Gendering Humanoid Robots: Robo-Sexism in Japan

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Abstract In humans, gender is both a concept and performance embodied by females and males, a corporeal technology that is produced dialectically. The process of gendering robots makes especially clear that gender belongs both to the order of the material body and to the social and discursive or semiotic systems within which bodies are embedded. This article explores and interrogates the gendering of humanoid robots manufactured today in Japan for employment in the home and workplace. Gender attribution is a process of reality construction. Roboticists assign gender based on their common-sense assumptions about female and male sex and gender roles. Whereas the relationship between human bodies and genders is a contingent one, I argue that gendered robots render that relationship a necessary one by conflating bodies and genders. Humanoid robots are the vanguard of posthuman sexism, and are being developed within a reactionary rhetorical climate.

Keywords cyborg, gender, Japan, robot

> Even Triumph Japan, the maker of intimate apparel, has joined in [the celebration of Astro Boy's 52nd birthday on 7 April 2003]. As part of its program of one-off theme items, it has produced the Astro Boy bra, with the cups in the shape of Astro Boy's head. For what it is worth, he faces away from the wearer, and unfortunately, his facial features have been omitted. This may have been the moment Astro Boy became Astro Man, but we will never know. (Green, 2003)

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> Fashion models! Pay attention! Is this the end of the beginning? Launching at the Tokyo Fashion Week A/W2009 is [HRP 4C] the Fembot, a walking, talking, posing, expressing, fashion model robot created by the [Advanced Institute of Science and Technology]. The modelbot has already her moves down, along with 2 super-poses, and rumor has it that she's already dating Robocop and the Terminator.... For now there are no scheduled photo shoots, however we think this petite beauty will surely make the inside of *Vogue* [*sic*].[1]
>
> Even robots can't escape the goddamn sexist pigs.[2]

Astro Boy's Gender(ed) Legacy

Many Japanese roboticists have a picture or a figurine of Tetsuwan Atomu ('Mighty Atom'; Astro Boy) in their laboratory, and most acknowledge the boy robot as a childhood inspiration – the reason for their interest in building sociable robots (Figure 1). Atomu played a key role in fostering among postwar Japanese an image of robots as cute, friendly and human-like, characteristics that currently inform the thriving humanoid robotics industry. In this article, I will analyze the gendering of 'real' humanoid robots designed to coexist and interact with human beings in the home and workplace. Among the questions informing my analysis are: how do robots embody ideas and notions of the relationship in humans between sex, gender and sexuality; and how do (the mostly male) roboticists design and attribute the female or male gender of humanoid robots?[3] As I will show, the gendering of humanoid robots draws from domains of gendering practices contingent upon shape, color, function and sociolinguistic convention. Most of the humanoids developed over the past two decades are gendered, if sometimes ambiguously (Robertson, 2007), and the recent trend is toward distinctly feminine/female and masculine/male robots.

Atomu's origin story is in part a case study, albeit a fictional one, of gender fluidity. Created in 1951 by the physician *cum* cartoonist Osamu Tezuka (1928–89), Atomu is Japan's most famous robot. A nostalgia-fueled revival of things Astro Boy peaked in 2003 when a new television *anime* series was broadcast to mark both the 40th anniversary of the first series and Atomu's birthday. Described by Tezuka as a 'reverse Pinocchio', Atomu's story begins in the Ministry of Science, headed by one Professor

Figure 1 Tetsuwan Atomu (Astro Boy)
Source: http://i63.photobucket.com/albums/h146/Estecraig/ASTROBOY2.jpg

Tenma who has been trying to create a robot capable of human emotions. His son Tobio suggests that he build a boy robot. Ironically, Tenma's obsession with his quest keeps him from giving Tobio fatherly love. The son runs away from home and is killed in an automobile accident, whereupon the grieving professor creates a robot in Tobio's likeness.

