adapted from Agarwat and Karahanna (2000), including 4 items: (1) "Watching this video was fun"; (2) "Watching this video gave me a lot of pleasure"; (3) "I enjoyed this video"; (4) "Watching this video made me feel bored" (item 4 reverse-scored).

The scale used a 7-point Likert scale (1 = strongly disagree, 7 = strongly agree), with higher scores indicating stronger perceived video enjoyment. In this study, Cronbach's α for all items was 0.89.

Collective anxiety (same measurement as Study 2; in this experiment, Cronbach's α for all items was 0.92) and prosocial tendencies (same measurement as Study 2; in this experiment, Cronbach's α was 0.89) were then measured. Attention check questions were interspersed among measurement items, followed by demographic information.

[1] High threat group video link: https://www.bilibili.com/video/BV1p8411f7Rm/?spm_{{{id}}}{{{from}}}=333
Low threat group video link: https://www.bilibili.com/video/BV1Ko4y1M7hi/?spm_{{{id}}}_{{from}}}=333
card.all.click

5.3 Results One-way ANOVA results showed that perceived robot threat in the high threat group (M = 4.09, SD = 1.31, 95% CI [3.86, 4.31]) was significantly higher than in the low threat group (M = 3.51, SD = 1.32, 95% CI [3.28, 3.73]), $F(1, 268) = 13.16$, $p < 0.001$, ^{2}p = 0.47, 90% CI [0.014, 0.093], indicating successful manipulation.

One-way ANOVA results showed that collective anxiety in the high threat group (M = 3.15, SD = 1.32, 95% CI [2.93, 3.37]) was significantly higher than in the low threat group (M = 2.84, SD = 1.26, 95% CI [2.62, 3.06]), $F(1, 268) = 4.01$, $p = 0.046$, ^{2}p = 0.02, 90% CI [0.000, 0.055].

One-way ANOVA results showed that prosocial tendencies in the high threat group (M = 5.20, SD = 0.96, 95% CI [5.04, 5.37]) were significantly lower than in the low threat group (M = 5.44, SD = 0.73, 95% CI [5.32, 5.57]), $F(1, 268) = 5.21$, $p = 0.023$, ^{2}p = 0.02, 90% CI [0.001, 0.054]. Correlation analysis showed that perceived robot threat level (low threat group = 0, high threat group = 1) was significantly positively correlated with collective anxiety (r = 0.12, p = 0.046) and significantly negatively correlated with prosocial tendencies (r = –0.14, p = 0.023). Collective anxiety was significantly negatively correlated with prosocial tendencies (r = –0.39, $p < 0.001$). ANCOVA with perceived video enjoyment as a control variable showed that prosocial tendencies in the high threat group remained lower than in the low threat group, with a marginally significant difference, $F(1, 267) = 3.58$, $p = 0.059$, ^{2}p = 0.01.

To test whether collective anxiety mediates the effect of perceived robot threat on prosocial tendencies, we used the PROCESS macro in SPSS for bias-corrected Bootstrap testing (Hayes et al., 2013), selecting Model 4 with 5,000 resamples. At a 95% confidence interval, with perceived robot threat as the independent variable (low threat group = 0, high threat group = 1), prosocial tendencies as the dependent variable, and collective anxiety as the mediator, mediation analysis was conducted. Mediation test results showed that the 95% confidence interval did not include 0, indicating that collective anxiety mediated the effect of perceived robot threat on prosocial tendencies (indirect effect = –0.08, SE = 0.04, 95% CI [–0.178, –0.004]). After controlling for collective anxiety, the

direct effect of perceived robot threat on prosocial tendencies was no longer significant (direct effect = –0.16, SE = 0.10, 95% CI [–0.348, 0.033]), indicating full mediation. These results show that perceived robot threat reduces prosocial tendencies because it enhances people's collective anxiety, which in turn makes them less inclined to engage in prosocial behavior.

5.4 Discussion Study 3 supported the causal effect of perceived robot threat on prosocial tendencies through experimental research and again supported the mediating role of collective anxiety. However, the effect of perceived robot threat on prosocial tendencies may also be influenced by other potential mediators, such as pan-humanism (Jackson et al., 2020), job insecurity/career anxiety (Yam et al., 2023), and negative emotions (Yam et al., 2023). Therefore, Study 4 will examine the influence of other potential mediators.

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6 Study 4: Excluding Other Mediating Mechanisms

To further enhance the robustness of Study 3's experimental results, Study 4 changed the manipulation method of the independent variable and the measurement method of the dependent variable, and included measurements of other potential mediating variables to again verify the mediating role of collective anxiety.

Study 4 measured pan-humanism, job insecurity/career anxiety, and negative emotions (Yam et al., 2023). Pan-humanism refers to people's perceived closeness with all other human groups, regardless of race, religion, or nationality. Previous research found that robot salience reduces intergroup bias through pan-humanism (Jackson et al., 2020). Job insecurity/career anxiety refers to employees' concerns or unease about the stability and security of their jobs and career future. Previous research found that workplace robot contact increases employee job burnout and workplace incivility through job insecurity (Yam et al., 2023).

