

# **Social Acceptance and Impact of Robots and Artificial Intelligence**

**—Findings of Survey in Japan, the U.S. and Germany—**

**Hiroyuki NITTO, Daisuke TANIYAMA and Hitomi INAGAKI**

**Nomura Research Institute**

# Social Acceptance and Impact of Robots and Artificial Intelligence

—Findings of Survey in Japan, the U.S. and Germany—

**Hiroyuki NITTO, Daisuke TANIYAMA and Hitomi INAGAKI**

- I Current Status of Social Acceptance of Robots and Artificial Intelligence
- II Differences in Attitudes toward and Acceptance of Robots in Japan, the U.S. and Germany
- III Needs and Potential of Nursing care Robots
- IV Senses of Values Related to Science and Technology in Japan, the U.S. and Germany, which Influence the Introduction of Robots and AI
- V Future Challenges

Today, it is increasingly common for people to use or come into contact with robots in various situations at home and in retail stores, hotels and hospitals. Robots are classified into several types based on their functionality (service and utility robots or those designed to communicate with humans) and appearance (humanoid robots or mechanical robots). The type of robot, to which each country attaches particular importance in the advance of robotics, reflects the sense of values and preferences of its population.

Nomura Research Institute, Ltd. (NRI) has conducted a consumer survey in Japan, the U.S. and Germany on the topic of robots and artificial intelligence (AI). In Japan, respondents often associate the term “robots” with “humanoid robots” that can communicate with humans and they have a high level of familiarity with robots. Of the three countries, the U.S. has the highest level of robot utilization at home and in retail stores with its people being the most enthusiastic about the future use of robots. Germany shows a strong tendency to consider robots for industrial purposes, and its people feel strong resistance to the presence of robots in their households.

Japanese consumers generally have positive attitudes towards robots. However, survey findings revealed that they still lack sufficient knowledge about robots and therefore think the rise of a robot society is still far in the future, causing them to not carefully consider the correlation between humans and robots. As a society, now is the time to properly understand and think about how humans should accept the potential of robots—and the artificial intelligence technologies that support the development of robots—which may essentially change our way of living. Given Japan’s rapidly aging population, there are a higher number of people who expect to utilize nursing care robots. As such, Japan is likely to see its market for nursing care robots ahead of the rest of the world.

# I Current Status of Social Acceptance of Robots and Artificial Intelligence

Advancements in robot and artificial intelligence (AI) technologies have drawn much attention in recent years. In fact, there are many discussions around the R&D initiatives being carried out by various companies in Japan and abroad as well as the impact these activities would have on society. For example, there was wide media coverage when Nomura Research Institute, Ltd. (NRI) released a joint research report with Dr. Michael Osborne, an Associate Professor at the University of Oxford, in December 2015 with the headline: “49% of all jobs performed by humans in Japan can be replaced by AI and robots.”

In November 2015, NRI conducted an online consumer survey in Japan, the U.S. and Germany on the topic of robots and artificial intelligence <sup>Note 1</sup>. The survey results revealed the differences among consumers in the three countries in terms of their knowledge, acceptance and usage intention of these technologies. This report provides the results of our analysis and implications for Japanese companies, along with a specific example of the possible emergence of the nursing care robot market.

This chapter first introduces the current state of social acceptance of robots and AI in the U.S. and Germany, followed by an overview of applications of the latest technologies related to robots and AI that are available for consumers.

## 1 Rise in the acceptance and contact with robots in the U.S.

According to surveys conducted by the Consumer Electronics Association (CEA) in 2013 and 2014, many American consumers show a certain degree of understanding for task-specific usage of robots. However, the usage in this case is limited to relatively simple tasks and consumers show much less interest in tasks involving interaction and communication. Specifically, more than 50 percent of consumers are interested in having a robot help with household chores, gardening and lawn care, and home security. One example of household robots, which has gained popularity in Japan, is “Roomba,” a series of floor-cleaning robots manufactured and distributed by iRobot Corporation. Another is the robotic lawn mower “Robomow” being sold in the U.S. and the U.K. Nonetheless, when it comes to leisure, time spent with friends or caring for pets and children, American consumers are noticeably less interested in being involved with robots <sup>Note 2</sup>.

Even so the number of opportunities for American consumers to come in direct contact with robots has been increasing in the business-to-business-to-consumer

(B2B2C) fields such as those installed by retailers in stores, and is expected to grow further. Robots of this and similar types include (1) ones that help consumers find items in stores, (2) room-service robots in hotels and (3) medical robots that deliver telemedicine service to patients. These robots are designed to assist consumers in receiving more convenient services.

### (1) Shopping assistant robots

Lowe’s, a U.S. chain of retail home improvement and appliance stores, has partnered with Fellow Robots, a Silicon Valley start-up, to install a retail service robot named “OSHbot” at its hardware supply stores in San Jose, California. In this trial, when a customer tells OSHbot what he or she is looking for, OSHbot provides information about the product and its inventory, and even guides the customer to the item’s location within the store <sup>Note 3</sup>.

### (2) Hotel room service robots

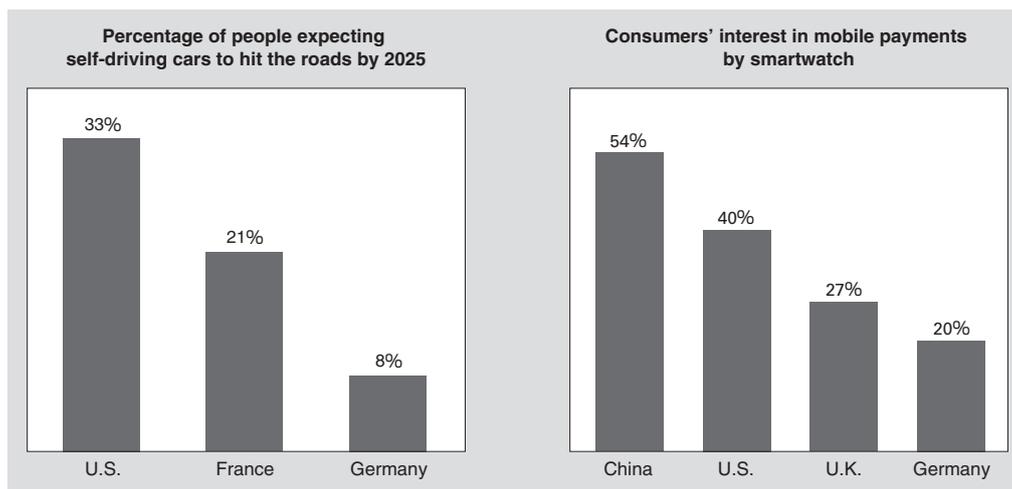
Similar trials are also taking place in hotels. Savioke, which is also a Silicon Valley start-up, developed a room service robot named “Relay,” which has the ability to autonomously deliver new towels, toothbrushes and tubes of toothpaste to guestrooms on behalf of hotel staff when guests call for room service. According to Savioke, Relay was being used at six hotels in California as of the end of 2015, having carried out more than 11,000 tasks altogether <sup>Note 4</sup>.

### (3) Telemedicine robots

Since 2012, iRobot, in partnership with InTouch Health, a U.S. telehealth network provider, has been operating its telemedicine robot “RP-Vita” equipped with a camera, microphone and display screen. The robot enables a doctor to move anywhere in the hospital and consult with patients remotely. Tractica, a U.S. market intelligence company, predicts that annual shipments of telepresence robots will reach 31,600 units by 2020, with cumulative shipments during the five-year forecast period totaling nearly 92,000 units <sup>Note 5</sup>.

## 2 Varying levels of interest in cutting-edge technologies from country to country

The levels of consumer interest in the utilization of the latest technologies vary even among the developed countries such as the U.S. and Germany (Figure 1). According to a survey by Dekra, a global leader in automotive inspection services, 33 percent of Americans and 21 percent of the French expect autonomous cars to experience their breakthrough by 2025. In contrast, the comparable figure in Germany is only 8 percent <sup>Note 6</sup>. Similarly, a survey held by GfK, a German market research institute, found that 40 percent of American respondents are interested in mobile payments using a smartwatch, whereas only 20 percent of German consumers have such interest <sup>Note 7</sup>.

**Figure 1. Country-by-country difference in consumers' interest in the latest technology**

Source: Dekra, "A general consumer survey on autonomous driving cars" (2015)

Source: GfK, "A survey on smartwatches with 1,000 smartphone owners interviewed" (2014)

### 3 Types of robots; different positioning strategies by U.S., European and Japanese companies

Both in Japan and in the U.S., the majority of robots being sold in the market are ones that perform specific functions such as "Roomba," the floor cleaning robot previously mentioned.