In actuality, as is well known, Tezuka's prototype for Atomu was the 'girl robot' in his comic, *Daitokai* (*Metropolis*) – not to be confused with Fritz Lang's film *Metropolis*, featuring the gynomorphous robot Maria that was screened in Japan in 1927. The girl robot in Tezuka's *Kasei Hakase* (*Doctor Mars*) was also a precursor to Atomu. In other words, in a reversal of the epigraph, the 'Astro Boy bra' might be understood figuratively as acknowledging and confirming Atomu's originary femininity and not his emergent manhood! An enthusiastic fan of the all-female Takarazuka Revue, in which females assume men's roles, Tezuka also created a number of tomboy characters in his comics, such as Sapphire, the protagonist in *Ribon no kishi* (*Princess Knight*). Sapphire alternates genders, living as both a prince and a princess.[4]

In humans, gender is both a concept and a performance embodied by females and males – a corporeal technology

produced dialectically. The process of gendering robots makes especially clear that gender belongs both to the order of the material body and the social and discursive or semiotic systems within which bodies are embedded (Balsamo, 1997: 36). Teresa de Lauretis' enduring insights into the 'technology of gender' are especially relevant to the exploration of robot gender. To paraphrase her argument, the construction of gender goes on through the various technologies of gender (such as robotics) and institutional discourses (such as nationalism and pronatalism) with 'power to control the field of social meaning' (value, prestige, kinship location, status, etc.) and thus 'produce, promote, and "implant" representations of gender' (de Lauretis, 1987: 18). As she astutely observed, if gender representations are 'social positions which carry differential meanings', then for someone or something – such as a humanoid robot – to be represented as female or male 'implies the assumption of the whole of those meaning effects' (de Lauretis, 1987: 5). However, the assumption of those 'meaning effects' is not necessarily conceived as part of a bigger picture. My aim in this article is to make visible that big picture and how its constituent components work effectively, if not necessarily intentionally, to reproduce a sexist division of gendered labor among humans and humanoids alike.

Gender and Contingency

Much of what roboticists take for granted in their own gendered socialization and quotidian lives is reproduced and reified in the robots they design and in their publications. In short, gender for them constitutes common-sense knowledge, or a cognitive style through which they experience the social world as a factual object. The practice of attributing gender to robots not only is a manifestation of roboticists' tacit, common-sense knowledge, or *habitus*, but also an application of this knowledge to create and sustain, or to leave self-evident, the facticity of their social world.[5] How robot-makers gender their humanoids is a tangible manifestation of their tacit understanding of femininity in relation to masculinity, and vice versa.

Gender attribution is a process of reality construction. In my investigation of the criteria by which roboticists assigned gender,

it became clear that their naive and unreflexive assumptions about humans' differences informed how they imagined both the bodies and the social performances of their creations. An online (Google Scholar) review of the small professional literature on gender and robots is revealing: the focus of the research is either on whether people interact differently with a feminine or masculine robot, or on whether females and males interact differently with robots per se. In the case of the former, the process of gender attribution is left self-evident and not interrogated, and in the case of the latter, sex is conflated with gender (e.g. Carpenter et al., 2009; Goetz et al., 2003; Powers et al., 2005). An excerpt from the abstract of Powers et al. (2005: 1) is illustrative of both cases:

> A 'male' or 'female' robot queried users about romantic dating norms. We expected users to assume a female robot knows more about dating norms than a male robot. If so, users should describe dating norms efficiently to a female robot but elaborate on these norms to a male robot. Users, especially women discussing norms for women, used more words explaining dating norms to the male robot than to a female robot.

The round, shiny gray, metallic robot bust that Powers and his colleagues employed was rendered as either female ('feminine' voice, pink lips) or male ('masculine' voice, grey lips) – apparently self-evident markers of gender(ed) differences.

Robots lack actual physical genitals and these play no role in their initial gender assignment.[6] However, as explained by Suzanne Kessler and Wendy McKenna (1985), in the absence of the visibility of physical genitalia – which is generally the case among humans who are usually clothed in public settings – 'cultural genitals' are invoked in attributing gender, such as pink or grey lips.

The relationship between cultural genitals and gender attribution is reflexive. The reality of a gender is 'proved' by the genital which is attributed, and, at the same time, the attributed genital only has meaning through the socially shared construction of the gender attribution process (Kessler and McKenna, 1985: 155).