6.1 Participants This study used G*Power 3.1 software to determine the required sample size. Using a medium effect size* f* = 0.2, significance level α = 0.05, a single-factor two-level between-subjects design required 266 participants to achieve 90% statistical power. On the Credamo platform, participants who failed attention checks were removed in real-time with rolling recruitment, leaving 270 valid participants. The mean age was 29.99 years (SD = 7.48), with 197 females (73.0%). All participants carefully read the experimental instructions and provided informed consent before the experiment began; participants with valid data received certain compensation after the experiment ended.

6.2 Procedure This study used a single-factor two-level between-subjects design, with participants randomly assigned to robot threat or control groups. In

the final valid sample, there were 135 participants in each group. To manipulate perceived robot threat level, participants were first asked to write according to a set of instructions (Xu et al., 2024). The threat group's instructions were:

"With the rapid development of AI, robots will bring many potential threats to humans (e.g., unemployment, insecurity, challenging human nature). Please imagine and describe the robot threats you currently face or may face in the future, and the situations you will face after being threatened (no less than 100 words)."

The control group's instructions were:

"With the rapid development of AI, robots will assist humans in many social activities (e.g., food delivery services, logistics transportation, educational assistance). Please imagine and describe a future scenario where robots assist humans (no less than 100 words)."

After completing the writing task, participants completed the Perceived Robot Threat Scale (same as Study 2; in this experiment, Cronbach's α for the realistic threat dimension was 0.87, for the identity threat dimension was 0.90, and for all items was 0.93) as a manipulation check.

Potential mediating variables were then measured. Collective anxiety was measured the same as in Study 2 (Cronbach's $\alpha = 0.90$ in this experiment). Panhumanism was measured using the scale by McFarland et al. (2012): Participants were shown 5 sets of graphics, each with two circles overlapping to varying degrees; one circle represented "me," the other represented "humanity." Participants selected the graphic that best represented how they viewed the relationship between themselves and humanity as a whole. For example, choosing two completely separate circles indicated participants felt isolated from humanity as a whole, while choosing two completely overlapping circles indicated extreme intimacy with all other humans.

Job insecurity/career anxiety was measured using the scale by Yam et al. (2023), which includes 3 items: (1) "I feel I will lose my job soon"; (2) "I feel uneasy about my job prospects"; (3) "I feel I may lose my job in the near future." The scale used a 7-point Likert scale (1 = strongly disagree, 7 = strongly agree), with higher scores indicating stronger job insecurity/career anxiety. In this study, Cronbach's α for all items was 0.90.

Negative emotions were measured with 6 items: (1) afraid; (2) frustrated; (3) anxious; (4) fearful; (5) worried; (6) angry. The scale used a 7-point Likert scale (1 = not at all, 7 = very strongly), with higher scores indicating stronger negative emotions. In this study, Cronbach's α for all items was 0.92.

Prosocial tendencies were then measured using the scenario measurement scale by Touré-Tillery and Light (2018). Participants read 8 brief scenarios and indicated how likely they would be to engage in the described behaviors (1 = definitely not, 7 = definitely yes), for example: "You are on your way to an

appointment and running late when someone approaches you asking for directions to a place you know. Would you stop to give this person directions?" Higher scores indicated stronger prosocial tendencies. In this study, Cronbach's α for all items was 0.79. Attention check questions were interspersed among mediator and dependent variable measurement items, followed by demographic information.

6.3 Results One-way ANOVA results showed that perceived robot threat in the threat group ($M = 4.83$, $SD = 0.97$, 95% CI [4.65, 5.01]) was significantly higher than in the control group ($M = 3.36$, $SD = 1.14$, 95% CI [3.18, 3.54]), $F(1, 268) = 130.51$, $p < 0.001$, $^2\text{p} = 0.33$, 90% CI [0.254, 0.394], indicating successful manipulation.

One-way ANOVA results showed that prosocial tendencies in the threat group ($M = 4.86$, $SD = 0.96$, 95% CI [4.71, 5.01]) were significantly lower than in the control group ($M = 5.11$, $SD = 0.82$, 95% CI [4.95, 5.26]), $F(1, 268) = 5.25$, $p = 0.023$, $^2\text{p} = 0.02$, 90% CI [0.001, 0.054]. Correlation analysis showed that perceived robot threat level (control group = 1, threat group = 2) was significantly positively correlated with collective anxiety ($r = 0.40$, $p < 0.001$) and significantly negatively correlated with prosocial tendencies ($r = –0.14$, $p = 0.023$). Collective anxiety was significantly negatively correlated with prosocial tendencies ($r = –0.39$, $p < 0.001$).