On the other hand, robots that communicate with humans are called "social robots," whose capabilities continue to improve as AI-related breakthroughs are seen in the area of deep learning (technology enabling machines to automatically identify and extract the most important information from an array of data). Furthermore, due to increased media coverage, social robots have quickly become well recognized among consumers. For example, in Japan, SoftBank Robotics' humanoid robot "Pepper" has already been introduced by Nestlé, Mizuho Bank and SoftBank mobile phone stores as well as by Benesse, an education and daycare service provider. At the same time, Aldebaran Robotics' humanoid and programmable robot "Nao" is being installed at Bank of Tokyo-Mitsubishi UFJ branches, while Fujisoft's communication robot "Palro" is being adopted by nursing facilities to help staff members.

The robots introduced thus far, including social robots, can be classified into several types based on their functionality and appearance (Figure 2). By using this classification framework, there are three main groups of robots.

The first group includes utility robots with a mechanical appearance such as "Roomba" and Amazon's voice-activated smart speaker robot, "Echo."

The second group includes "Jibo" and "Buddy" that are not humanoid robots but are categorized as social robots because of their ability to communicate with humans. American and European manufacturers have taken the lead in the development of robots in this group.

The third group consists of robots with human-like appearance such as "Pepper" that also communicate with humans. Many of the robots that belong to this category are being manufactured by Japanese companies. Although Aldebaran Robotics, which develops and markets "Nao," is originally a French company, the fact that it is a subsidiary of SoftBank in Japan means the third group as a whole consists almost entirely of Japanese products.

The country-by-country differences in robotics development trends are considered to be largely influenced by the sense of values and preferences of the population of each country. As more robots become commercially available in the global market in the near future, how best to overcome such differences will be the key.

## II Differences in Attitudes toward and Acceptance of Robots in Japan, the U.S. and Germany

Based on the findings of NRI's "Online Survey on Robots/AI in Japan, the U.S. and Germany" conducted in 2015, Chapters II, III and IV reveal how consumers in the three countries react to and perceive robots.

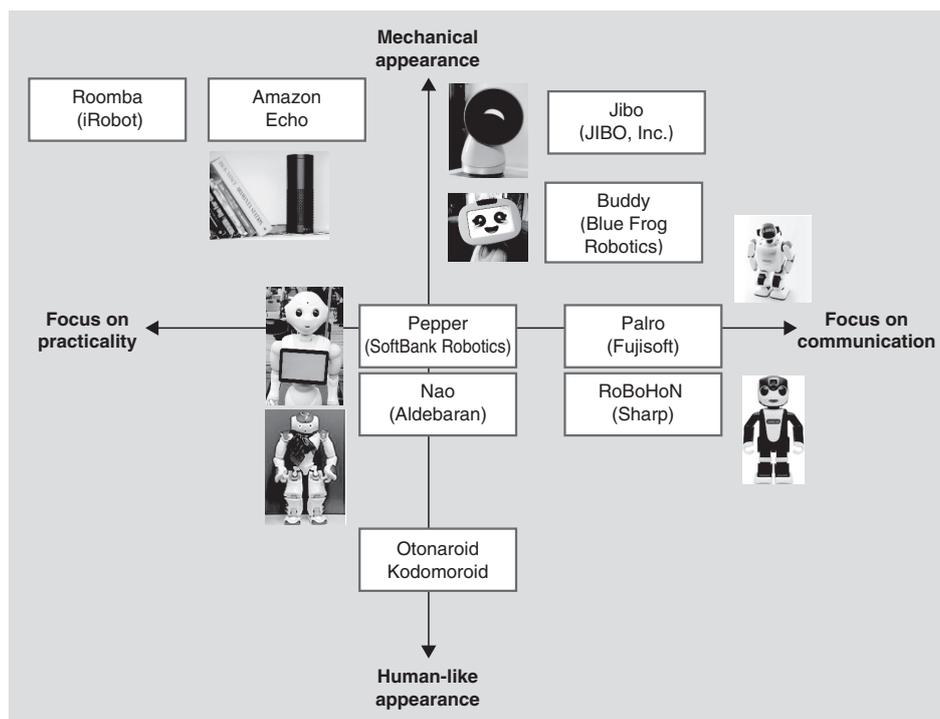
### 1 Consumers' perceptions of and experiences with robots

#### (1) Consumers' perceptions of robots

There is a wide variety of automated systems and services that fall under the umbrella term "robot." The first survey question is related to how closely respondents associate the image shown to them with their definition of a robot.

In the first question, pictures of four robot types are

Figure 2. Types of robots classified according to function (horizontal axis) and appearance (vertical axis)



Sources of pictures: Nao: [http://www.nri.com/jp/news/2016/160208\\_1.aspx](http://www.nri.com/jp/news/2016/160208_1.aspx)  
 Amazon Echo: <http://www.theverge.com/2015/1/19/75488059/amazon-echo-review-speaker>  
 Jibo: <http://postscapes.com/smart-home-voice-recognition-robot-jibo>  
 Buddy: <http://sdtimes.com/french-robot-company-raising-moneyl-for-open-source-companion-robot-buddy/>  
 RoBoHoN: <https://robohon.com/special/>  
 Other pictures were taken by NRI

shown. They are “humanoid robot,” “cleaning robot,” “guidance robot in a store” and “industrial robot.” Figure 3 introduces answers to the question of “Please see the picture below, and rate how closely you associate the image with your definition of a robot.” The percentages of respondents selecting “Completely or somewhat matches” were generally high for a “humanoid robot” and an “industrial robot.” However, as to nonhuman-like robots such as a “cleaning robot” and a “guidance robot in a store,” the percentages of respondents selecting “Somewhat or completely different” were high. This tendency is particularly noticeable in Japan. Many Japanese people who grew up watching robot anime such as *Astro Boy* (known in Japan as *Tetsuwan Atomu* or *Mighty Atom*) and *Doraemon — Gadget Cat from the Future* in their childhood tend to define a robot as a partner having a human-like shape and living together with humans.

In Germany, a highly industrialized country like Japan, consumers have a strong tendency to define “robots” as industrial robots that are emotionless and faithfully obey humans’ orders.

In the NRI survey, a robot is defined as “a machine that can autonomously assist humans without relying on continuous instructions or programming” and therefore does NOT include “appliances that require human operation, such as a refrigerator, coffee machine or microwave oven.” Instead, the survey includes “industrial robots in factories,” “cleaning robots,” “lawn mower robots” and

“disaster rescue robots designed to operate in places inaccessible to humans” as robots. Respondents were asked to provide their answers based on that definition.

## (2) Consumers’ experiences with robots

The second question relates to the extent to which consumers have come in contact with a robot, that is, their experience. Because the market for robots is still in its early stages, the percentages of respondents who have experience in using a robot were as small as about 20 to 30 percent in each of the three countries (Figure 4). In terms of places where they have used a robot, percentages were high in the order of “home,” “work or school” and “retail stores, restaurants or hotels.” Rather than a social robot, a robot focusing on a specific task such as a cleaning robot is considered mainly used at home.

## (3) Consumers’ acceptance of robots and purchase intention

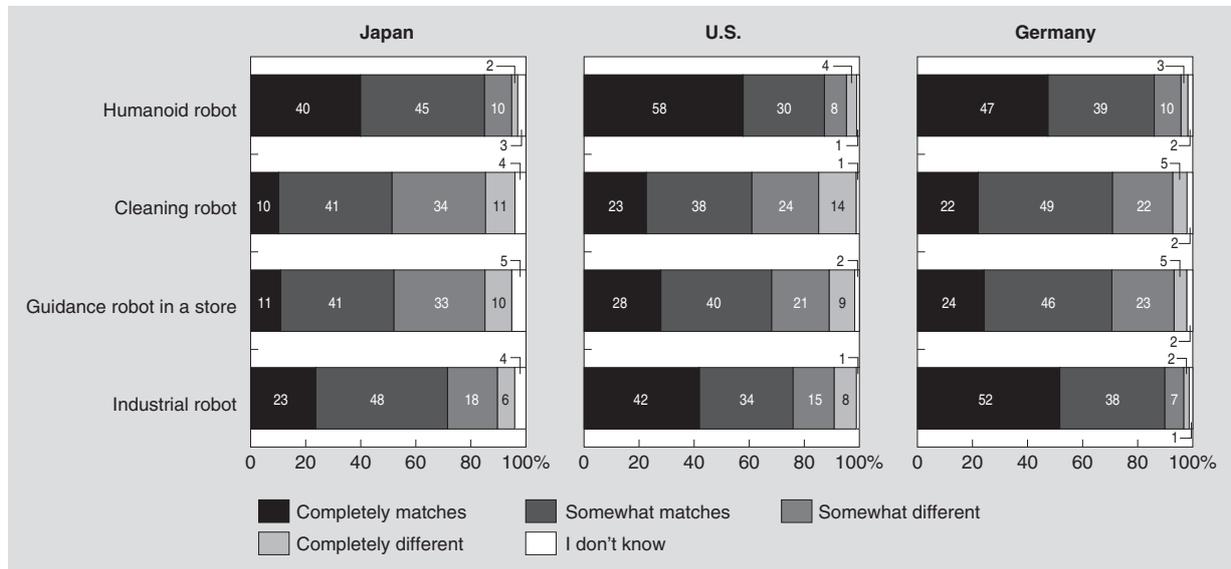
Whatever consumers’ perceptions of robots are, robotic manufacturers are expected to be marketing a variety of robots within a few years. How do consumers feel about welcoming robots into their everyday lives? To find out, NRI asked respondents their attitude toward use of robots in their daily lives and their intention to purchase robots (Figure 5).

