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Does Japan really have robot mania? Comparing attitudes by implicit and explicit measures

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Abstract Japan has more robots than any other country with robots contributing to many areas of society, including manufacturing, healthcare, and entertainment. However, few studies have examined Japanese attitudes toward robots, and none has used implicit measures. This study compares attitudes among the faculty of a US and a Japanese university. Although the Japanese faculty reported many more experiences with robots, implicit measures indicated both faculties had more pleasant associations with humans. In addition, although the US faculty reported people were more threatening than robots, implicit measures indicated both faculties associated weapons more strongly with robots than with humans. Despite the media's hype about Japan's robot 'craze,' response similarities suggest factors other than attitude better explain robot adoption. These include differences in history and religion, personal and human identity, economic structure, professional specialization, and government policy. Japanese robotics offers a unique reference from which other nations may learn.

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1 Introduction

1.1 Robot ambivalence

Among all human artifacts, perhaps robots share the most in common with their maker. Like computers, and in fact because they are controlled by computers, they can process huge amounts of information. Like powered equipment, they can manipulate their environment and move within it. And like dolls, mannequins, and other effigies, they can resemble us—either abstractly or down to the dimples on our cheeks. Nevertheless, the differences between machine and maker are profound. *Metabolism, life span, sexual reproduction, ancestry, culture*, and *consciousness* for now distinguish us from robots. Thus, the similarities and differences between us and them circumscribe a chasm that is at once narrow and deep.

It should be unsurprising then that we view our creations with a certain ambivalence. This ambivalence seems strongest for robots designed with the goal of impersonating us in all respects.[1] The Japanese roboticist Mori (1970) noted this when he proposed that, as we make machines more humanlike, they would seem more familiar until they became so human as to seem eerie. *Bukimi no tani*, his graph of the relation between human likeness and familiarity, was translated into English as the *uncanny valley*—thus forging an unintended link with Freud's 1919 essay on the uncanny. Freud (1919/2003) argued that the uncanny are things that are very familiar but repressed. Because the source of our feeling is not consciously accessible, Freud advocated a lengthy process of psychoanalysis. In this study we explore ways of examining the uncanny that do not rely on introspection.

Mori's own hunch—which he did not elaborate—was that the uncanny valley relates to the human need for self-preservation. But that only raises the question, "What do we mean by self?" If by *self* we mean the human phenotype that must survive long enough to pass on its genes to the next generation and ensure its success, we are led to a biological explanation of negative feelings toward robots that must hold regardless of culture (e.g., the issues surrounding mate selection or pathogen avoidance discussed in MacDorman and Ishiguro 2006). However, *self* may be understood another way: as the person a human body constructs from the social environment, with a biography and a narrative to justify both its words and deeds (MacDorman and Cowley 2006; Ross and Dumouchel 2004). To enjoy status and esteem, persons are motivated to live up to the standards of their culture (Cowley and MacDorman 2006), and their worldview and sense of identity reflect that purpose.

Solomon et al. (1998) have argued that, by living up to cultural standards, we make our lives meaningful. Our cultural worldview explains our place in the universe and, in some religious contexts, offers us an afterlife. For these researchers self-preservation is about defending not just the body but the worldview that gives our lives meaning in the face of physical mortality—defending that worldview against those who would transgress it. So the question remains, "Are our robotic creations potential transgressors, trammeling our sense of identity and purpose?"

[1] In other words, robots that could pass the Total Turing Test (Harnad 1989).

Ramey (2005) argues that they are. There is something disturbing about things that cross category boundaries: like the undead of the horror genre. Douglas (1966) had discussed this in relation to the dietary laws of Leviticus. According to Douglas, restricted foods do not fit known categories. Eating pork is prohibited, for example, because pigs unlike other cloven-hoofed animals do not chew their cud. The category boundary problem is particularly acute for robots, which are electromechanical, but share some human qualities (MacDorman and Cowley 2006). From the standpoint of human perception, not only do they exist on a category boundary, but we are one of the categories—and in that sense, they could be seen as a threat to our personal and human identity. If perfect human replicas were ever created, how much room would that leave for our sense of human specialness? How would our "hoped for" immortality stand up against their real ability to outlive us?

1.2 The roots of East–West differences

The cognitive dissonance caused by objects that lie on category boundaries may not be universal. For example, although some cultures push intersex individuals to choose a male or female gender, other cultures afford room for a third gender (e.g., two-spirit people among the Native Americans). Although common category membership produced the strongest object association in US children and adults, Chinese children and adults were most sensitive to contextual and functional relations between objects (Ji et al. 2000). This was attributed to a difference in cognitive style: The West may sanction an analytic cognitive style, whereas a cognitive style involving many relative comparisons may be more prevalent in Asia. So cultural factors may influence the perception of an entity lying on a category boundary.

The roots of these factors are to be found in the historical development of East Asian and European cultures. Greek philosophy saw a separation of human and nonhuman phenomena into ethics and nature; Socrates considered sense experience (*phenomena*) to be a pale shadow of the true forms of objects (*noumena*, Plato 360 BCE/1888; Woelfel 1987). While Western philosophy sought absolute truth in perfect, unchanging knowledge (*universal laws*), Eastern philosophy took a holistic view on a universe seen as being in constant flux. The Western distinction between the whole and its parts was less pronounced. Indeed, the whole and its parts were seen as inseparable: "each 'one' defines the other, and indeed is the other" (Kincaid 1987, p. 332). However, given the rapid modernization of Asia, the spread of Western-style education, and the globalization of information, there is a risk of overemphasizing these differences.

Nevertheless, many of the dualisms that are ingrained in Western thinking, such as the mind–body dualism, do not exist or are less pronounced in South and East Asian cultures.[2] For example, Buddhism broke from its Hindu roots by introducing the concept of *anātman* (from Sanskrit, meaning *no soul*). As all things arise owing

[2] Ironically, Western philosophy has progressively backed away from substance dualism (MacDorman 2004).

to causes and conditions, they are considered devoid of selfhood or intrinsic nature.[3] Life's purpose is to see through conditioned existence by obtaining enlightenment. Mori (1982) even proposes that, just like people, robots could pull their workings into alignment to realize their Buddha-nature. *Shinto*, the original religion of Japan, derives from animism: the belief that spirits can inhabit objects. This affords a different sort of relationship, not only with nature, but with human creations like robots. If a stone or tree can have a spirit, why not a robot? Although few present-day Japanese believe in the literal truth of Shinto or Buddhism, they were part of the cultural background during Japan's modernization. Their philosophical elements have held an enduring influence on attitudes toward technology over the years.