To test whether collective anxiety mediates the effect of perceived robot threat on prosocial tendencies, we used the PROCESS macro in SPSS for bias-corrected Bootstrap testing (Hayes et al., 2013), selecting Model 4 with 5,000 resamples. At a 95% confidence interval, with perceived robot threat as the independent variable (control group = 1, threat group = 2), prosocial tendencies as the dependent variable, and collective anxiety as the mediator, mediation analysis was conducted. Mediation test results showed that the 95% confidence interval did not include 0, indicating that collective anxiety mediated the effect of perceived robot threat on prosocial tendencies (indirect effect = –0.29, SE = 0.06, 95% CI [–0.427, –0.190]). After controlling for collective anxiety, the direct effect of perceived robot threat on prosocial tendencies was no longer significant (direct effect = –0.04, SE = 0.11, 95% CI [–0.175, 0.260]), indicating full mediation. These results again support the mediating role of collective anxiety, i.e., perceived robot threat reduces prosocial tendencies by enhancing people's collective anxiety.

To exclude other potential mediators, we conducted mediation analyses for pan-humanism, job insecurity/career anxiety, and negative emotions using the same method. Pan-humanism mediation test results showed that the 95% confidence interval included 0, indicating that pan-humanism cannot mediate the effect of perceived robot threat on prosocial tendencies (indirect effect = –0.05, SE = 0.03, 95% CI [–0.132, 0.004]). Job insecurity mediation test results showed that the 95% confidence interval did not include 0, indicating that job insecurity mediated the effect of perceived robot threat on prosocial tendencies (indirect

effect = –0.13, SE = 0.05, 95% CI [–0.235, –0.052]). After controlling for job insecurity, the direct effect of perceived robot threat on prosocial tendencies was no longer significant (direct effect = –0.12, SE = 0.12, 95% CI [–0.344, 0.111]), indicating full mediation. Negative emotions mediation test results showed that the 95% confidence interval included 0, indicating that negative emotions cannot mediate the effect of perceived robot threat on prosocial tendencies (indirect effect = –0.07, SE = 0.05, 95% CI [–0.167, 0.019]).

Although job insecurity's mediating effect was significant, its indirect effect (–0.13) was smaller than that of collective anxiety (–0.29), indicating a weaker mediating effect. To further compare the mediating effects of job insecurity and collective anxiety between perceived robot threat and prosocial tendencies, we first used regression analysis to examine their differences. With prosocial tendencies as the dependent variable, perceived robot threat (first level), job insecurity, and collective anxiety (second level) as independent variables in hierarchical linear regression, results showed that collective anxiety significantly predicted prosocial tendencies (standardized $\beta = -0.45$, $t = -5.80$, $p < 0.001$), while job insecurity did not significantly predict prosocial tendencies (standardized $\beta = 0.08$, $t = 1.02$, $p = 0.307$). Path analysis with prosocial tendencies as the dependent variable, perceived robot threat as the independent variable, and collective anxiety and job insecurity as mediators showed that the path coefficient from collective anxiety to prosocial tendencies was –0.325 (SE = 0.044, CR = –7.421, $p < 0.001$), while the path coefficient from job insecurity to prosocial tendencies was 0.049 (SE = 0.038, CR = 1.310, $p = 0.190$). Comparing them in the same model shows that job insecurity's effect on prosocial tendencies is weaker than collective anxiety's effect.

6.4 Discussion Study 4 further supported the causal effect of perceived robot threat on prosocial tendencies and again supported the mediating role of collective anxiety. Additionally, Study 4 excluded the mediating roles of pan-humanism and negative emotions in the effect of perceived robot threat on prosocial tendencies. Although previous research found that robot salience can promote pan-humanism (Jackson et al., 2020), this may be based on situations where threat is not salient. However, when the threat posed by robots becomes obvious, this effect may not exist. Furthermore, Study 4 found that job insecurity can also mediate the effect of perceived robot threat on prosocial tendencies, which is consistent with previous research (Yam et al., 2023).

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7 Study 5: The Moderating Role of Ingroup/Outgroup Distinction

Study 5 examined the moderating role of ingroup/outgroup distinction in the effect of perceived robot threat on prosocial tendencies through manipulation of ingroup/outgroup categories.

7.1 Participants G*Power 3.1 software (Faul et al., 2007) was used to calculate the required sample size for this experiment. For the two-way ANOVA applicable to this experiment, using a medium effect size* f* = 0.2, significance level $\alpha = 0.05$, and 4 groups, at least 359 participants were needed to achieve 90% statistical power. Participants were recruited through the Credamo platform and randomly assigned to ingroup high threat, ingroup low threat, outgroup high threat, and outgroup low threat groups. Participants who failed attention checks were removed in real-time with rolling recruitment, leaving 400 valid participants (264 females). Participants' ages ranged from 19 to 60 years ($M = 30.95$, $SD = 6.99$), with 100 participants in each group. All participants carefully read the experimental instructions and provided informed consent before the experiment began; participants with valid data received certain compensation after the experiment ended.

7.2 Procedure Study 5 used a 2 (perceived robot threat: high vs. low) × 2 (ingroup/outgroup: ingroup vs. outgroup) between-subjects experimental design, with all participants randomly assigned to one of four groups.