In all three countries, about 60 to 70 percent of respondents said “Very comfortable” or “Somewhat comfortable” regarding robots being part of their daily

lives, revealing that the percentages of respondents feeling resistance (uncomfortable) are low. In the U.S., to the question about purchase intention, 28 percent answered that they want to purchase “Within the next 12 months.” When the percentage of respondents who want to purchase “Within the next 5 years” is added, the

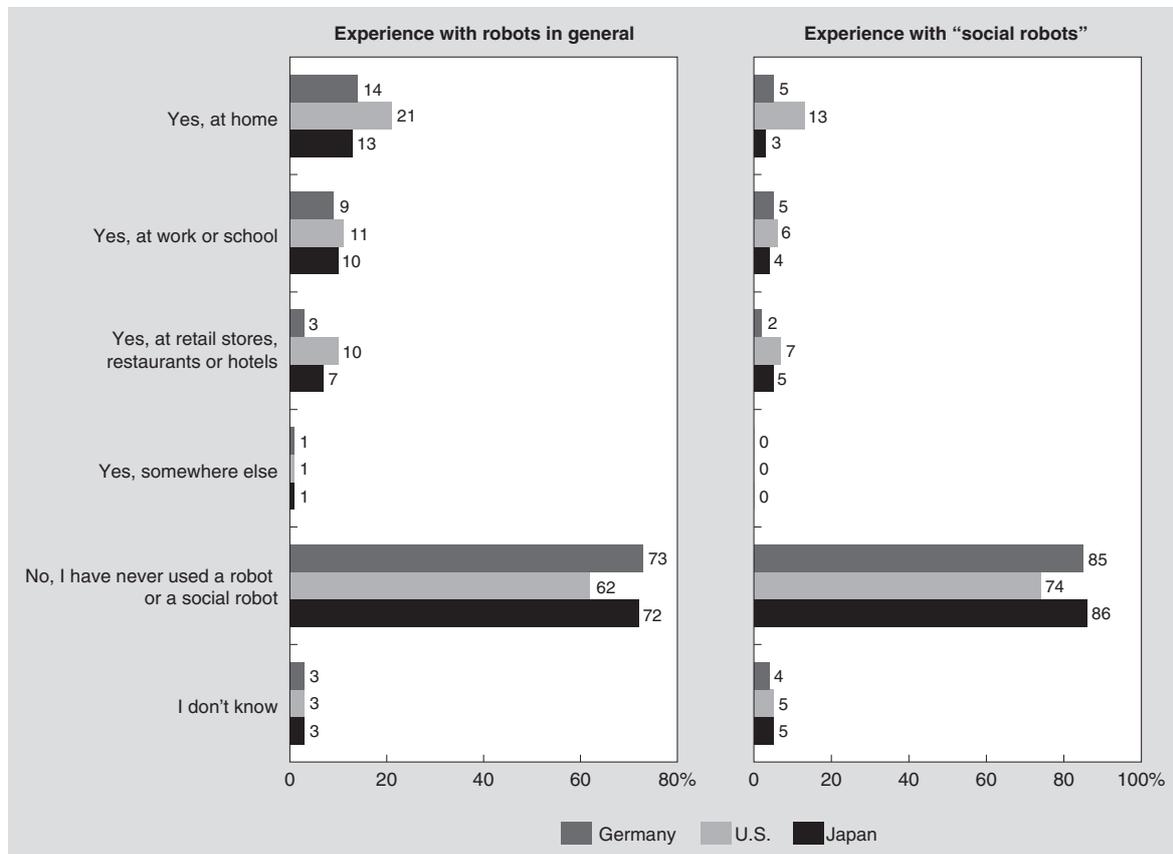
percentage of respondents who have a positive attitude towards purchasing a robot rises to as much as 51 percent, whereas the rate of those who are not interested in purchasing a robot was only about 20 percent. In Japan, only 6 percent want to purchase “Within the next 12 months” and as many as 61 percent selected either “No,

**Figure 3. Images of Robots: Does the image of each robot match what you imagine?**



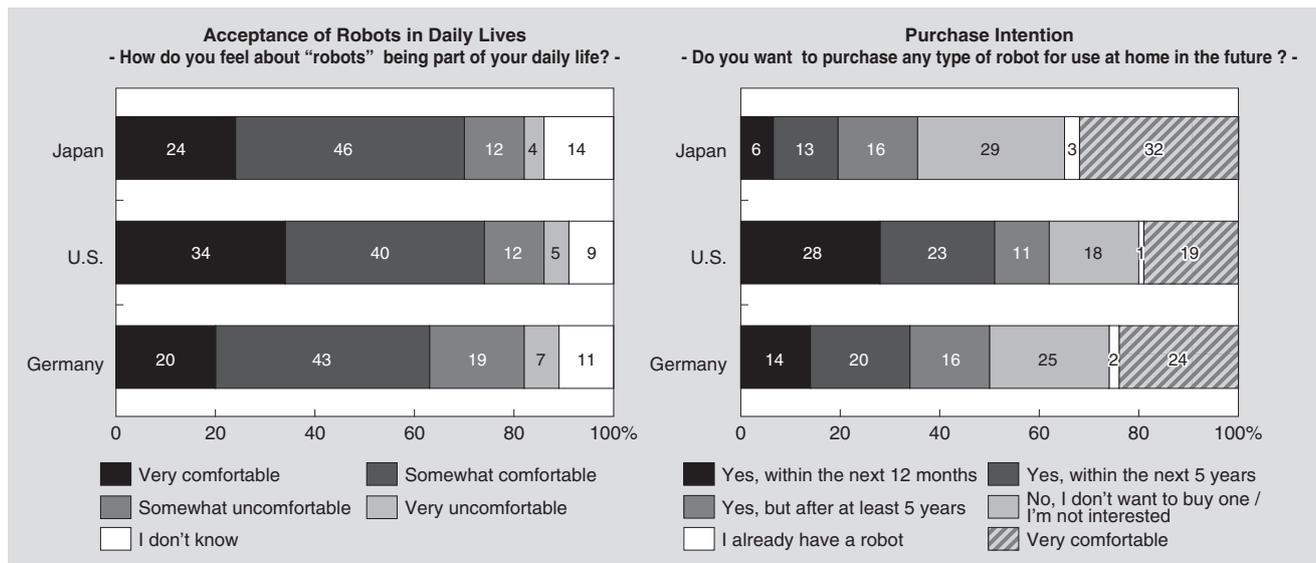
Note: Number of respondents aged 16 – 69 via the internet: 1,390 in Japan, 1,369 in the U.S. and 1,382 in Germany  
 Source: NRI, “Online Survey on Robots/AI in Japan, the U.S. and Germany” (November 2015)

**Figure 4. Consumers’ experiences with robots**



Note: Number of respondents aged 16 – 69 via the internet: 1,390 in Japan, 1,369 in the U.S. and 1,382 in Germany  
 Source: NRI, “Online Survey on Robots/AI in Japan, the U.S. and Germany” (November 2015)

Figure 5. Consumers' acceptance of robots and purchase intention



Note: Number of respondents aged 16 – 69 via the internet: 1,390 in Japan, 1,369 in the U.S. and 1,382 in Germany  
 Source: NRI, "Online Survey on Robots/AI in Japan, the U.S. and Germany" (November 2015)

I don't want to buy one/I'm not interested" or "I don't know." Germany is positioned between the U.S. and Japan, with 34 percent wanting to purchase "Within the next 5 years."

In all three countries, consumers are becoming aware of the need to accept the presence of robots, with the U.S. feeling the strongest about it becoming a reality in the near future. In fact, there is a concentration of companies developing cutting-edge robots and AI technologies in Silicon Valley, California. Hence, it is likely for the U.S. to be at the forefront of robotics innovation and consequently emerge with a viable robotics market before others.