In examining Western and Japanese differences, Yamamoto (1983) contrasts the creation story of Genesis with the neo-Confucian teachings of Zhu Xi (1130–1200). Zhu Xi mixes Confucian and Taoist elements with traditional Chinese beliefs. Crucially, there is no God and no mind/matter distinction in neo-Confucianism. Xi's (1967) neo-Confucian views on the oneness of reality, which were especially popular among the samurai class during the Edo period (1603–1868), were seen as broadly compatible with the materialistic views of the architects of Japan's modernization during the Meiji era (1868–1912, e.g., Hiroyuki Katō's biological materialism, discussed in Davis 1996; Yamamoto 1983). Thus arose a kind of *scientism* in Japan, or heroic view of science and technology that developed without resistance from Shinto or Buddhism. This differs from the relationship between science and religion in the West, where frequent conflicts arise between scientists and believers on topics ranging from the origin of life to the ethics of stem-cell research.

For a devout Jew, Christian, or Moslem, what is the significance a humanlike robot? All of these religions have prohibitions against idolatry and the usurpation of God's role: "You shall not make for yourself an idol in the form of anything in heaven above or on the earth beneath or in the waters below" (Exodus 20:4 New International Version; cf. The Spider 29:25 Koran). Islam bans all icons from mosques, just as the Puritans banned icons from their churches. The Amish do not take photographs. The Taliban went as far as destroying any art that depicted a human form. The Bible states, "God created man in his own image" (Genesis 1:27). Thus, to build machines in man's image, that is, with human qualities, would be to usurp God's role. An Arab journalist once described the creation of robots as a "God-crushing act" (Yamamoto 1983). This view contrasts with the sentiment expressed in 1928 by Makoto Nishimura, a Japanese robotics pioneer, "If one considers humans as the children of nature, artificial humans created by the hand of man are thus nature's grandchildren" (cited in Hornyak 2006, p. 38). These examples indicate differences in how East Asian and other cultures confront ambiguities in general and humanlike machines in particular.

Perhaps the most concise way to illustrate these differences is to consider what Mazlish (1993) identifies as the four discontinuities: the Earth-centric view of the universe; the creation myth of Genesis; Descartes view of the mind as rational and controllable; and the notion that different principles govern the mental and

[3] Nevertheless, Buddhism does make a distinction between sentient and nonsentient beings, and prohibits the slaughter of sentient beings.

mechanical. For those coming from a Judeo-Christian worldview, the four discontinuities have historically buttressed humankind's sense of self-importance—and not only as a species. These assumptions have influenced how each individual's sense of self is socially constructed. They ennoble us as human beings and emphasize our uniqueness. Mazlish cites four events in the progress of science and technology that have demolished the four discontinuities: the Copernican Revolution; Darwin's theory of natural selection; Freud's work on the unconscious; and the advent of intelligent machines. In the West, these have been ego shattering events, undermining our self-image and personal and human identity (Cooley 2007). If an electromechanical copy of a human being were ever created, this might be the most ego shattering event of all.

However, what is fascinating about Japan is the historical absence of *any* of these four discontinuities. In Buddhist or neo-Confucian cosmology, for example, we reside in but one of myriads of multimillions of galaxies; no single act resulted in the creation of humankind; the mind is as restless and uncontrollable as a wild monkey; and there is no mind/matter—or mind/machine—distinction. For these reasons, the existence of an android double would not threaten a Japanese sense of self the way it would threaten a Judeo-Christian sense of self.

1.3 Attitudes toward robots in Japan

People around the world have different levels of exposure to robots because of their personal experiences and what is covered in the media. The structure of a country's economy, its technological development, national funding priorities, and the historical and religious context affect the social and cultural significance of robots, and these factors in turn shape individual attitudes.

In the West the idea of using machines for rote work to free people to engage in creative pursuits may be traced at least to Blaise Pascal's invention of an adding machine in 1642 (Singer et al. 1954). However, fictionalized accounts of robots have been used to express ambivalence about technological progress, industrialization, and the social dislocations caused by them. Since Capek (1921/2004) first coined the term robot (from Czech *robata*, meaning *serf labor, drudgery*) in the 1921 science fiction play *R.U.R.*, robots have frequently been depicted in a negative light. The scenario in Capek's play of robots bent on revolt or world domination has been echoed in countless films and novels, such as the Hollywood blockbusters *Blade Runner, Terminator*, and *I, Robot*. The robots running amok in these stories symbolize the gap between human aspirations and the achievable reality. The stories reveal what happens to society when human motives are allowed to play out without the constraints of nature and morals. Even films presenting robots as heroes, such as *Short Circuit* and *Bicentennial Man*, hold up a mirror not so much to the technology as its creator. The very desire to create technology in our own image can reflect human narcissism and hubris (Cooley 2007), which has often been critiqued in the science fiction and horror genres.

Robots have had their greatest impact in Japan, where cultural perspectives on robots have developed rather differently from perspectives in the West. From Japan's early Edo period, the elaborate performances of clockwork *karakuri* puppets have left audiences awestruck, and this tradition of craftsmanship and artistry has continued to animate human-looking machines for the past 400 years (Hornyak 2006; Schodt 1988). *Karakuri* automata, for example, served tea, plucked and shot arrows, and drew Chinese characters with brush and ink—all without human control.

Perhaps the most famous hero of Japanese *manga* (comics) is not human but the fictional robot Astro Boy, serialized by Osamu Tezuka from 1951 to 1981 and also adapted to film and television. Designed by Dr. Tenma to replace his son—and then rejected by him—Astro Boy represents a convergence of human and machine in his form, values, and sense of aesthetics. The robot could experience human emotions, and through the guidance of a second mentor, Professor Ochanomizu, came to fight crime, injustice, and evil. In 1956 Ironman appeared in *manga* as the remote-controlled, crime-fighting robot of the boy detective Shotaro Kaneda. Another action hero, Amuro Ray, pilots Gundam, his giant robotic suit of armor. A similar man–machine symbiosis earlier appeared in the Go Nagai series, *Mazinger Z*. These and other examples suggest that mass-audience fictional portrayals of robots in Japan have generally been positive. But even so, in showing men's desire to dominate their sentient creations, these stories express ambivalence concerning whether human beings and machines can find an ethical symbiosis, or whether the compassion and judgment of the machine's creator will be reduced to a "mechanical" calculation of personal or human benefit (Cooley 2007).

Beyond popular culture, robots—and especially industrial robots—play an important role in the Japanese economy. Japan's postwar economic growth has been fueled by exports in the automotive and electronics industries, which enjoyed efficiency gains in part through increased automation. During the 1970s and 1980s, Japan maintained its manufacturing sector while most other developed economies were shifting to services (Castells 2000). By 2000 Japan had ten times as many industrial robots per capita as the United States.[4] Automation has never been seen as a threat to jobs in Japan, because companies employing robots would retrain workers for other jobs rather than dismiss them as is more common in the US (Lynn 2002; Hornyak 2006).

In addition, Japan has promoted new applications for robots that support human interaction. Japanese companies have pioneered entertainment, pet companion, and humanoid robots, such as Sony's robot dog Aibo and humanoid Qrio, Honda's Asimo, and AIST's therapeutic robot seal *Paro*. Social robots frequently appear at public events, expositions and conventions, and on television. Robots have even been an integral part of the Japanese government's plans for addressing the country's demographic crisis: the combination of an aging population and low birthrate (Barry 2005).