First, participants' perceived robot threat level was manipulated. Referencing relevant research (Jackson et al., 2020; Xu et al., 2024), two different news webpage images were created (Figure 1 [Figure 1: see original paper]). In the high perceived robot threat group, participants read a tech news article titled "Robots: Replacing Human Labor?" describing how robots would take human jobs and pose a real threat to humans. In the low perceived robot threat group, participants read a tech news article titled "Robots: Just a Passing Fad?" describing how the possibility of robots taking human jobs was small and they would not pose a real threat to humans. The layout, length, and format of the two news webpages were basically the same.

After viewing the news materials, participants completed the Robot Threat Scale as a manipulation check (same as Study 2; in this study, Cronbach's α for the perceived realistic robot threat dimension was 0.94, for the perceived identity robot threat dimension was 0.94, and for all items was 0.96).

[Figure 1: see original paper]

Next, participants' prosocial tendencies toward ingroup or outgroup members were measured. Participants in both ingroup and outgroup conditions read the following conceptual explanation of ingroups/outgroups: "In social psychology, an ingroup refers to a group that a person regularly participates in or lives in, works in, or conducts other activities in. Members in the group feel a close relationship with the group and have a strong sense of belonging to the group. Correspondingly, an outgroup generally refers to groups that people do not participate in and have no sense of belonging to" (Brewer, 1999). Ingroup participants were asked to write down the name of someone they considered to be in their ingroup, while outgroup participants were asked to write down the name of someone they considered to be in their outgroup (initials only were sufficient).

Then, participants were asked to substitute the written name into the prosocial tendency measurement (same as Study 2; in this experiment, Cronbach's α was 0.97), for example, "It is important to help him/her (the person you wrote in the previous question) when they need help." Additionally, to test whether the ingroup/outgroup manipulation was successful, participants completed the ingroup/outgroup measurement using an adapted Inclusion of Other in the Self Scale (Aron et al., 1992). Participants were shown 7 sets of graphics, each with two circles overlapping to varying degrees. One circle represented "self," the other represented the "him/her" written by the participant. Participants were asked to select the graphic that best represented how they viewed the relationship between themselves and the person they wrote about. The greater the overlap between the two circles, the closer participants considered their relationship with the written person to be.

Attention checks were then conducted. Two attention check questions were interspersed among the scales, such as "Please select strongly agree for this question." Additionally, attention checks were included for the manipulation material content: (1) "According to the research, the proportion of jobs currently occupied by robots is (1 = large, 2 = small)"; (2) "According to the study's author, the time required for progress in robot capabilities and intelligence will be (1 = longer, 2 = shorter) than expected." Finally, participants reported demographic variables of age and gender.

7.3 Results One-way ANOVA results showed that perceived robot threat in the high threat group ($M = 4.93$, $SD = 1.33$, 95% CI [4.74, 5.11]) was significantly higher than in the low threat group ($M = 2.76$, $SD = 1.21$, 95% CI [2.59, 2.93]), $F(1, 398) = 292.47$, $p < 0.001$, $^2\mathrm{p} = 0.42$. Self-other overlap in the ingroup group ($M = 5.49$, $SD = 1.12$, 95% CI [5.33, 5.65]) was significantly higher than in the outgroup group ($M = 2.93$, $SD = 1.96$, 95% CI [2.65, 3.20]), $F(1, 398) = 257.77$, $p < 0.001$, $^2\mathrm{p} = 0.39$, indicating successful manipulations.

ANOVA with perceived robot threat (low threat group = 0, high threat group = 1) and ingroup/outgroup (ingroup group = 0, outgroup group = 1) as independent variables and prosocial tendencies as the dependent variable showed that prosocial tendency scores in the ingroup group ($M = 5.80$, $SD = 0.69$, 95% CI [5.70, 5.90]) were significantly higher than in the outgroup group ($M = 4.01$, $SD = 1.73$, 95% CI [3.76, 4.25]), $F(1, 396) = 188.16$, $p < 0.001$, $^2\mathrm{p} = 0.32$. Prosocial tendency scores in the low threat group ($M = 5.02$, $SD = 1.51$, 95% CI [4.81, 5.23]) were higher than in the high threat group ($M = 4.78$, $SD = 1.67$, 95% CI [4.55, 5.02]), with a marginally significant difference, $F(1, 396) = 3.31$, $p = 0.070$, $^2\mathrm{p} = 0.01$. The interaction between perceived robot threat and ingroup/outgroup was significant, $F(1, 396) = 3.99$, $p = 0.046$, $^2\mathrm{p} = 0.01$. Simple effects analysis found that in the outgroup condition, prosocial tendency scores in the high threat group ($M = 3.76$, $SD = 1.71$, 95% CI [3.50, 4.01]) were significantly lower than in the low threat group ($M = 4.26$, $SD = 1.72$, 95% CI [4.00, 4.51]), $F(1, 396) = 7.29$, $p = 0.007$, $^2\mathrm{p} = 0.02$. In the ingroup condition,

there was no significant difference in prosocial tendency scores between high and low threat groups, $F(1, 396) = 0.02$, $p = 0.900$, $^2\mathrm{p} < 0.001$ (see Figure 2 [Figure 2: see original paper]).