In contrast, Japanese consumers are less enthusiastic about purchasing robots despite showing a high level of consumer acceptance. This indicates that it will take time before a "robotic society" becomes a reality in Japan.

## 2 Theory of the "uncanny valley" and consumers' attitudes toward the appearance of robots

### (1) Theory of the "Uncanny Valley"

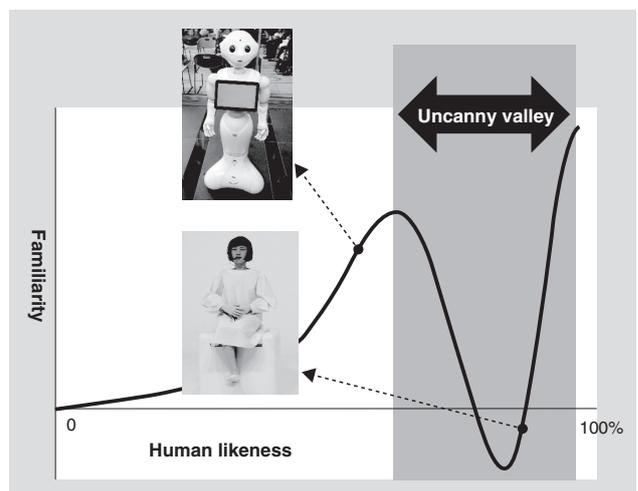
In the future, it will become common for robots to coexist with humans, and for this "robotic society," it is imperative that humans feel empathy and affinity towards robots. However, what stands in the way is an emotional wall, known as the "Uncanny Valley," in which robots will reach a certain point where they look too human-like, to the extent that they paradoxically evoke a sense of revulsion in most human beings. This concept was introduced by Japanese Roboticist, Masahiro Mori in 1970 (Figure 6).

While this phenomenon was merely a hypothesis in the past, in recent years, researchers have been validating the existence of the valley. In 2011, a research team led

by Ayse Pinar Saygin, an assistant professor at the Department of Cognitive Science and Neurosciences Program, University of California, San Diego, has been successful in ascertaining the credibility of this phenomenon from a neuroscientific approach <sup>Note 8</sup>. This team explored the reaction of the brain that causes the uncanny valley phenomenon, and found that when the brain's expectations for movement that come from a robot's appearance are not met with a robot's actual movement, the brain generates a prediction error.

In experiments <sup>Note 9</sup> conducted by Maya Mathur and David Reichling in 2015, subjects were asked to rate the likability of 80 robot faces presented to them. The results revealed that as the appearance of a robot moves from mechanical to human-like, likability increases. Ratings increased up until the faces looked almost human, at which point ratings dropped significantly into the uncanny valley. Forming the shape of a "V," ratings

Figure 6. Relationship between human likeness and familiarity based on the uncanny valley theory



increased again when robots began to look identical to humans. These findings suggest that the uncanny valley actually exists and that it influences a human’s emotional response to robots.

**(2) Consumers’ preferences for the appearance of robots and the material used**

Based on the uncanny valley concept, NRI conducted a survey of Japanese, American and German consumers on the appearance of robots to identify the shape and surface that consumers find favorable.

What appearance makes a robot more likeable? Does the shape of a social robot need to be human-like? To find answers to these questions, the survey provided four options. They are: (1) a robot whose shape and surface are like a real human (Otonaroid, Kodomoroid, etc. [Note 10](#)), (2) a robot whose shape is human-like but whose surface is different from a human (Pepper, etc.), (3) a robot whose shape and surface are different from a human (Jibo, etc.) and (4) a robot whose appearance resembles an animal, such as a dog or cat (seal-shaped Paro developed by the National Institute of Advanced Industrial Science and Technology, etc.)

The survey revealed that in all three countries, the larger proportions of respondents found that robots whose shape is human-like but whose surface is different from a human are very or somewhat favorable, and found uncomfortable for robots similar to real humans. The U.S. scored the largest proportion of respondents who found very or somewhat favorable for “(3) a robot whose shape and surface are different from a human,” exposing the tendency that consumers do not care about whether the shape of a robot is human-like. While large proportions of Japanese and American respondents were very or somewhat favorable for animal-shaped robots, the proportion was low in Germany. These findings

suggest that a large proportion of German respondents consider that robots should appear more machine-like. (Figure 7)

**(3) Consumers’ preferences for the faces and expressions of robots**

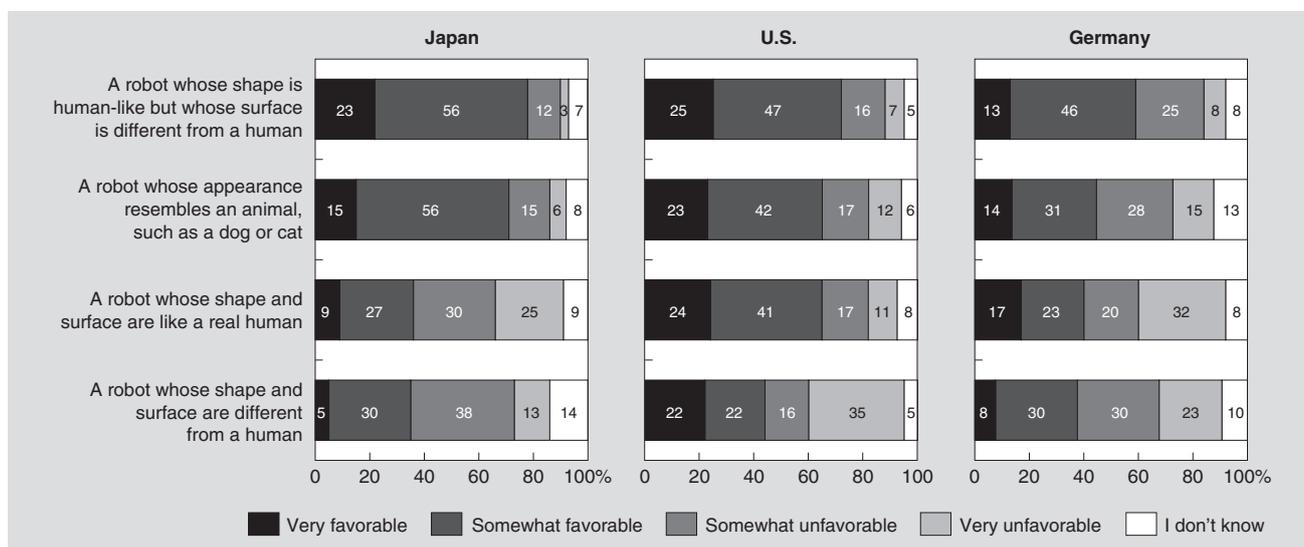
Many companies have been developing robots with a human-like face and changing facial expressions in response to their interaction with humans. The survey asked whether a social robot needs a human-like face and changing facial expressions. About 50 percent of respondents in each of the three countries answered either “Definitely needed” or “Somewhat needed.” Nevertheless, in the U.S., the proportion of respondents who answered “Not needed at all” amounted to 26 percent.

As to changes in facial expressions, 55 percent of Japanese respondents preferred or somewhat preferred a changeable face, whereas only 36 percent in the U.S. said so. Conversely, as many as 44 percent in the U.S. preferred or somewhat preferred a fixed face, revealing that American consumers do not need explicit face features (Figure 8).

One of the reasons for these differences can be attributed to a cultural background where, because of the popularity of games and anime, Japanese consumers feel greater familiarity with robots. On the contrary, in Europe and the U.S., movies such as *2001: A Space Odyssey*, *Terminator* and *Blade Runner*, in which robots or AI are featured, may have helped create a negative feeling towards robots in that computers and machines control humans.