It is useful to approach a topic as complex as US–Japanese attitudes toward robots from different angles, collecting information about what people do, their reported attitudes, and perhaps attitudes they would prefer not to report. Such an approach provides method triangulation. This study uses implicit measures, based on the implicit associate test, and explicit measures, based on the self-reported results of questionnaires, to determine whether cultural differences exist among faculty

[4] *The Economist*, December 1, 2001, p. 96.

members at a Japanese and US university. Specifically, it uses explicit and implicit measures to compare attitudes toward robots in relation to human beings along two dimensions: *pleasant–unpleasant* and *safe–threatening*. It is hoped that the results might shed light on cultural differences between Japan and the United States.

2 Background

2.1 Cross-cultural research on attitudes toward robots

Few cross-cultural surveys have examined how people make judgments about robots. Shibata et al. (2004) studied humans' subjective evaluations of Paro in Italy, Japan, Korea, Sweden, and the UK. Their results found differences according to gender, age, and nationality. British and Italian participants were concerned about the necessity of Paro; Italian and Swedish participants focused on its animal-like qualities; and Japanese participants noted its visual and tactile impression. Another study on social interaction with the communication robot *Robovie-II* and *Robovie-M* suggested that in Japan, younger generations do not necessarily prefer robots to older generations (Nomura et al. 2007). However, the study was conducted at a robotics exhibition. This kind of event is likely to attract robot enthusiasts of all ages.

While these studies focused on specific robots, other studies examined attitudes toward robots in general. Nomura et al. (2006) developed the negative attitude toward robots scale (NARS), which was used in a study with Chinese, Dutch, and Japanese participants (Bartneck et al. 2005). The questionnaire consisted of three parts: attitude toward the interaction with robots; attitude toward the social influence of robots; and attitude related to emotions felt during interaction with robots.

The study found that only nationality had a significant influence on the social dimension and that Japanese participants rated social influence significantly higher than Chinese and Dutch participants. Gender and other participant variables did not have any significant effect. In a follow-up study, Mexican, German, and US participants were included with Chinese, Dutch, and Japanese participants, and the same questionnaire was used (Bartneck et al. 2007). The results indicate that participants from the USA were the most positive about interactions with robots, and participants from Mexico were the most negative. The results for Japan were unexpected:

> In contrast to the popular belief that the Japanese love robots, our results indicate that the Japanese are concerned about the impact robots might have on society and that they are particularly concerned about the emotional aspects of interacting with robots. A possible explanation could relate to their higher exposure to robots in real life, and particularly through the Japanese media. The Japanese could be more aware of robots' abilities and also their shortcomings. (Bartneck et al. 2007, p. 225)

One limitation of the above studies is that participants were recruited from among groups with special interests, such as members of online robot forums. This makes it difficult to generalize about the broader cultures.

2.2 Explicit and implicit measures

Given the complex historical and philosophical differences between Japan and the West, an important issue concerns how to measure culturally rooted attitudes toward robots. Previous cross-cultural studies have relied on questionnaires. These *explicit* measures simply ask people their opinions. Questionnaires usually provide a fixed number of responses and may collect the results into an index or scale.

Unfortunately, these kinds of explicit measures are susceptible to two kinds of bias. First, participants may not be aware of attitudes affecting their behavior. When people are unsure of their attitudes or do not understand the reasons behind them, they may fall back on whatever explanation happens to be popular (i.e., a shared report). Japanese, for example, see themselves collectively as a robot-friendly culture (Hornyak 2006). But being on the front lines of robot adoption, individual Japanese may feel anxiety and misgivings about robots, say, when it is *their* grandmother being turned over by a robot in her hospital bed. Second, participants may be aware of the attitudes affecting their behavior but choose to conceal them. People of all cultures are incentivized to align to the feelings of others, and that tendency is strong in Japan. When this results in a desire to conform, it can lead to a self-presentational bias: how participants choose to present themselves to others (or to themselves) may not accurately reflect their attitudes and dispositions owing to concerns about social desirability (Greenwald et al. 1998; Ashburn-Nardo et al. 2003).

Past interviews with Japanese researchers raised concerns about both kinds of bias. For example, several robotics professors and students asserted that they began to study robotics because robots heroes in *manga* sparked their interest in childhood; however, other researchers were skeptical of such claims. Japanese researchers commonly mentioned Shinto animism as a reason for Japan's acceptance of robots, but nobody admitted to believing in animism personally. On the contrary, their metaphysical position on the possibility of robot consciousness seemed closer to the functionalism of Putnam (1967) or Dennett (1991). It would be exciting to measure people's positive or negative associations with robots, setting aside how participants think they should answer, because these explanations often do not ring true.

One method to overcome self-presentational bias is to measure a participant's underlying automatic evaluation by means of an implicit measure. Implicit measures are measurement outcomes that may indicate a purported construct by means of processes that are uncontrolled, unintentional, unconscious, efficient, effortless, fast, goal-independent, autonomous, or driven solely by the stimulus (De Houwer and Moors 2007). Implicit measures may differ from explicit measures, such as the self-reported attitudes and preferences collected from a questionnaire. Examples of implicit measures include the implicit association test (Greenwald et al. 1998), go/no-go association task (GNAT, Nosek and Banaji 2001), and cognitive priming procedures (Bargh et al. 1992).

Recently, certain interpretations of implicit measures have been seriously criticized because of claims made by early authors—for example, that the IAT measures implicit attitudes stored in memory. There is nothing about the procedures of implicit measures that ensures participants are not aware of their attitudes or that the response is "accessed" rather than constructed (Fazio and Olson 2003). Nor is it safe to assume that implicit measures are a better indicator of what a person "really believes." Beliefs and associations are not the same. Associations are related to personal history and often differ from personal preferences (Houben and Wiers 2007). Thus, implicit measures may be influenced by associations that are "extrapersonal"—picked up from the culture but not necessarily aligned with one's personal beliefs, preferences, and attitudes (Karpinski and Hilton 2001; Olson and Fazio 2004). In interpreting implicit measures, it is important to understand that they are just one more source of evidence.

2.3 The implicit association test and its new scoring algorithm

The IAT measures automatic evaluative associations (Greenwald et al. 1998; Banaji 2001), namely, the differential associations of two target concepts (e.g., *robot* and *human*) along an attribute dimension (e.g., *safe–threatening*) based on response latencies during a combined categorization task. "IAT responses are considered automatic because they are expressed without intention or control" (Dasgupta et al. 2000, p. 317). Indeed, the participant is unlikely to be aware of the causal processes responsible for the evaluation (Greenwald and Banaji 1995). Performance is faster if a more strongly associated attribute-concept pair shares the same response key than if a less strongly associated attribute-concept pair shares the same response key. For example, if we gave someone the task of pressing *E* when a robot or weapon appeared and pressing *I* when a human or nonweapon appeared, we might expect faster performance if the person associated robots and weapons more strongly than humans and weapons.