[Figure 2: see original paper]

7.4 Discussion Study 5 further supported the effect of perceived robot threat on prosocial tendencies. Additionally, Study 5 supported the moderating role of ingroup/outgroup distinction. For outgroup members, robot threat significantly reduced prosocial tendencies; however, robot threat did not increase prosocial tendencies toward ingroup members. This may be because our ingroup manipulation asked participants to write down the name of an ingroup member rather than a group, so participants may have written down their closest person, resulting in high prosocial tendencies regardless of robot threat.

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8 Study 6: The Moderating Role of Moral Comparison Orientation

Study 6 examined the moderating role of moral comparison orientation in the effect of perceived robot threat on prosocial tendencies by measuring upward and downward moral comparison tendencies.

8.1 Participants This study used G*Power 3.1 software to determine the required sample size. Using a medium effect size* $\mathrm{f}^* = 0.2$, significance level $\alpha = 0.05$, a single-factor two-level between-subjects design required 266 participants to achieve 90% statistical power. Considering possible participant dropout or failure to pass attention checks, 297 participants were recruited on the Credamo platform. Twenty-seven participants failed the attention check, resulting in a final sample of 270 participants. The mean age was 32.62 years (SD = 8.79), with 155 females (57.4%).

8.2 Procedure This study used a single-factor two-level between-subjects design, with participants randomly assigned to high or low threat groups. In the final valid sample, there were 135 participants in each group. The manipulation method for perceived robot threat was the same as in Study 4. After viewing the news materials, participants completed the Robot Threat Scale as a manipulation check (same as Study 2; in this study, Cronbach's α for the perceived realistic robot threat dimension was 0.95, for the perceived identity robot threat dimension was 0.95, and for all items was 0.97).

Next, participants' prosocial tendencies (same as Study 2; in this experiment, Cronbach's α was 0.82) and moral comparison orientation were measured. Moral comparison orientation was measured using the Moral Comparison Orientation Questionnaire by Fleischmann et al. (2021). The questionnaire includes six short stories, three measuring upward moral comparison tendency: (1) Surprising grandma; (2) Helping homeless youth; (3) Volunteering at a hospital. The

other three measure downward moral comparison tendency: (1) Cheating on an exam; (2) Deceiving one's wife; (3) Lying to a friend. Participants were presented with the six story titles in random order and asked to select their level of interest in these stories using a 7-point Likert scale (1 = not interested at all, 7 = very interested). The three items measuring downward moral comparison tendency were reverse-scored. Higher questionnaire scores indicated stronger upward moral comparison tendency, while lower scores indicated stronger downward moral comparison tendency. In this study, Cronbach's α was 0.80. Finally, participants completed attention checks (same as Study 3) and reported demographic information.

8.3 Results One-way ANOVA results showed that perceived robot threat in the high threat group (M = 5.14, SD = 1.29, 95% CI [4.92, 5.36]) was significantly higher than in the low threat group (M = 2.68, SD = 1.26, 95% CI [2.46, 2.89]), $F(1, 268) = 251.53$, $p < 0.001$, $^2\text{p} = 0.48$, indicating successful manipulation. Prosocial tendencies in the high threat group (M = 5.60, SD = 0.79, 95% CI [5.47, 5.74]) were significantly lower than in the low threat group (M = 5.79, SD = 0.64, 95% CI [5.68, 5.90]), $F(1, 268) = 4.82$, $p = 0.029$, $^2\text{p} = 0.02$.

Examining the interaction between perceived robot threat (low threat group = –1, high threat group = 1) and moral comparison orientation on prosocial tendencies showed a marginally significant interaction ($b = 0.07$, SE = 0.04, $t = 1.89$, $p = 0.060$). Prosocial tendencies were lower in the high threat group than the low threat group (b = –0.12, SE = 0.04, t = –3.47, p = 0.001). Stronger upward moral comparison tendency was associated with stronger prosocial tendencies ($b = 0.44$, SE = 0.04, $t = 11.76$, $p < 0.001$). The model's $\Delta R^2 = 0.01$, $F(1, 266) = 3.56$, $p = 0.060$. The interaction is shown in Figure 3 [Figure 3: see original paper]. Simple slope analysis showed that under conditions of stronger downward moral comparison tendency, the effect of perceived robot threat on prosocial tendencies was significant (b = –0.19, SE = 0.05, t = –3.79, $p < 0.001$). Under conditions of stronger upward moral comparison tendency, the effect of perceived robot threat on prosocial tendencies was not significant (b = –0.06, SE = 0.05, t = –1.12, p = 0.266).

[Figure 3: see original paper]

8.4 Discussion Study 6 further supported the negative effect of perceived robot threat on prosocial tendencies. Additionally, Study 6 partially found a moderating effect of moral comparison orientation: robot threat significantly reduced prosocial tendencies among those with downward moral comparison tendency but did not affect prosocial tendencies among those with upward moral comparison tendency. Although Studies 1–6 all found effects of perceived robot threat on prosocial tendencies, and Study 4 verified the effect on self-reported prosocial behavior, there may be self-report bias. Therefore, Study 7 aims to further examine the effect of perceived robot threat on actual prosocial behavior.