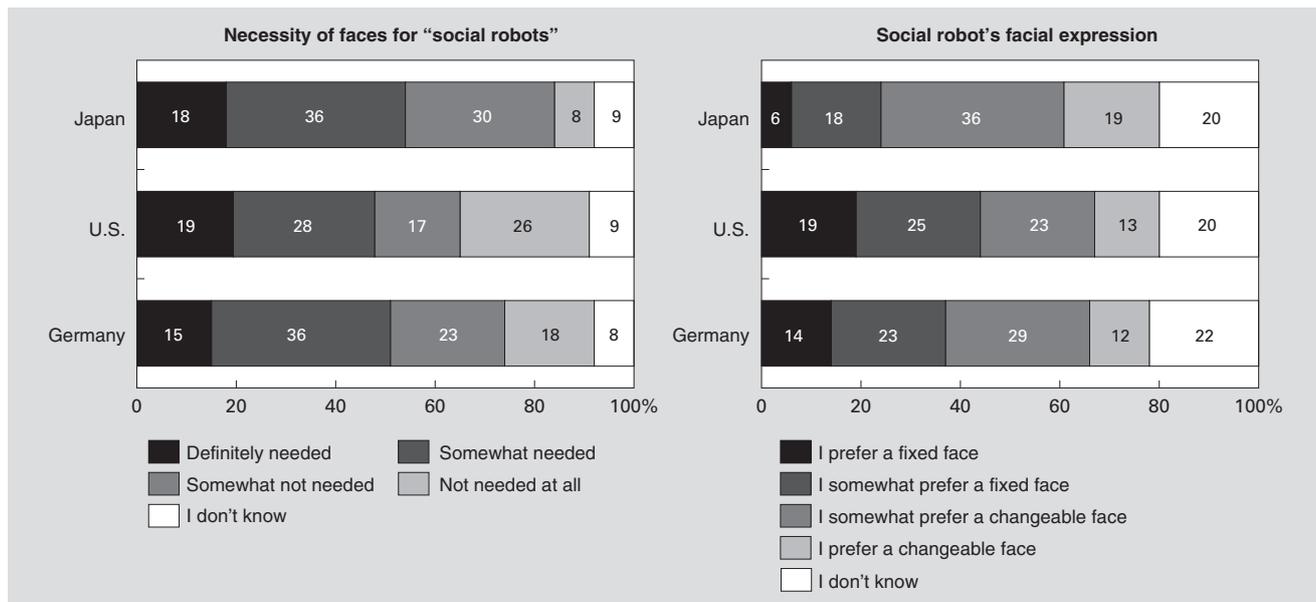
For instance, in Hollywood movies, good robots are depicted in a machine-like or non-humanlike shape such as those seen in *Big Hero 6* and *WALL-E*, whereas human-like appearance is used for bad robots such as those seen in *Terminator*. Based on the hypothesis

**Figure 7. Consumers’ preferences for materials used for robots**



Note: Number of respondents aged 16 – 69 via the internet: 1,390 in Japan, 1,369 in the U.S. and 1,382 in Germany  
 Source: NRI, “Online Survey on Robots/AI in Japan, the U.S. and Germany” (November 2015)

Figure 8. Consumers' preferences for faces of "social robots"



Note: Number of respondents aged 16 – 69 via the internet: 1,390 in Japan, 1,369 in the U.S. and 1,382 in Germany  
 Source: NRI, "Online Survey on Robots/AI in Japan, the U.S. and Germany" (November 2015)

that consumer perception is influenced by movies that feature robots or AI, the survey asked respondents for their impression of the robots and AI depicted in the films. Mainly in the U.S., the proportion of respondents who have the impression of "Amicable" was low for movies in which robots having a human-like appearance appear; the proportion of those who feel "Frightening" or "Unpredictable, mysterious" was high.

### III Needs and Potential of Nursing care Robots

#### 1 Robotics market in the service sector is likely to expand rapidly

According to the forecast by the New Energy and Industrial Technology Development Organization (NEDO), the market size of the entire Japanese robot industry will reach 10 trillion yen by 2035, of which service robots are projected to account for about half or 5 trillion yen <sup>Note 11</sup>. Because the market size of service robots is estimated to be approximately 37 million yen as of 2015, the NEDO forecast predicts the rise of a new market totaling more than 4.5 trillion yen.

Given the rapid growth expected for the service robot market, the Japanese government has established a strategy to promote the development of this industry. The "Japan Revitalization Strategy, Revised in 2014" announced by the Ministry of Economy, Trade and Industry envisages the promotion of the entire robot industry, which includes not only industrial robots but also those that will become part of our daily lives such as those used in medical services, nursing care, agriculture and transport. These moves suggest that we are entering

the stage where even industries that have had nothing to do with robots in the past are attempting to propose new lifestyles through the use of robots.

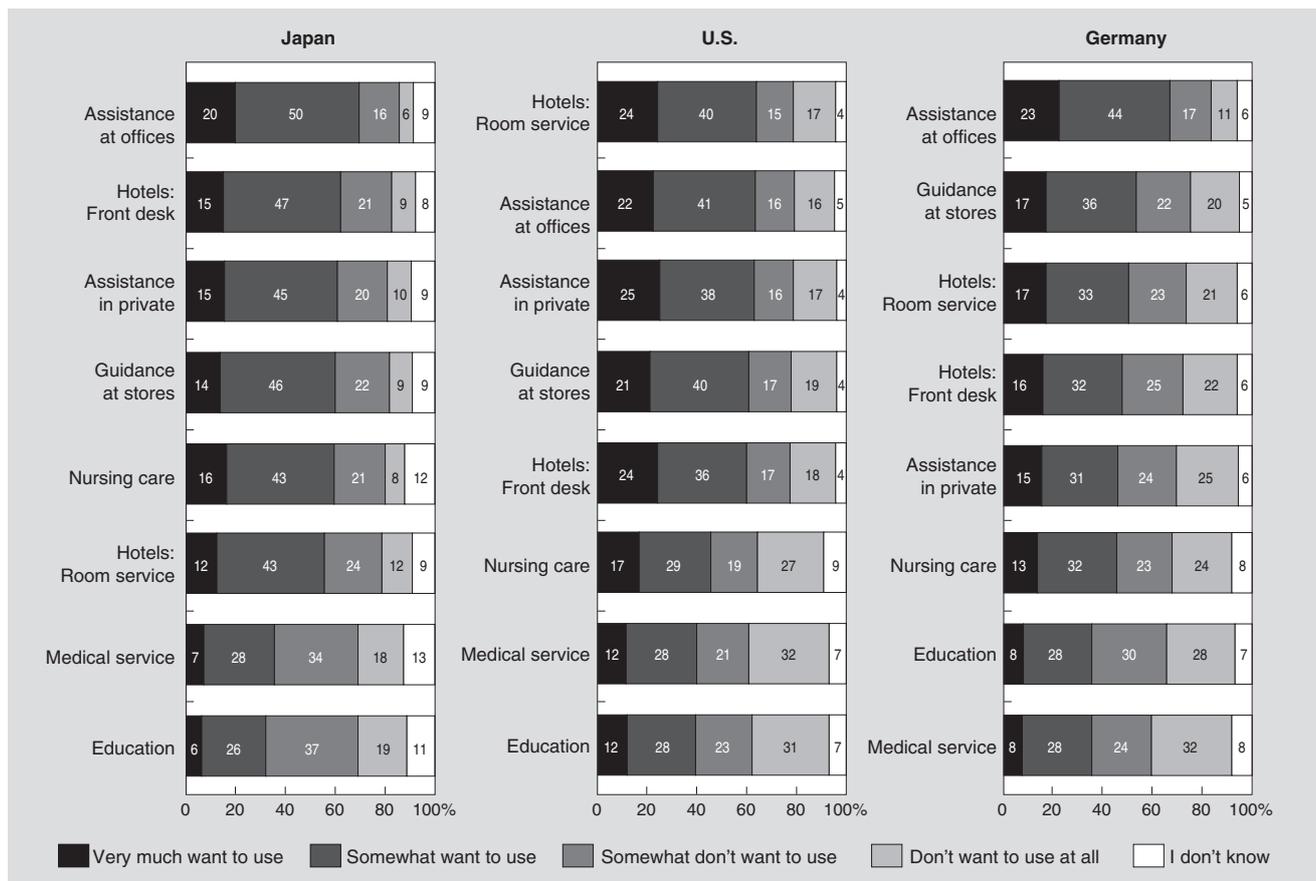
#### 2 Consumers' attitudes toward use of robots

What are the specific situations in which consumers will use service robots? To explore potential demand from the consumer perspective, the survey listed situations where robots are expected to be used and asked respondents the extent to which they would want to use robots in each of these situations such as medical service, nursing care, education, hotels, guidance at stores, assistance at offices and assistance in private.

The largest proportions of respondents both in Japan and Germany said either "Very much want to use" or "Somewhat want to use" for assistance at offices such as managing schedules and assisting in clerical tasks. While usage intention for assistance in private such as managing schedules, setting alarms, taking photos and videos, or placing phone calls to family members and friends was somewhat low in Germany, it was high in Japan and the U.S. (Figure 9).

In all three countries, respondents showed relatively low intention to use robots in the fields of education and medical services. In particular, the proportions of American and German respondents who expressed strong resistance by answering "Don't want to use at all" amounted to as many as about 30 percent in each country. These findings suggest that consumers have a relatively favorable stance towards the use of robots up to the point at which such use has no direct effect on oneself or one's health, and that they have psychological barriers in leaving children's education or medical treatment to robots.