The IAT consists of five blocks of categorization tasks. In the first block, the task is to discriminate among a set of items according to their target concept membership (e.g., either *robot* or *human*). In the second block, the task is to discriminate among a different set of items according to their value on an attribute dimension (e.g., either *pleasant* or *unpleasant*). In the third block, the tasks of the first and second block are interspersed. (The order is shuffled.) The fourth block is the same as the first block except the response keys for the target concepts are reversed. In the fifth block, the tasks of the second and fourth blocks are interspersed. The third and fifth blocks are used in scoring. The basic assumption behind the design of the IAT is that the participant should be able to perform either the third block or the fifth block faster depending on how the target concepts and attribute dimension are differentially associated.

To test this method, Greenwald et al. (1998) presented on a computer screen names of flowers, names of insects, pleasant words, and unpleasant words. Participants were asked to categorize these words by pressing one of two keys. It can be assumed on a priori grounds that the target concept *flower* and *pleasant* are automatically associated as are the target concept *insect* and *unpleasant*. Therefore, responses should be faster when *flower* and *positive* are both assigned to one key and *insect* and *negative* are both assigned to another key, because the assignments are compatible with existing associations. Furthermore, responses should be slower for the reverse. The results clearly confirmed that the reaction times were faster with compatible assignments.

Experiments were conducted to assess the usefulness and efficiency of the IAT in measuring automatic evaluative associations (Greenwald et al. 1998). Explicit self-report measures of attitude were compared with IAT measures. Researchers found that the IAT is more resistant to self-presentational bias than explicit measures. When researchers introduced a sensitive domain of social attitudes (e.g., racial bias), the effect size of explicit measure dropped very low even though the IAT measure was high. The purported ability of the IAT to overcome self-presentational bias partly accounts for its popularity in social psychology research (e.g., Ashburn-Nardo et al. 2003).

Further studies were conducted to examine the relations between the IAT and explicit self-report measures. In the Greenwald et al. (1998) study, the correlations between the IAT and explicit measures ranged from 0.04 to 0.64 with only two out of the 16 values being significant. Karpinski and Hilton (2001) suggested that social desirability concerns in reporting attitudes toward racial or ethnic groups are the reason for the lack of significance. These studies indicated that for sensitive topics self-reports and the IAT were independent. This result was replicated in two independent samples and in subsequent studies.

Greenwald et al. (2003) collected large data sets from demonstration IATs posted on the Internet. These data sets were used to evaluate alternative scoring procedures. It was found that the data from practice trials, which were thrown out in the conventional algorithm, actually provided a better IAT measure. It was also found that including error latencies improved the IAT measure. In the next study, Greenwald et al. (2003) determined that among all the six available latency transformations, the *D* measure performed best. His team also proposed to improve the *D* measure by including error latencies. Based on the findings of their study, Greenwald et al. (2003) developed a new scoring algorithm for the IAT that

> should generally (a) better reflect underlying association strengths, (b) more powerfully assess relations between association strengths and other variables of interest, (c) provide increased power to observe the experimental manipulations on association strengths, and (d) better reveal individual differences that are due to association strengths rather than other variables. (p. 215)

This study uses the new IAT scoring algorithm.

2.4 Hypotheses

The following hypotheses are meant to compare attitudes toward robots and familiarity with them in Japan and the US using implicit and explicit measures. They follow the trend of stereotypes promulgated by the Western news media, which identifies Japan with an enthusiasm for robots bordering on the irrational (e.g., Schodt 1988). These stereotypes perhaps reveal more about the misperceptions of Western journalists than about Japan. Although the Japanese have demonstrated the greatest willingness to imagine and work toward a future populated by friendly, useful robots, they are also the most aware of the limitations of current robotic technology. Thus, rather than labeling as irrational the current direction of Japan, other countries may benefit by understanding the reasons behind it. A Japanese and US faculty were compared, because student lists are confidential in Japan.

H1. The Japanese faculty have more robot-related experiences than the US faculty.
H2. The Japanese faculty report a stronger preference for robots and warmer feelings toward robots than the US faculty.
H3. The US faculty rate robots as more threatening than the Japanese faculty.
H4. Implicit measures indicate the Japanese faculty more strongly associate robots with pleasant words than the US faculty.
H5. Implicit measures indicate the US faculty more strongly associate robots with weapons than the Japanese faculty.

3 Method

3.1 Participants

A total of 731 participants completed at least one of the two IATs or the questionnaire on attitude toward robots, and 74.8% of those completed all three. Participants were recruited by email from a random sample of faculty members at Indiana University, USA (Bloomington and Indianapolis campuses) and Osaka University, Japan (Suita and Toyonaka campuses). A follow-up email was sent to those who had not responded.

There were 479 US participants and 237 Japanese participants. In the US group, gender was almost equally distributed (52.1% male). In the Japanese group, 95.2% of participants were male. The average age among the participants was 43.9, and the average years of education was 20.5.

3.2 Materials

Figure 1 shows the silhouettes and words used in the robots pleasant IAT and the robots threatening IAT. Both IATs used ten silhouettes of humanoid robots to represent instances of the target concept *robot* (Fig. 1a) and ten silhouettes of people to represent instances of the target concept *human* (Fig. 1b). The robots pleasant IAT used eight pleasant and eight unpleasant words for the attribute dimension (Fig. 1c). The robots threatening IAT used ten silhouettes of weapons and ten silhouettes of nonweapon artifacts for the attribute dimension (Fig. 1d). The IATs used silhouettes instead of photographs to make it impossible to identify the race of human stimuli. This was intended to prevent bias introduced by the choice of stimuli, so that silhouettes of the same people could be used in both Japan and the USA.

In addition to the two IATs, participants indicated on a questionnaire their relative preference for robots or people, how warm or cold they felt toward them, which they felt was more threatening, and how safe or threatening they felt each was. Participants also indicated their level of interest and familiarity with robots,