Euro-American feminists were instrumental in establishing the now accepted view that bodies are not simply given or neutral. There are at least two kinds of bodies: the male body and the female body. That said, male and female bodies are themselves

distinguished by a great deal of biological variability, from phenotype to physiology. Corporeal variability is also expressed in the form of intersexed bodies, with genitals and reproductive organs that are neither clearly male nor clearly female. Suzanne Kessler (1998) details how this natural 'variability' – a word she uses deliberately instead of the medical referent, 'ambiguity' – both confounds and underscores the dominance of sociocultural constructions (and medical reconstructions) of the sex/gender dichotomy.

Gender is not simply a feature or characteristic of a given female body or a given male body. Examining the processes whereby Japanese roboticists assign gender to humanoids necessarily involves looking closely at the socio-historical particularities of the sex/gender system in Japan. In Japan past and present, for example, femininity and masculinity have been enacted or lived by *both* female *and* male bodies as epitomized by the 400-year-old all-male Kabuki theater and all-female Takarazuka Revue founded in 1913. Nevertheless, both theaters continue to reproduce not alternative but dominant stereotypes of femininity and masculinity. Moreover, there is a qualitative, socially reinforced – and socially sanctioned – difference between the kind of femininity performed and lived by male bodies and the kind of masculinity performed and lived by female bodies whether on or off stage (Robertson, 1991, 2001 [1998]). In short, the kind of body matters in the meaning and function of gender that emerges in practice. The point to remember here is that the relationship between human bodies and genders is *contingent* (cf. Bloodsworth-Lugo, 2007: 18–19; Grosz, 1994: 58). Whereas human female and male bodies are distinguished by a great deal of variability, humanoid robot bodies are effectively used as platforms for reducing the relationship between bodies and genders from a contingent relationship to a fixed and *necessary* one.

Roboticists may perceive female and male bodies as 'specific forms of livability in the world', but they do not interrogate them as feminists especially have done (e.g. Sheets-Johnstone, 1992).[7] Rather, as I discuss further on, they tend to uncritically reproduce and reinforce dominant stereotypes (or archetypes) attached to female and male bodies. An anecdote from my fieldwork is illustrative. Given the highly formalized and formulaic, and even

robotic, nature of typical women's jobs, such as 'elevator girl' and 'receptionist', it would seem probable that fembots would take their places. Yet, when I asked (male) roboticists why they did not urge the replacement of robotic elevator girls in particular with humanoid robots, the answer I received from Takashi Maeno, on the occasion of my visit to his Keio University laboratory on 27 February 2007, was typical. With a bemused look, he dismissed my 'Western (*ōbei*) idea', noting that flesh-and-blood women supplied an authentic aura of human service so crucial to ensuring customer satisfaction. To refer to a seemingly perplexing perception as 'Western' (or 'other') is a not uncommon reactive way of avoiding a given subject. One could also dismiss science itself as 'Western' and therefore somehow not legitimate in Japan. Japanese feminists have had to refute similar charges for over a century!

I greatly respect Takashi Maeno and his research, but I could not help but ponder what seemed to be a glaring (and sexist) paradox. On the one hand, despite a dire labor shortage coupled with a flat birth rate and rapidly graying population, humanoid robots are preferred over immigrants as caretakers of children and elderly persons to assist housewives, ostensibly freeing them to stay home and have more children (and future workers) instead of pursuing professional careers (not including elevator girldom).[8] On the other hand, Japanese consumers apparently want to be greeted at the entrance of elevators and escalators by human females trained, not as roboticists, but to execute robotically precise bows and greetings!

Robots Я Us

At this juncture, an overview of the relationship in Japan between people and robots is in order. The archipelago is home to over half of the global share of the 1 million industrial robots, 295 for every 10,000 manufacturing workers; Singapore is second with 169 industrial robots per 10,000 workers.[9] Japan also leads in the creation – and most importantly, acceptance – of humanoid household robots that are being developed to care for children and the elderly, to provide companionship and to perform domestic tasks. By 2016, by which time each household is predicted to own at least

one robot, the size of the household robot market in Japan is expected to top 18.6 million units.[10] Japanese robots are forecast to be in this century's global marketplace what Japanese automobiles were in the last century's.