Figure 9. Usage intention of robots in different situations



Note: Number of respondents aged 16 – 69 via the internet: 1,390 in Japan, 1,369 in the U.S. and 1,382 in Germany  
 Source: NRI, “Online Survey on Robots/AI in Japan, the U.S. and Germany” (November 2015)

### 3 Future growth potential of the nursing care robot market in Japan

While nursing care is similar to medical treatment in that both services are directly related to a person’s health, the percentage of respondents who want to use robots in nursing care facilities in ways such as communicating with robots and being assisted by robots was about 10 points higher than using robots for medical services in all three countries. In Japan, many robots such as “Palro,” a humanoid robot developed by Fujisoft, and “Paro,” a seal-shaped therapeutic robot developed by the National Institute of Advanced Industrial Science and Technology, are assisting elderly people in nursing care facilities.

The survey asked the respondents whether they knew that “A research paper on nursing facilities showed that robots in the shapes of animals (e.g., seals) had healing effects on residents.” There was a large difference between Japanese and American respondents in terms of the degree of recognition (Figure 10). After respondents were made aware of this information, the survey further asked how they felt about this fact. The proportions of both Japanese and American respondents who replied “Favorable” exceeded 60 percent. These findings suggest that if the degree of recognition increases, the

acceptability of such robots is likely to increase in the U.S. In contrast, the proportion of German respondents who replied “Favorable” was low at 47 percent.

As such, because the acceptability of robots in the nursing care field is high in Japan where the population is aging faster than in any other country, efforts should first be made to gather cases of actual use within the Japanese markets. Based on these experiences and achievements, companies could move to the American markets to deploy nursing care robots in nursing care facilities as well as in the market for at-home nursing care. In that way, the potential of nursing care robots is noteworthy.

## IV Senses of Values Related to Science and Technology in Japan, the U.S. and Germany, which Influence the Introduction of Robots and AI

### 1 Social impact of science and technology from the consumers’ perspective

Consumer acceptability of robots and their thoughts about robots among Japanese, American and German consumers, which have been discussed thus far in Chapters I, II and III, are influenced by the overall values of consumers in each country. The following sections compare the characteristics of each country's consumers based on the survey findings.

**(1) Consumers' interest in science and technology**

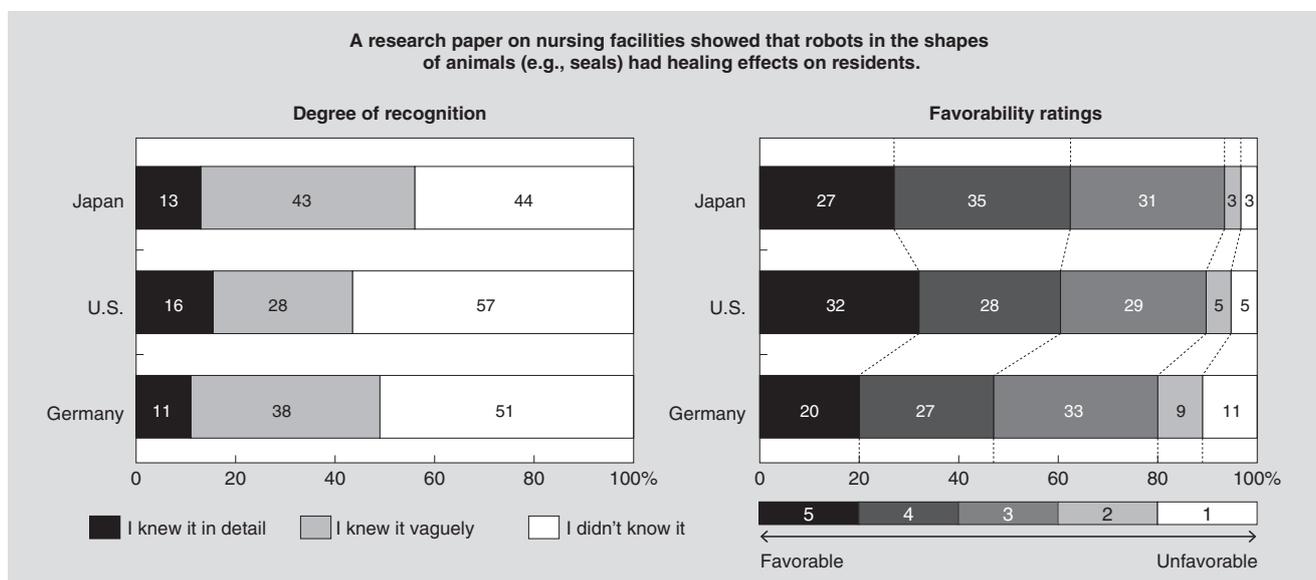
How much interest do consumers have in science and technology developments? Or, to what extent do they have a favorable impression of such developments?

Regarding self-driving cars, which is a topic frequently taken up by news media recently, the proportions of respondents who said "Very much want to use" or

"Somewhat want to use" were high at about 60 percent both in Japan and the U.S. The percentage of respondents who replied "Completely acceptable" or "Somewhat acceptable" for AI-based phone operator systems was highest in Japan. In contrast, Germany scored low percentages in terms of both the intention to use a self-driving car and acceptance of phone operator systems using AI. Overall, as to new technologies that are expected to contribute to the improvement of consumer convenience, both Japanese and American consumers have high intentions to use and high levels of acceptability, whereas the proportion of German respondents who are not willing to use or accept in both cases was high (Figure 11).

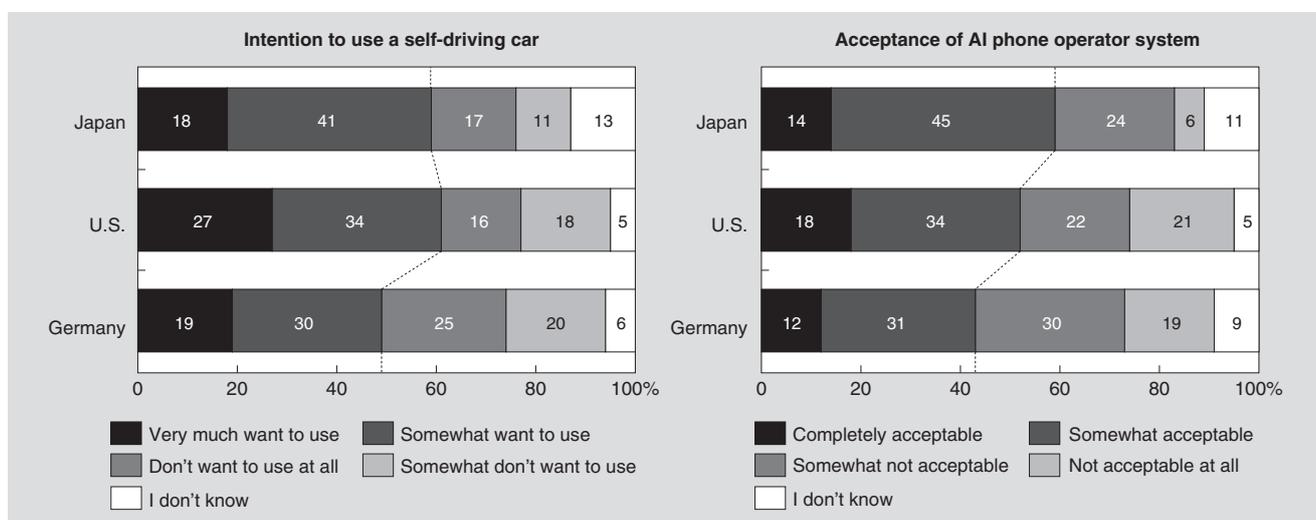
The degree of recognition and the favorability rating regarding the fact that "A computer beat the human world

**Figure 10. Use of robots in nursing care facilities**



Notes: 1) Number of respondents aged 16 – 69 via the internet: 1,390 in Japan, 1,369 in the U.S. and 1,382 in Germany  
 2) A five-point scale (5 to 1) was used for favorable/unfavorable responses, with "5" being most favorable.  
 Source: NRI, "Online Survey on Robots/AI in Japan, the U.S. and Germany" (November 2015)

**Figure 11. Consumers' intention to use new technologies**



Note: Number of respondents aged 16 – 69 via the internet: 1,390 in Japan, 1,369 in the U.S. and 1,382 in Germany  
 Source: NRI, "Online Survey on Robots/AI in Japan, the U.S. and Germany" (November 2015)



each have an unfavorable view of this fact (Figure 12).

Overall, Japanese respondents gave highest favorability ratings for the development of science and technology in various fields, followed by their American, then, their German counterparts. The survey revealed that among the three countries, German respondents generally have conservative attitudes towards possibilities and opportunities that new technologies would bring about.

**(2) Social impact of science and technology**

To understand what consumers think about the effects of science and technology on society, respondents were asked to comment on several examples of scientific and technological breakthroughs and trends. The result indicates about 80 percent of respondents in each country agree that advances in science and technological breakthroughs help enrich society and improve human lives.