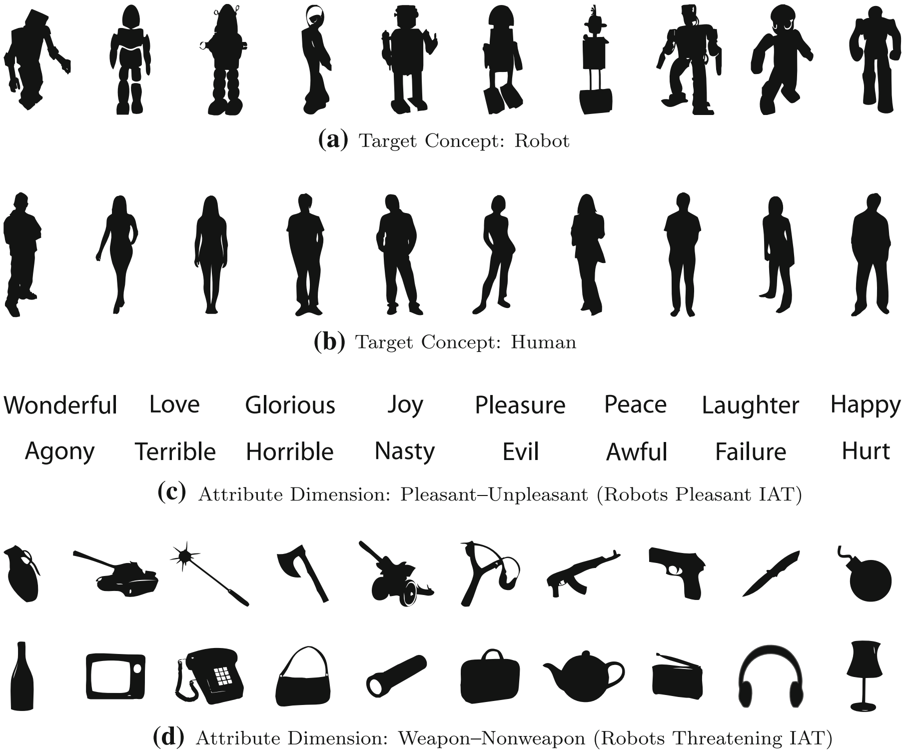

Fig. 1 Images and words used in the IATs

and the frequency with which they read material, watched media, and attended events that were robot-related, had physical contact with robots, and built or programmed robots. The list of questions is provided in "Appendix".

3.3 Procedure

The robots pleasant IAT, the robots threatening IAT, and the questionnaire on attitudes toward robots and robot-related experiences were conducted at an Internet-accessible website. The presentation order of the IATs and the questionnaire was counterbalanced. The presentation order of the attribute–concept pairings within each IATs was also counterbalanced.

4 Results

4.1 Frequency of robot-related experiences

Because the ratio of male faculty to female faculty at the Japanese university was so much higher than at the US university, participants were divided into groups by nationality and gender. In addition, the entire sample was divided into groups by age, education, familiarity with robots, and interest in robots. The group labeled *Below 43.9* is below the average age, and the group labeled *below 20.5* is below the average years of education. The group labeled *Not familiar* identified itself as not at all familiar with robots, and the group labeled *Familiar* identified itself as slightly, somewhat, moderately, or completely familiar with robots. *Not interested* and *Interested* were divided similarly.

Japanese participants had many more experiences with reading robot-related material, watching robot-related media, having physical contact with robots, attending robot-related events, or building or programming robots than US participants (Table 1). Male participants had more robot-related experiences than female participants. Younger participants had more robot-related experiences than older participants.

Factor analysis resulted in only one component, which explained 58.7% of the variance. The standardized factor loadings ranged from 0.67 to 0.82. Cronbach's α was 0.82, indicating sufficient reliability.

The results indicate that simply summing the number of robot-related experiences for each question could produce a reasonable index of robot-related experiences. The mean total number of robot-related experiences for male Japanese

Table 1 Frequency of robot-related experiences by group

	Reading material	Watching media	Physical contact	Attending events	Built or programmed
Nationality male only					
Japan	3.63***	3.13***	2.50***	1.57***	1.00***
USA	2.23	2.07	1.73	0.63	0.63
Nationality female only					
Japan	3.82***	3.00*	2.55*	1.45**	0.45
USA	1.64	1.68	1.37	0.44	0.25
Age					
Below 43.9	2.69**	2.59***	2.14***	1.04**	0.61*
43.9 and above	2.26	1.94	1.56	0.68	0.38
Education					
Below 20.5	2.45	2.29	1.79	0.80	0.45
20.5 and above	2.45	2.23	1.89	0.88	0.52
Robot familiarity					
Not familiar	0.79***	1.18***	0.62***	0.20***	0.12***
Familiar	2.81	2.51	2.10	1.01	0.58
Robot interest					
Not interested	0.62***	0.87***	0.62***	0.03***	0.01***
Interested	2.70	2.46	2.01	0.98	0.56

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

participants was 11.8 versus 7.0 for male US participants and 11.3 for female Japanese participants versus 5.4 for female US participants. The index showed highly significant differences in all groups ($p = 0.000$) except years of education. The robots experiences index is employed later in the correlation analysis.

4.2 Self-reported attitudes toward robots

Table 2 shows the mean preference and warmth ratings by group. Although both Japanese and US participants preferred people to robots, US participants preferred people more than Japanese participants [$F(458) = 16.19$, $p = 0.000$, $r = 0.79$]. Older participants preferred people more than younger participants [$F(705) = 11.54$, $p = 0.001$, $r = 0.40$], and the preference for people increased for those more familiar with robots or more interested in them [$F(725) = 9.90$, $p = 0.002$, $r = 0.34$]. Japanese participants felt somewhat warmer toward robots than US participants [$F(457) = 9.13$, $p = 0.003$, $r = 0.39$]. Participants who were not familiar with robots or not interested in them felt a bit warmer toward robots than those who were more familiar with them or more interested in them [$F(724) = 33.83$, $p = 0.000$, $r = 0.78$ and $F(724) = 29.51$, $p = 0.000$, $r = 0.74$, respectively]. There was no significant difference in warm feelings toward people by nationality, age, years of education, or familiarity.

Table 2 Mean self-reported *Prefer Robots* and *Warm* ratings by group

	Prefer robots	Robots warm	People warm
Nationality male only			
Japan	−1.76***	0.94**	1.22
USA	−2.23	0.42	1.23
Nationality female only			
Japan	−1.00***	1.00	2.18
USA	−2.41	0.60	1.12
Age			
Below 43.9	−1.97**	0.65	1.31
43.9 and above	−2.28	0.64	1.09
Education			
Below 20.5	−2.18	0.65	1.04
20.5 and above	−2.09	0.61	1.35
Robot familiarity			
Not familiar	−2.42**	1.53***	1.13
Familiar	−2.04	0.45	1.23
Robot interest			
Not interested	−2.45**	1.71***	0.44*
Interested	−2.06	0.50	1.31

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 3 Mean self-reported *Robots More Threatening* and *Safe* ratings by group

	Robots more threatening	Robots safe	People safe
Nationality male only			
Japan	−0.43**	0.02**	0.38
USA	−0.86	−0.51	0.21
Nationality female only			
Japan	−0.36	−0.36	−0.27
USA	−0.41	−0.29	0.34
Age			
Below 43.9	−0.57	−0.33	0.11*
43.9 and above	−0.57	−0.19	0.48
Education			
Below 20.5	−0.46	−0.04*	0.29
20.5 and above	−0.69	−0.52	0.29
Robot familiarity			
Not familiar	−0.43	0.01	0.08
Familiar	−0.59	−0.32	0.32
Robot interest			
Not interested	−0.41	0.12	0.14
Interested	−0.58	−0.31	0.30

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 3 shows the mean relative threatening ratings and safe ratings for robots and people by group. On average US participants and especially Japanese participants felt people were somewhat more threatening than robots [e.g., $F(458) = 8.77$, $p = 0.003$, $r = 0.38$ for males]. US participants also rated robots as being a bit unsafe [e.g., $F(457) = 8.79$, $p = 0.003$, $r = 0.38$ for males], while Japanese participants were neutral [$F(457) = 8.79$, $p = 0.003$, $r = 0.38$].