9 Study 7: The Effect of Perceived Robot Threat on Prosocial Behavior (Field Experiment)

Study 7 examined the effect of perceived robot threat on prosocial behavior through a field investigation.

9.1 Participants This study collected data in the field at a well-known university. A total of 164 participants were recruited, with 3 failing the attention check, resulting in a final sample of 161 participants. The mean age was 20.52 years (SD = 1.68), with 83 females (51.6%). All participants voluntarily participated in the experiment and provided informed consent.

9.2 Procedure This study used a single-factor two-level between-subjects design, with participants randomly assigned to robot threat or control groups. To manipulate perceived robot threat level, participants were first asked to write according to a set of instructions (Xu et al., 2024), using the same paradigm as Study 4.

After completing the writing task, participants completed the Perceived Robot Threat Scale (same as Study 2; in this experiment, Cronbach's α for the realistic threat dimension was 0.65, for the identity threat dimension was 0.75, and for all items was 0.79) as a manipulation check.

Prosocial behavior was then measured following the paradigm by Gaesser et al. (2020), requiring participants to write an encouraging letter to children in need, with letter length as the measure of prosocial behavior. The instructions were:

"In remote and impoverished areas, many children face severe difficulties in pursuing education. Due to various reasons, such as inconvenient transportation, scarce school resources, and family poverty, they may find it difficult to obtain good educational opportunities and may not even be able to complete basic schooling. In addition to educational difficulties, they may also face psychological pressure and struggles, feeling lonely, anxious, inferior, and self-doubting.

In such difficult situations, these children need external care and support even more. Therefore, we invite you to write an encouraging letter to children in remote and impoverished areas. This letter will bring them encouragement and hope, and will also demonstrate your kindness and warmth. You can share some encouraging words or tell stories about your own or others' learning experiences and growth, hoping to inspire these children to persist in their efforts and pursue their dreams. Your encouraging letter will be an important step in bringing them encouragement and hope. Thank you for your participation and support! (No word limit)."

Finally, participants' gender and age demographic variables were collected.

9.3 Results One-way ANOVA results showed that perceived robot threat in the high threat group (M = 4.20, SD = 0.89, 95% CI [4.02, 4.38]) was significantly higher than in the low threat group (M = 3.88, SD = 0.82, 95% CI [3.68, 4.07]), $F(1, 159) = 5.65$, $p = 0.019$, ^{2}p = 0.34, indicating successful manipulation.

One-way ANOVA results showed that encouraging letter length in the high threat group ($M = 71.74$, $SD = 122.52$, 95% CI [39.32, 104.15]) was significantly lower than in the low threat group (M = 121.09, SD = 182.67, 95% CI [85.97, 156.24]), $F(1, 159) = 4.16$, $p = 0.043$, ^{2}p = 0.25. That is, prosocial behavior in the high threat group was significantly lower than in the low threat group. Anthropomorphism tendency (M = 4.33, SD = 1.22, 95% CI [4.08, 4.59] vs. M = 4.39, SD = 1.16, 95% CI [4.12, 4.67]), perceived agency ($M = 4.62$, $SD = 1.05$, 95% CI [4.40, 4.85] vs. $M = 4.39$, $SD = 1.09$, 95% CI [4.15, 4.64]), and perceived experience ($M = 2.13$, $SD = 1.21$, 95% CI [1.88, 2.39] vs. $M = 2.20$, $SD = 1.16$, 95% CI [1.93, 2.48]) did not differ significantly between high and low threat groups (all Fs < 1.90, ps > 0.170). ANCOVA with anthropomorphism tendency, perceived agency, and perceived experience as control variables showed that prosocial behavior in the high threat group remained lower than in the low threat group, with a marginally significant difference, $F(1, 156) = 3.46$, $p = 0.065$, ^{2}p = 0.02, indicating that perceived robot threat reduces prosocial behavior.

9.4 Discussion Study 7 further supported that perceived robot threat not only reduces self-reported prosocial tendencies but also reduces actual prosocial behavior through a field investigation.

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10 General Discussion

Through eight recursive studies, we found that perceived robot threat reduces people's prosocial tendencies. This conclusion was tested in large-scale survey databases corresponding to national-level data (Studies 1a, 1b), correlational studies (Study 2), and experiments (Studies 3–7). Moreover, this effect is moderated by ingroup/outgroup distinction: although perceived robot threat reduces people's prosocial tendencies, this mainly occurs for outgroup members, while the effect is attenuated for ingroup members (Study 5). Additionally, the direction of moral comparison also moderates this effect: for those inclined toward downward moral comparisons, perceived robot threat reduces prosocial tendencies; but for those inclined toward upward moral comparisons, this effect is not significant (Study 6). Furthermore, we found that perceived robot threat also affects actual prosocial behavior (Study 7).