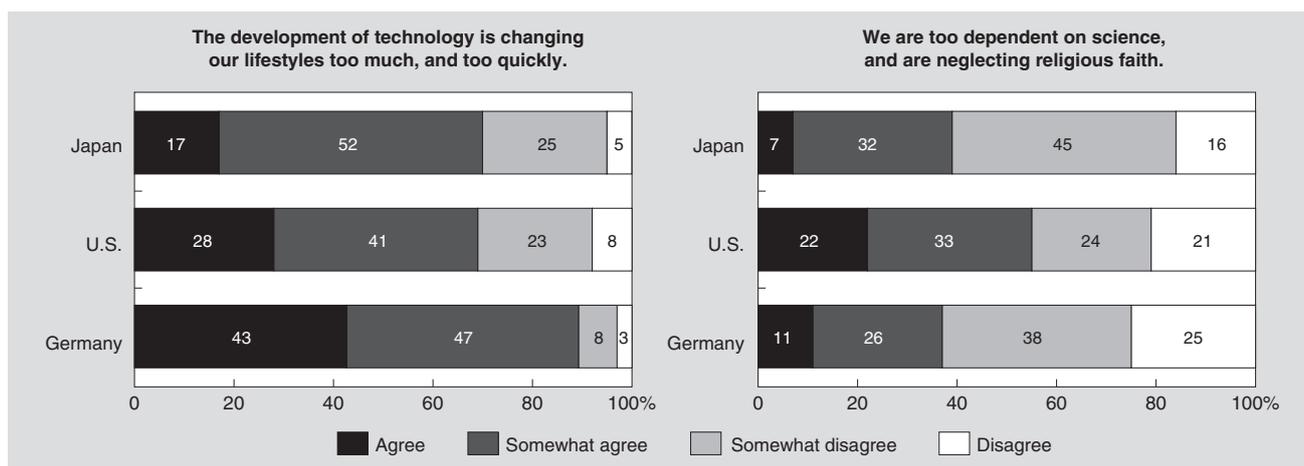
Then, what do consumers think about the impact of technological advances? The proportion of respondents who “Agree” or “Somewhat agree” to the statement that

“The development of technology is changing our lifestyles too much, and too quickly” was 90 percent in Germany and about 70 percent each in Japan and the U.S. These findings suggest that German consumers are more sensitive to rapid lifestyle changes caused by technological advances (Figure 13).

To clarify the extent to which people think their current jobs will become replaceable by machines, the survey asked that “To what extent do you think your current job will become replaceable by robots in the future?” The results show that many Japanese respondents think their current jobs will become replaceable. If “partly replaceable” replies are added to “completely replaceable” and “mostly replaceable” responses, the proportion of Japanese respondents who think “replaceable by robots” amounted to about 70 percent, whereas the proportions of their U.S. and German counterparts were low (Figure 14).

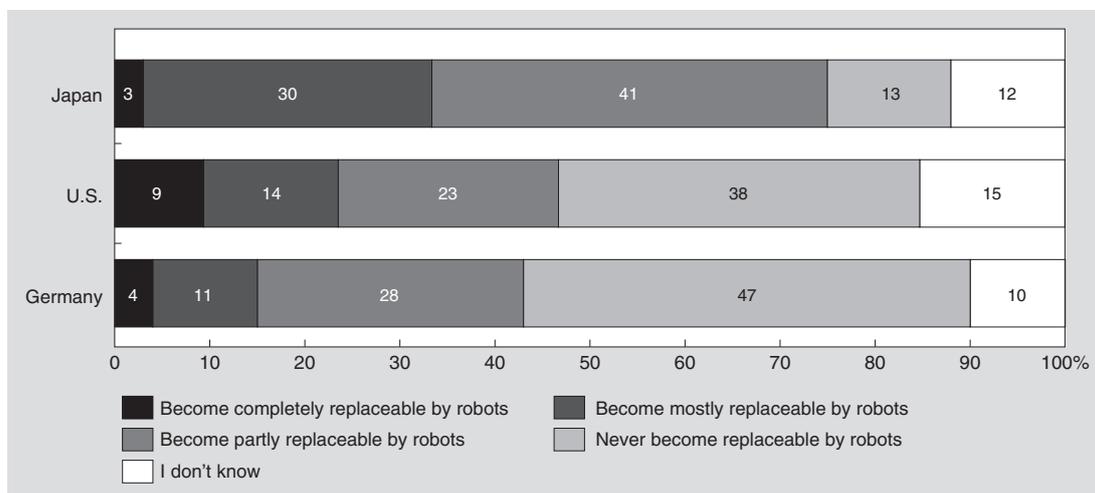
Last, to clarify the relationships between technological advances and religious faith, the survey included the

**Figure 13. Effects of advances in technology on lifestyles and religious beliefs**



Note: Number of respondents aged 16 – 69 via the internet: 1,390 in Japan, 1,369 in the U.S. and 1,382 in Germany  
 Source: NRI, “Online Survey on Robots/AI in Japan, the U.S. and Germany” (November 2015)

**Figure 14. Jobs done by humans are replaceable by robots**



Note: Number of respondents aged 16 – 69 via the internet: 1,390 in Japan, 1,369 in the U.S. and 1,382 in Germany  
 Source: NRI, “Online Survey on Robots/AI in Japan, the U.S. and Germany” (November 2015)

statement, “We are too dependent on science and are neglecting religious faith.” While about 40 percent each of Japanese and German respondents replied “Agree” or “Somewhat agree,” the proportion was higher among American respondents at 55 percent. These findings suggest that a certain number of Americans who have doubts about excessive dependence on science do exist in the U.S. The fact that the proportion of respondents who replied “None” to the question of “Do you regard yourself as belonging to any particular religion?” was 67 percent in Japan, 22 percent in the U.S. and 40 percent in Germany endorses the idea that people in the U.S. have the highest level of religious conviction.

## 2 Impact of science and technology on society: Is AI really a threat to humanity?

“With artificial intelligence, we are summoning the demon,” said Elon Musk, the founder of Tesla Motors. Currently, it is said that the rise of deep learning has ushered in the third artificial intelligence boom. Be that as it may, in 2005, Ray Kurzweil predicted that the singularity would arrive around 2045. In the wake of this prediction, world-renowned scientists and business leaders such as Dr. Stephen Hawking, Microsoft founder Bill Gates, Apple co-founder Steve Wozniak and many others have expressed concerns over a world in which artificial intelligence surpasses human intelligence, and issued a letter calling for a ban on offensive robot/AI-based autonomous weapons, which was announced at the International Joint Conference on Artificial Intelligence.

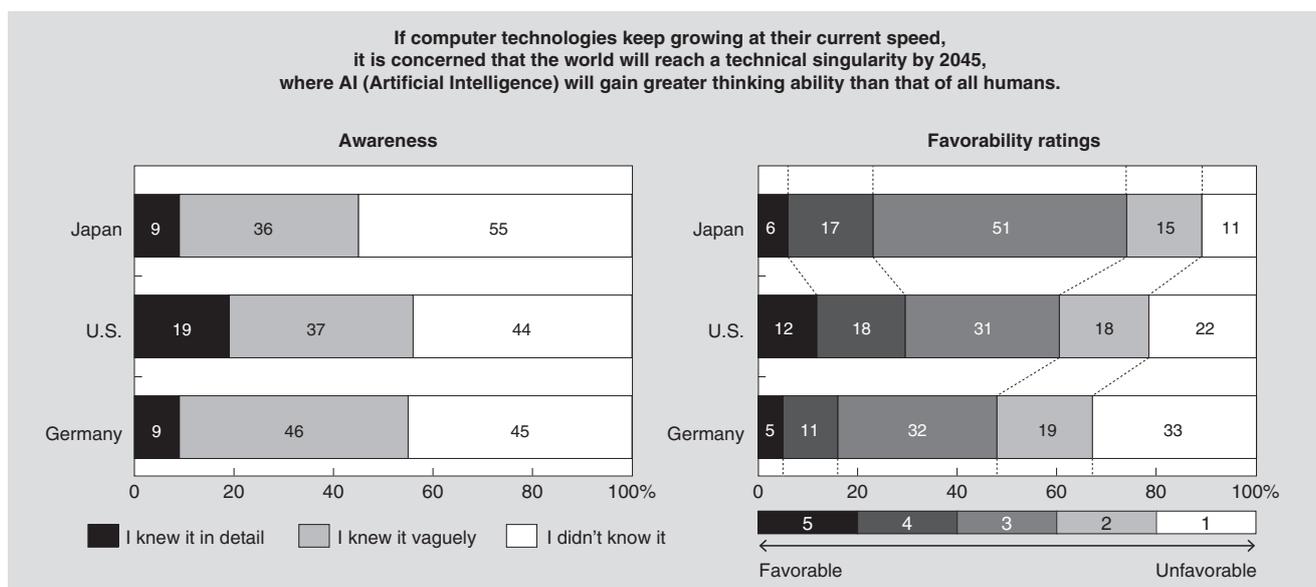
In this context, the survey asked the respondents whether they knew the concern that “If computer

technologies keep growing at their current speed, it is considered that the world will reach a technical singularity by 2045, where AI (Artificial Intelligence) will gain greater thinking ability than that of all humans.” The proportions of American and German respondents who were aware of this issue before the day of the survey were 56 percent and 55 percent, respectively, whereas the proportion among their Japanese counterparts was somewhat low at 45 percent. When the respondents were asked how they felt about this fact, their opinions were split almost in half in the U.S., with 30 percent replying favorable and 40 percent unfavorable. While 52 percent of German respondents said unfavorable, about half (51 percent) of Japanese respondents selected Point 3 (midpoint), revealing a situation in which Japanese respondents have not yet formed a definite opinion on the matter (whether favorable or unfavorable) (Figure 15).