It is typical of IAT studies that the relative preference scale and warm/cold thermometer scale are combined (e.g., Greenwald et al. 2003). However, the Cronbach's α for the three variables *prefer robots, robots warm*, and *people warm* after z-score conversion was only 0.04, and the Cronbach's α for *robots more threatening, robot safe*, and *people safe* was −0.88. For US participants only, the values were 0.16 and −1.08, respectively; and for Japanese participants only, 0.10 and −1.06, respectively. Other combinations were attempted, but they all showed low reliability. Many researchers will not use an index that has a Cronbach's α below 0.70. Factor analysis confirmed that each of the two groups of variables would not load on a single factor. The first factor explained very little of the variance.

4.3 Implicit measures of attitudes toward robots

In the robots pleasant IAT, the average D measure was −0.41 with an effect size of 0.22. This D measure indicates that participants had more pleasant associations with humans than with robots. There was no significant difference in the D measure by

Table 4 Mean self-reported and implicit measures by group

	Prefer robots		Robots more threatening	
	Self-report	IAT *D*	Self-report	IAT *D*
Nationality male only				
Japan	−1.76***	−0.40	−0.43**	0.15*
USA	−2.23	−0.40	−0.86	0.23
Nationality female only				
Japan	−1.00***	−0.31	−0.36	0.02Δ
USA	−2.41	−0.42	−0.41	0.21
Age				
Below 43.9	−1.97**	−0.41	−0.57	0.14***
43.9 and above	−2.28	−0.40	−0.57	0.26
Education				
Below 20.5	−2.18	−0.39	−0.46	0.19
20.5 and above	−2.09	−0.42	−0.69	0.21
Robot familiarity				
Not familiar	−2.42**	−0.42	−0.43	0.25
Familiar	−2.04	−0.41	−0.59	0.19
Robot interest				
Not interested	−2.45**	−0.41	−0.41	0.23
Interested	−2.06	−0.41	−0.58	0.20

Δ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

nationality, gender, age, educational level, or robot familiarity or interest (Table 4). The differences that appeared in the self-report did not appear in the IAT.

In the robots threatening IAT, the average *D* measure was 0.20 with an effect size of 0.07. This *D* measure shows that overall participants felt somewhat threatened by robots. However, the *D* measure showed significant differences by age and nationality (Table 4). US participants associated robots with weapons to a greater extent than Japanese participants, and older participants associated robots with weapons to a greater extent than younger participants. Although participants reported that people were more threatening than robots, the *D* measure shows that they more strongly associated robots and weapons than people and weapons. These gaps were more pronounced for US participants than for Japanese participants [$F(404) = 4.47$, $p = 0.035$, $r = 0.22$]. The *D* measure shows that older people more strongly associate robots with weapons than younger people [$F(625) = 19.20$, $p = 0.000$, $r = 0.61$].

4.4 Correlations among self-reported and implicit measures

The number of robot-related experiences and self-reported "I prefer robots to people" (*Prefer Robots*) were correlated for both Japanese ($r = 0.15$, $p = 0.027$, two-tailed) and US ($r = 0.13$, $p = 0.003$, two-tailed) participants. The number of robot-related experiences and differential association between robots and weapons (*Robots More Threatening* IAT *D*) were negatively correlated for Japanese participants ($r = -0.14$, $p = 0.042$, two-tailed). The *Robots More Threatening* IAT *D* and *Prefer Robots* self-report were negatively correlated for Japanese participants ($r = -0.22$, $p = 0.001$, two-tailed). The number of robot-related experiences and the self-report "Robots are more threatening than people" were negatively correlated ($r = -0.19$, $p = 0.000$, two-tailed) for US participants. The *Robots More Threatening* self-report was also negatively correlated with the *Prefer Robots* self-report for US participants.

5 Discussion

5.1 The hypotheses revisited

H1 predicts the Japanese faculty have more robot-related experiences than the US faculty. On average female faculty members of the Japanese university had 110% more robot-related experiences than female faculty members of the US university (Table 1). Male faculty members of the Japanese university had 69% more robot-related experiences. The heightened prevalence of robot-related experiences at the Japanese university was consistent across all five questions. This supports H1.

Although the Global Gender Gap Report 2007 ranks Japan as having greater gender inequality than the US,[5] and only 4.5% of the participants from the Japanese university were female, among the Japanese faculty, there was not much of a gender gap concerning robot experiences except with respect to building and programming robots. However, there was a consistent gender gap among US participants: male participants had on average 30% more robot-related experiences overall and 152% more experiences with building or programming robots than female participants. In both the US and Japan, younger people had more robot-related experiences.

H2 predicts the Japanese faculty report preferring robots and rate feeling warmer toward robots than the US faculty. While the self-report results indicate this is true, on average both Japanese and US participants moderately prefer people to robots (Table 2). The difference between Japanese and US male participants is only 0.47 on a 7-point relative preference scale and 0.42 on an 11-point warm/cold thermometer scale. In addition, Japanese felt warmer toward people than toward robots, though not as warm toward people as their US counterparts. These small cultural differences hardly indicate Japan is a culture in the throes of "robot mania."

H3 predicts the US faculty rate robots as more threatening than the Japanese faculty. The results do not support H3. On average both Japanese and US participants reported that people are more threatening than robots. This opinion was stronger for US participants. However, on the safe/threatening thermometer scale, US participants rated robots as slightly dangerous, whereas Japanese participants rated them as neutral.

[5] Sweden ranks first of 128 countries with the narrowest gender gap. The US is listed at 31 compared to 91 for Japan (Hausmann et al. 2007).

Why were people rated as more threatening than robots in the self-report, especially among US participants? The participants probably understand that robots are controllable but people are not and, insofar as robots are a threat, it is because of how people use them (e.g., as weapons). Although one might think the negative rating for the *Robots Safe* self-report in the United States might be explained by a higher prevalence of technophobia, empirical studies do not support that stereotype (Weil and Rosen 1995).

The view that robots are threatening but people are even more threatening among US participants may be a result of the higher rate of violent crime in the US and its frequent coverage in the media. In 2005, the crime rate in the US was five times higher than Japan for murders, 20 times higher for rapes, 30 times higher for robberies, and 23 times higher for other acts of violence.[6] Japanese police have a close relationship with the local community. Most neighborhoods have a *koban* (police box), and officers still walk the beat and make home visits to learn about people's lives (Reubenfien 1989). Forced confessions are common, there is no plea bargaining or jury system (though that is changing), and even guilty pleas must go to trial. The result is a conviction rate approaching 99.9% (Scanlon 2003). In a cultural study of Japan's low crime rate, Komiya (1999) concludes

> In Japan, the locality-based group formation causes both a sense of security and an infinite number of repressive rules; these two elements are bound together to produce high self-control, which acts as a strong force restraining people from committing crime. (p. 369)

Thus, even though US participants felt robots were slightly threatening, they could still feel that people were more threatening than robots.