The main findings of this paper address the controversy over how robots entering human society, especially when posing threats to people, will affect interpersonal relationships. First, we found that perceived robot threat reduces people's prosocial tendencies, providing new evidence for the negative interper-

sonal consequences of perceived robot threat found in previous research and offering a new perspective for enriching research on the interpersonal aftermath of robot intergroup threat theory. That robot threats can deteriorate human-robot relationships has almost become consensus, with scholars obtaining consistent conclusions from different angles such as negative attitudes and usage tendencies (Huang et al., 2021), trust (Lin et al., 2022), and support for subsequent R&D investment (Yogeeswaran et al., 2016). However, consensus has not been reached on whether the impact of perceived robot threat on interpersonal relationships is good or bad. Optimistic scholars believe that robot salience will strengthen human common identity, thereby bringing positive interpersonal consequences such as reduced prejudice (Jackson et al., 2020). However, more research evidence seems to find negative consequences, such as the same article also mentioning that data collected from 37 countries show that over the past 42 years, countries with the fastest automation development have also seen increases in explicit prejudice toward outgroups (Jackson et al., 2020); other research finds that concerns about the rise of automation lead to negative attitudes and discriminatory behavior toward immigrants (Gamez-Djokic & Waytz, 2020), and workplace robot threats also increase incivility toward colleagues (Yam et al., 2023) and objectification (Xu et al., 2024). This paper focuses on prosocial tendencies, a key variable in interpersonal relationships, not only providing an important perspective for research on the interpersonal aftermath of robot intergroup threat theory but also directly addressing theoretical and practical controversies about the impact of perceived robot threat on interpersonal relationships.

Second, this paper found that collective anxiety is the mediating mechanism through which perceived robot threat affects prosocial tendencies. This not only provides a new theoretical explanation for the negative interpersonal consequences of perceived robot threat but also further expands the research domain of collective anxiety aftermath. Previous research on the interpersonal impact of perceived robot threat mostly explained it from individual perspectives such as insecurity (e.g., Gamez-Djokic & Waytz, 2020; Im et al., 2019) and control compensation (Xu et al., 2024), while our research selected collective anxiety as a group variable, providing a group perspective explanation for why perceived robot threat leads to negative interpersonal outcomes. Additionally, research on collective anxiety has mostly been limited to human groups, and its interpersonal consequences also have both positive and negative sides (Wohl et al., 2012). This paper extends collective anxiety research to the AI domain, finding that robot threat also triggers collective anxiety, expanding the boundaries of collective anxiety research. Moreover, this study found that this collective anxiety does not enhance prosocial tendencies but instead reduces them. One possible explanation is that although robot threat triggers collective anxiety, it does not unite humanity but instead triggers a "scapegoat" mentality when facing common threats (Brewer, 1999). Another possible explanation is that when people face external common threats and develop collective anxiety, they usually protect ingroup interests by confronting outgroups. However, when the

external threat comes from robots, people do not view robots as behavioral agents with full mental capacities like humans (Gray et al., 2007), and therefore cannot fully treat them as outgroups to confront, but instead continue to distinguish outgroups among humans and engage in negative interpersonal interactions. Finally, due to the discovery of potential negative interpersonal consequences of perceived robot threat and its psychological mechanisms, this study has prospective warning significance in practice in the AI era.

At the same time, this paper also found the moderating roles of ingroup/outgroup distinction and moral comparison orientation in the effect of perceived robot threat on prosocial tendencies. First, the moderating role of ingroup/outgroup distinction may provide new ideas for explaining previous research discrepancies. For example, the reason why previous research found that robots can reduce intergroup prejudice is that people view robots as outgroups and all humans as ingroups, so the positive or negative interpersonal consequences caused by robots are actually due to people's psychological group categorization (Jackson et al., 2020). If we follow this positive effect logic, perceived robot threat should increase rather than reduce prosocial tendencies, because if everyone is viewed as an ingroup, we should help ingroup members more. So why do our results show the opposite? There may be two reasons. On the one hand, previous research explored the variable of robot salience rather than threat (Jackson et al., 2020). Salience does not necessarily cause negative perceptions such as threat, and there are also differences in degree, which may be one reason for the divergent results. On the other hand, perceived robot threat causes a kind of collective anxiety, which is an abstract process with high construal level that does not depend on specific situations to generate emotional states. However, when people make judgments about prosocial tendencies, it is a lower construal level and more concrete situational judgment. When people are asked questions about their willingness to help others, they may have already viewed "others" as outgroups to some extent (Peng et al., 1997). This leads to people viewing humanity as a whole when experiencing collective anxiety, but quickly viewing "others" as outgroups when considering helping others. As we found in Study 4, once ingroup/outgroup distinction is clarified, the effect of perceived robot threat reducing prosocial tendencies does not appear in the ingroup condition.