## V Future Challenges

In 2015, the Abe Cabinet unveiled a “New Robot Strategy” plan to promote the utilization of smart machines. According to the council, robotics possess enormous potential to solve social issues such as labor shortages and improve productivity in a broad range of industries from manufacturing to medical service and nursing care to agriculture, construction and infrastructure maintenance. While it remains some way off to see self-driving cars running freely on public roads, some autonomous driving technologies are already at the stage of practical use. In the not too distant future, we will be relieved from some routine driving tasks and the constraints associated with driving.

Figure 15. Consumers’ attitudes toward the “singularity”



Notes: 1) Number of respondents aged 16 – 69 via the internet: 1,390 in Japan, 1,369 in the U.S. and 1,382 in Germany

2) A five-point scale (5 to 1) was used for favorable/unfavorable responses, with “5” being most favorable.

Source: NRI, “Online Survey on Robots/AI in Japan, the U.S. and Germany” (November 2015)

Looking at the other side of the coin, such technologies could end up taking over most jobs from humans. According to the joint study conducted by NRI and Dr. Michael Osborne, an Associate Professor at the University of Oxford, 49 percent of Japan's labor force will be replaced by recent developments in machine learning and robotics technologies over the next two decades. Jobs that are most susceptible to computerization in Japan include train engineers, accounting clerks, tax preparers, mail clerks, taxi drivers and receptionists <sup>Note 12</sup>.

Since the computer revolution in the 1980s, income inequality in the U.S. and European countries has increased. In the years ahead, along with the introduction of robots and AI technologies, a portion of the skills held by the work force will become obsolete. Such a situation will likely result in the shrinkage of the middle class and increase the unemployment rate of unskilled workers. Japan also faces the challenge of expanding income inequality, although the issue is not as serious as it is in the U.S. and Europe. In order for workers to retain their jobs that are less susceptible to computerization, they have to choose jobs that are not vulnerable to automation and, therefore, it is necessary to put more emphasis on education in social skills such as creativity and communication ability. To be specific, jobs that require such skills include software developers, court judges, nurses, high school teachers, dentists and university lecturers.

On a positive note, importance should also be placed on the provision of opportunities to people to acquire technological expertise essential for the utilization of robots and AI solutions. This survey revealed that Japanese consumers do not yet have sufficient knowledge and information concerning new technologies such as robots and AI technology. It would be essential to provide consumers with appropriate knowledge and information so that they can recognize what is necessary and what is not.

The utilization of robots and AI is no longer a quaint science fiction concept. Rather, such technologies have great potential to change our ways of living and eventually, our society as a whole. The survey findings introduced in this paper revealed that the perception of Japanese, American and German consumers regarding robots and AI technology is generally positive, and that they are trying to integrate these technologies into their daily lives. On the other hand, the survey also disclosed their negative attitudes in terms of factors such as the appearance and tasks performed by robots. The time has come for us to seriously think about how we should respond to the technology surrounding robots and AI considering the consumers' sense of values in each country.

#### Acknowledgements

This paper was written based on the "Online Survey on Robots/AI in Japan, the U.S. and Germany" conducted

by Nomura Research Institute. The concept of this survey was proposed by NRI Chief Counselor Shiro Tanikawa, who gave the authors valuable advice and information on various aspects such as in developing a survey design and analyzing survey results.

Kazumi Aoki, Senior Research Analyst at the Service & Healthcare Division of NRI America, also helped the survey team at the design stage of the survey by combining U.S. and European research papers, journals and related publications.

---

#### Notes:

- 1 Overview of "Online Survey on Robots/AI in Japan, the U.S. and Germany" conducted by Nomura Research Institute  
Survey method: Online survey  
Survey period: November 2015  
Survey subjects:  
Survey subjects were chosen in each country based on the following criteria.
  - (1) Japan: 1,390 respondents aged 16 - 69
    - Gender and age distributions correspond to gender and age compositions of the population based on Japan's population census. The sample size was determined according to the ratio of population in each administrative division.
  - (2) U.S.: 1,369 respondents aged 16 - 69
    - The sample size was determined according to the ratio of population by gender, age and ethnicity in each of the four census regions (East, South, Midwest and West), as defined by the U.S. Census Bureau.
  - (3) Germany: 1,382 respondents aged 16 - 59
    - The sample size was determined according to the ratio of population by gender and age in the entire country.
- 2 "The Rise of the Machines," Consumer Technology Association, 2014/10/22
- 3 "Meet Dash and OSHbot," Mark Harris, The Guardian, 2015/10/2
- 4 "Intel Joins Robotics Investing Boom, Backing Startup Savioke," Alistair Barr, WSJ.com, 2016/1/13
- 5 "Telepresence Robots Poised To Multiply," Patrick Seitz, Investor's Business Daily, 2015/10/13
- 6 Dekra press release, 2015/9/16
- 7 "Europeans wary of smartwatch e-wallets, Americans & Chinese more open ahead of Apple Watch launch," Sam Oliver, AppleInsider.com, 2014/10/14
- 8 A. P. Saygin, T. Chaminade, H. Ishiguro, J. Driver, C. Frith. The thing that should not be: predictive coding and the uncanny valley in perceiving human and humanoid robot actions. *Social Cognitive and Affective Neuroscience*, 2011; DOI: 10.1093/scan/nsr025
- 9 Maya B. Mathur, David B. Reichling. (2015). Navigating a social world with robot partners: A quantitative cartography of the Uncanny Valley
- 10 Robots names indicated in parentheses in the paper were not shown to respondents when answering survey questions.

- 11 NEDO, “Market Outlook for Robot Industry through 2035”
- 12 M. Osborne, C. Frey, “Jinkou-chinou ha shoku wo ubauka, nihon, seisansei koujyou no kouki ni (Will artificial intelligence take jobs? Good opportunity for Japan to improve productivity),” Nikkei, 2016/1/12

---

**Hiroyuki NITTO** is Senior Consultant at NRI’s Consumer Goods/Service & Healthcare Industry Consulting Department. His specialties include developing marketing strategy, formulating business strategy in the service industry and analyzing consumer perception and behavior. He is also Visiting Professor at the Japan Advanced Institute of Science & Technology.

**Daisuke TANIYAMA** is Senior Consultant at NRI’s Consumer Goods/Service & Healthcare Industry Consulting Department. His specialties include planning management strategy in the B2C field, studying and implementing organizational restructuring and new business models.

**Hitomi INAGAKI** is Consultant at NRI’s Management Consulting Department. Her specialties include developing marketing strategy and business strategy, and overseas business development.

As a leading think tank and system integrator in Japan, Nomura Research Institute is opening new perspectives for the social paradigm by creating intellectual property for the benefit of all industries. NRI's services cover both public and private sectors around the world through knowledge creation and integration in the three creative spheres: "Research and Consulting," "Knowledge Solutions" and "Systems Solutions."

The world economy is facing thorough structural changes led by the dramatic growth of IT industries and the rapid expansion of worldwide Internet usage—the challenges of which require new concepts and improvement of current systems. NRI devotes all its efforts to equipping its clients with business strategies for success by providing the best in knowledge resources and solutions.

*NRI Papers* present selected works of NRI Group's 9,000 professionals through its worldwide research network. The mission of *NRI Papers* is to contribute new ideas and insights into business management and future policy planning, which are indispensable for overcoming obstacles to the structural changes in our society.

All copyrights to *NRI Papers* are reserved by NRI. No part of this publication may be reproduced in any form without the prior written consent of NRI.

Inquiries to: Corporate Communications Department  
Nomura Research Institute, Ltd.  
E-mail: [nri-papers@nri.co.jp](mailto:nri-papers@nri.co.jp)