H4 predicts the Japanese faculty more strongly associate robots with pleasant words than the US faculty as indicated by the IAT *D* measure. This hypothesis is not supported. All groups had about the same association. They uniformly associated humans more strongly with pleasant words than robots.

H5 predicts the US faculty more strongly associate robots with weapons than the Japanese faculty as indicated by the IAT *D* measure. Japanese and US participants more strongly associated robots with weapons than humans. However, the strength of this association was stronger for US participants, so H5 is partially supported.

On average why do US participants say people are more threatening than robots but implicitly associate weapons with robots more than with humans? These results are surprising given our expectation that the difference between implicit and explicit measures would be greater for Japanese. US participants might be unaware of their negative associations with robots, and these negative associations may not represent their personal opinions. US participants might also be more likely to associate robots with military applications rather than social applications. While Japanese companies, research institutes, and universities and their funding agencies have

[6] In 2005, Japan's population was 127,756,000, and there were 1,392 murders, 5,988 robberies, 2,076 rapes, and 25,815 acts of violence (*Japan Statistical Yearbook 2008*, Chap. 25, Justice and police, p. 773, Statistics Bureau, Ministry of Internal Affairs and Communications). In 2005, the USA's population was 296,507,061 and there were 16,740 murders, 417,438 robberies, 94,347 rapes, and 1,390,745 acts of violence (*2006 Crime in the United States*. Federal Bureau of Investigation, Department of Justice).

invested heavily in social robotics, in the US more money has poured into defense-related work. In addition, US participants may have some unconscious fears concerning robots. The fears could stem from a lack of knowledge about robots or familiarity with them; however, the results show that robot familiarity had little effect on the IAT *D* measure.

More plausible explanations of unconscious fears of robots could include some of the observations made in the introduction. People may feel ambivalent about robots, because they constitute a mix of human and machine traits. Before the advent of modern technologies, if an entity crossed such category boundaries as human/nonhuman or alive/dead, it would be considered highly disturbing. However, robots inhabit precisely these category boundaries (Turkle 2007). An additional concern is that these are not just arbitrary categories. Rather, they are related to our notions of who we are as human beings—in other words, our personal and human identity (Ramey 2005). Entities that undermine these kinds of category boundaries could be seen as particularly threatening, if only unconsciously. This could influence implicit measures even though rationally participants may think people are more threatening than robots.

5.2 Lessons learned

The standard method of creating a self-reported preference index by combining relative preferences and warm/cold thermometer items (Greenwald et al. 2003) failed for robots. One explanation is that many faculty members, especially in Japan, may not conceive of robots as social or personified entities with independent agency (Kahn et al. 2007). Several researchers reported using robots in laboratory experiments and at first imagining the kinds of programmable mechanisms they use that are in no way personified. Someone might feel cold toward such robots but prefer them to people because they are fun to program.

This might also explain why those unfamiliar with robots felt warmer toward them. When they think about robots, they may be imagining the personified robots of popular culture. These robots have more humanlike characteristics that elicit anthropomorphism. Also, because people who lack experience with robots understand less about their internal workings, they may be more likely to treat them as social agents than as machines.

From this discussion we might conclude that faculty members may not have one concept of robot but many: laboratory robot, industrial robot, humanoid robot, human double, and so on (Nomura et al. Kato 2005). Personal experience and how the questionnaire and IAT are presented may influence which concepts of robot are active. One solution might be to give the participant a clear idea of the kind of robot the questionnaire is asking about. For example, if the questionnaire is about *humanoid robots*, a definition of humanoid robot could be provided with short video clips demonstrating well-known humanoid robots (e.g., Honda's ASIMO, MIT's Cog, KAIST's Hubo KHR-2). In addition, a validated self-report scale could be developed specifically for attitudes toward humanoid robots.

It may also be a mistake to use people as a benchmark for judging attitudes toward robots because of a wide variance in participants' attitudes toward people in this study. Alternatives include using a neutral object instead or simply eliminating the second target concept. This is the approach of the single target IAT (Penke et al. 2006) and go/no-go association task (Nosek and Banaji 2001).

As an implicit measure of association, the IAT does not distinguish associations rooted in personal preferences from those rooted in extrapersonal information, such as cultural norms, educational training and material, the news media, or other people's opinions (Karpinski and Hilton 2001; Olson and Fazio 2004). Although this distinction is not essential to this study, because it concerns general attitudes that are prevalent in Japan and the US, it can be relevant to studies on behavioral choices. Olson and Fazio (2004) developed a personal IAT to handle these cases. Houben and Wiers (2007) have successfully applied the personal IAT to the study of alcohol consumption. While studies based on the IAT showed that heavy drinkers had negative associations with alcohol, perhaps resulting from the prevalence of negative attitudes in society, the personal IAT showed that they had positive associations. In future research the personal IAT could be used to help separate robot associations that concern personal preferences from those that concern societal preferences. This might shed light on the differences in implicit and explicit measures in this study.

5.3 Institutional and economic factors

The self-reported and IAT results reveal some striking similarities between Japan and the US in attitudes toward robots. One possibility is that faculty members of the chosen universities are not representative of their cultures as a whole. Another possibility is that Japan's robot culture is built on factors other than warm and safe feelings about robots. These factors include Japan's historical development, economic structure, professional specialization, and government planning and policy. Japan's manufacturing sector has maintained its strength (Castells 2000) in part through robotic automation; Japan's universities graduate a high percentage of native-born engineers, especially when compared to the US; Japan's government has envisioned robots as a possible solution to the demographic crisis; and given Japan's unique, tight-knit culture with many social rules and complexities, bringing in foreign labor has long been considered problematic.

Sara Kiesler has proposed that Japan is experiencing a positive feedback loop in robotics related to how commitment and expertise function in organizations and economies.[7] Once Japan acquired expertise in robotics, developed robots for factory automation, and trained a substantial number of robotics engineers, these experts began to create additional markets for their skills.

In the United States, this pattern is well known in the legal profession as exemplified by the explosive growth not only in the supply of lawyers during the past 40 years but also in the demand for their skills. According to Kagan (1994), lawyers have advocated a progressive expansion of their role in society:

[7] Personal communication.

> Lawyers, law professors, and judges generate a legal culture that supports adversarial legalism as an essential aspect of governance. Organized groups of lawyers systematically lobby courts and legislatures to extend the realm of adversarial legalism and to block reforms that would reduce it. (p. 60)

In addition, lawyers have helped to foment an explosion in litigation. Elite firms encourage corporate clients to adopt a "rent seeking" strategy by investing heavily in lawsuits:

> As litigants become more accustomed to launching large legal battles, their opponents are compelled to follow suit. The big lawyer teams produce increasingly complex and sophisticated legal strategies, making legal battles more like a lottery—more dependent on big investments for successful outcomes. (Sander and Williams 1989, p. 473)

The end result is spiraling demand for lawyers that the profession itself partly generates. Could robotics engineers be doing the same in Japan?