However, we did not observe an increase in prosocial tendencies toward ingroup members due to perceived robot threat. One possible explanation is that our ingroup manipulation asked participants to write down the name of an ingroup member rather than a group, so participants may have written down their closest person, resulting in high prosocial tendencies regardless of robot threat. If participants were asked to write down a group they belong to, different results might be obtained. Because for the closest person, prosocial tendencies are already high even without robot threat; but for an ingroup one belongs to, ingroup attachment and preference are not particularly prominent without threat, while ingroup consciousness becomes more salient when threatened (Brewer, 1999, p. 431; Sherif, 1966; Sumner, 1906). Future research can examine whether the

effect of perceived robot threat on ingroup prosocial tendencies differs at the individual and group levels.

Second, this study also explored the boundaries of robot threat leading to reduced prosocial behavioral tendencies at different theoretical levels. Ingroup/outgroup distinction is a horizontal group comparison, while moral comparison is a typical vertical self-comparison. Study 5 found that the effect of perceived robot threat reducing prosocial tendencies only works for those inclined toward downward moral comparisons but not for upward comparators. The reason for this result is that downward moral comparisons produce moral licensing, allowing oneself to indulge and engage in some immoral behaviors (Merritt et al., 2010). Of course, besides this explanatory path, this finding may also be related to decreased motivation levels caused by downward comparisons. Previous research shows that comparing with higher standards (i.e., upward comparison) can form an incentive effect, thereby increasing people's motivation to continue efforts (Diel & Hofmann, 2019); while comparing with lower standards (i.e., downward comparison) makes people satisfied with existing progress, thereby reducing their motivation to further efforts, a process called coasting (Fulford et al., 2010). Coasting can enhance self-esteem to some extent but does not motivate people to continue proactive behaviors; instead, it reduces people's motivation to engage in positive behaviors including prosocial behavior (Diel et al., 2021). Therefore, coasting caused by downward comparison may also be a possible reason why the effect of perceived robot threat reducing prosocial tendencies is particularly significant among downward moral comparators. From a practical perspective, our findings on these two moderating variables—ingroup/outgroup distinction and moral comparison orientation—have reference significance for how to prevent or weaken the negative interpersonal consequences caused by perceived robot threat in real life. For example, interventions on people's ingroup/outgroup categorization and moral comparison orientation can be used to weaken negative consequences.

Of course, although this paper made beneficial explorations of the effect of perceived robot threat on prosocial tendencies and its internal mechanisms and boundary conditions through a series of studies, there are still some limitations that need to be addressed in future research. First, according to the logic of the experimental causal chain approach, the mediating variable (i.e., collective threat) must be further manipulated to test its effect on the dependent variable (i.e., prosocial tendencies) (Spencer et al., 2005; Yang et al., 2024). Future research should explore appropriate experimental paradigms to manipulate collective threat and verify its effect on prosocial tendencies. Second, this study mainly examined robot threat's effect on prosocial attitudes and behaviors toward outgroups. Future research should consider more about robot threat's effect on prosocial behavior toward ingroups, exploring whether robot threat can have constructive effects on ingroups. Third, this paper examined the effect of perceived robot threat on prosocial tendencies but did not deeply analyze the two dimensions of robot threat. Perceived robot threat is divided into realistic threat and identity threat dimensions. Although these two dimensions are al-

ways highly correlated and both lead to negative attitudes toward robots (e.g., Złotowski et al., 2017), their effects may differ. For example, identity threat better predicts negative attitudes toward robots (Huang et al., 2021) and workplace objectification (Xu et al., 2024). Therefore, future research can distinguish between the two dimensions of perceived robot threat to explore whether realistic threat and identity threat have different effects on prosocial tendencies. Fourth, although this study's research on prosocial behavior involved specific prosocial behaviors at the national level, it still mainly explored prosocial tendencies at the individual level. Although prosocial tendencies significantly predict prosocial behavior, tendencies are not behaviors after all, and prosocial behavior includes many types such as helping, cooperation, charitable donation, and volunteering (Penner et al., 2005). Therefore, future research can use laboratory experiments, field experiments, etc., to explore different prosocial behaviors and further verify the association between perceived robot threat and actual prosocial behavior. Finally, this study found that robot threat negatively affects interpersonal interactions by reducing people's prosocial tendencies through collective anxiety. However, previous research found that collective anxiety may also promote intergroup solidarity. Future research can further explore what properties of robot threat make the collective threat it generates reduce people's prosociality, and whether there are factors that can reverse the negative effect of robot threat on prosociality (e.g., threat level, whether personal interests are harmed, resource scarcity).

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11 Conclusion

The main conclusions of this study are as follows: First, perceived robot threat reduces prosocial tendencies; second, this effect is mediated by collective anxiety—that is, perceived robot threat increases collective anxiety, which in turn reduces prosocial tendencies; third, this effect is moderated by ingroup/outgroup distinction—that is, perceived robot threat mainly reduces prosocial tendencies toward outgroup members; fourth, this effect is moderated by moral comparison orientation—that is, perceived robot threat mainly reduces prosocial tendencies among those who engage in downward moral comparisons.

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Note: Figure translations are in progress. See original paper for figures.