Despite high initial starting salaries, engineering seldom provides a long-term career in the US, and there is little job security. US engineers often take management courses, because management is seen as a good exit strategy from the profession. This contrasts with Japan where companies "are unusually effective in delaying the technological obsolescence of their engineers" (Lynn 2002, p. 97). Japan's lifetime employment system implies that the largest firms will provide long-term employment in exchange for employee loyalty. This encourages companies to invest in the periodic in-house retraining of engineers. Some US engineers argue that in the US the profession has been hamstrung for years by lawyers, regulators, and corporate "bean counters" whose main concern is maximizing quarterly profits (see comments on Engardio 2005). The prevalence of company cross-holdings in Japan provides a buffer against the immediate concerns of shareholders, enabling healthier companies to focus on long-term product development.

In addition to Japan's high retention rates in engineering, the subject is a popular major. Sixty-four percent of bachelor's degrees in Japan are in science and engineering compared with about one-third in the US (National Science Board 2006, pp 2–21). That figure is considerable given that a higher percentage of Japanese high school students are college bound. In robotics Japan's success is not limited to industry. Japanese researchers dominate major robotics conferences, such as the *IEEE International Conference on Robotics and Automation*. Patents provide a means of measuring the intellectual productivity of Japanese engineers: "Japan-based organizations lead the U.S. patent-assignee list with 9 of the top 20 slots."[8] The success of Japanese engineering and automation has helped Japan maintain its manufacturing base unlike all other G8 countries except Germany. This promotes continued employment for engineers in Japan.

Since Japan's economic slump of the 1990s ("the lost decade"), drawing economic lessons from Japan has become unfashionable. Nevertheless, the US preference for importing goods from countries with relatively low labor costs, such

[8] IFI Patent Intelligence Issues Annual Rankings of Top U.S. Patent Assignees, *PR Newswire*, January 11, 2008.

as China, rather than maintaining its manufacturing base may have long-term consequences. Manufacturers escape stricter occupational safety, workers' compensation, and pollution regulations in the US. This is of global concern, for instance, because pollution does not respect national boundaries. While today's products from China and elsewhere may be filling US landfills in a few years, China will own a larger share of the US as it grows toward superpower parity. Is this really what the US and other democracies want?

Japan has gambled that robots will provide a solution to its demographic crisis by providing care to the elderly. Delirium, dementia, and depression caused by social isolation pose a serious threat to the quality of life of older adults. Robots have the potential to head off or postpone the onset of these conditions by providing cognitive therapy, alleviating loneliness, and encouraging exercise to reduce obesity and improve cardiovascular health. Robots have already been employed as social mediators, rehabilitation coaches, and in monitoring care (Feil-Seifer et al. 2007). The robot pet Paro, developed at Japan's National Institute of Advanced Industrial Science and Technology, has been used in nursing homes in Japan, the United States, and Europe for companionship and to stimulate social interaction among patients (Turkle 2007).

The use of eldercare robots in Japan is seen by some planners as preferable to coping with the social problems that might result from a large influx of foreign healthcare workers (Barry 2005). As more baby boomers retire, a shortage of healthcare workers is also of concern to the US and other industrialized nations. With most of the investment in robots for eldercare coming from Japan, this might be another segment of the US economy—in addition to automobiles and consumer electronics—that Japanese companies would dominate.

6 Conclusion

Although the Japanese faculty had many more experiences with robots than the US faculty, the cross-cultural similarities in attitudes toward robots were more striking than the differences. Implicit measures showed that both faculties associated pleasant words more strongly with humans than with robots—and by similar margins. Although the Japanese faculty reported feeling a bit warmer toward robots than the US faculty, both faculties reported feeling warmer still toward people. Both faculties also reported preferring people to robots, though the margin was wider in the US. So implicit and explicit measures show a preference for people among both faculties.

Both the Japanese and US faculty rated people as more threatening than robots, but implicit measures showed that both faculties associated weapons with robots more than with humans. This effect was significantly greater for the US faculty. There are at least four possible explanations of this difference between implicit and explicit measures: (1) Both faculties, and especially the US faculty, may have rational safety concerns about people combined with unconscious fears of robots. (2) Different concepts of robot may be active for participants during the IAT and self-reports. (3) Participants may want to appear more favorable toward robots than they are (self-presentational bias). (4) The participants' personal preferences may differ from their extra-personal associations, such as those picked up from their culture and upbringing. Although greater implicit/explicit differences were expected in Japan, the differences were in fact greater in the US.

The differences between the Japanese and US faculty were not sufficient to substantiate the view that Japan is a robot-loving society. This may indicate that the Japanese and US faculty were not representative of their wider cultures, or that factors other than attitude play a greater role in Japan's adoption of robots. Major differences exist in the historical development of Japan and the West. The main religious and philosophical doctrines of Japan—Shinto, Buddhism, and neo-Confucianism—have never impeded Japan's progress in science and technology. This contrasts with the enduring conflict between science and religion in the West. Western assumptions about the uniqueness of human beings—from the creation myth to notions of the soul and mind/matter duality—are of little consequence in Japan. Thus, entities lying on the boundary between human and nonhuman do not pose the same challenge to an individual's sense of personal and human identity in Japan as in the West.

There are several practical reasons for the prominence of robots in Japan. Robots have played an important role in maintaining Japan's manufacturing base. Owing to a stronger commitment to retrain employees at companies adopting automation, robots are not considered a threat to jobs. On the contrary, they are a key component of government plans to address labor shortages in healthcare and eldercare. Japan's progress toward peaceful applications of robots is motivate by sound reasoning, not irrational exuberance. An understanding of Japan's case will help other nations make more informed choices.

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Appendix: Questionnaire

Robot-related experiences

1. How many times in the past one (1) year have you read robot-related stories, comics, news articles, product descriptions, conference papers, journal papers, blogs, or other material? (6-point scale) 0, 1, 2, 3, 4, 5 or more
2. How many times in the past one (1) year have you watched robot-related programs on film, television, DVD, the Internet, or other media?
3. How many times in the past ten (10) years have you had physical contact with a robot?
4. How many times in the past ten (10) years have you attended robot-related lectures, exhibitions, trade shows, competitions, or other events?
5. How many times in your life have you built or programmed a robot?

Attitudes toward robots

1. Select the statement that best describes your opinion. (7-point scale)

- I strongly prefer robots to people. (+3)
- I like robots and people equally. (0)
- I strongly prefer people to robots. (−3)

2. Rate how warm or cold you feel toward robots. (11-point scale)

- Very cold (−5)
- Neutral (0)
- Very warm (+ 5)

3. Rate how warm or cold you feel toward people. (11-point scale)
4. Select the statement that best describes your opinion. (7-point scale)

- Robots are much more threatening than people. (+ 3)
- Robots and people are equally threatening. (0)
- People are much more threatening than robots. (−3)

5. Rate how safe or threatening you feel robots are. (11-point scale)
6. Rate how safe or threatening you feel people are. (11-point scale)
7. How familiar are you with robots? (6-point scale)

- Not at all familiar (0)
- Completely familiar (+5)

8. How interested are you in robots? (6-point scale)

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