Why robots, why now? Faced with a rapidly aging and shrinking population, Japanese politicians are maintaining, if by default, the postwar precedents of pursuing automation over replacement migration and disregarding women as a talented and vital labor force, although pundits are quick to blame women alone for the low birthrate. The birthrate presently stands at about 1.3 children per married woman, and over 21 percent of the population of nearly 127.7 million people (which includes about 2 million legal foreign residents) is over 65 years of age; that percentage is expected to increase to over 40 percent by 2050. The latest estimates produced by the health ministry project that the population will shrink to less than 111 million in 2035 and to less than 90 million in 2055. Demographic estimates made back in 1995 indicated that over 600,000 immigrants a year for the next 50 years were needed to keep the labor force at its 1995 level of 87.2 million persons, advice that has yet to be heeded (*Japan Times*, 2007; Kondo, 2000).[11]

Already in Japan there is a market for intelligent, autonomous humanoid robots that can push or carry heavy loads (Hitachi's Emiew); patrol premises and extinguish fires (Alsok's Reeborg Q); replace human service sector employees (Kokoro's Actroid, ATR's Robovie, Honda's Asimo); babysit and tutor children (NEC's PaPeRo, Mitsubishi Heavy Industry's Wakamaru); house-sit (ZMP's Nuvo); nurse the infirm and elderly (Riken's Ri-man); provide companionship and entertainment (Business Design and Futaba Industries' ifbot, Flower Robotics' Posy and Pino); and perform as a fashion model (HRP 4C, noted in the second epigraph). Although some of these, like Riman, are still prototypes, of the 60 or more household robots now commercially available, 'entertainment robots are the most popular, followed by surveillance, educational, research, nursing, and cleaning robots.[12] Of course, several of these functions are performed by a single robot.

During my fieldwork in Japan during the winter of 2007 and the fall of 2008,[13] I conversed with roboticists, government

ministry bureaucrats, corporate officials, academics and consumers, visited robotics laboratories and critically perused the ever ballooning scientific and popular literature in Japanese and English on humanoid household (or partner) robots. One prevalent sentiment expressed in conversation and text alike was the sense that humanoid robots were regarded by the public as preferable to foreign laborers, and especially to foreign caretakers, ostensibly for the reason that, unlike migrant and minority workers, robots have neither cultural differences nor, in the case of (especially) East Asians, unresolved historical (or wartime) memories to contend with. Household or partner robots are fitted with algorithmic software which enables them to learn from their immediate environment, quickly memorizing the names and routines of family members or office staff. They carry no inconvenient historical baggage. After their own children, elderly Japanese apparently prefer robot caretakers to foreign ones (see 'Better than People', 2005). Robots are perceived by many Japanese, but especially the elderly and conservative politicians, as eliminating the sociocultural anxieties provoked by foreign laborers and caretakers. Limiting the number of foreigners also reinforces the tenacious ideology of ethnic homogeneity.

Over the course of my fieldwork, I quickly realized that the declining birthrate, labor shortage and the rapidly aging population are being addressed to a significant degree as problems calling for technological solutions. In the popular media and robotics literature, these trends are mostly not contextualized or analyzed in terms of the constellation of historical, political, social and economic conditions that occasioned their emergence. They are simply treated as surface abnormalities rather than as indicative of a deeper malaise within the sociocultural system itself.[14] The New Japan Women's Association (Shin'nippon Fujin no Kai) attributes the low birthrate to several overlapping factors: the shrinking family budget, the high cost of educating children, the dearth of public childcare facilities and after-school programs, excessively long working hours and unpaid overtime work, and the replacement of regular employees with 'just-in-time workers' ('NJWA Views', 2004). Others have also noted that Japanese women's refusal to marry, or tendency to marry very late – the

average age of marriage is now around 29 – and their reluctance to have children, constitutes a form of resistance or protest against a social system that continues to regard women as second-class citizens (Nishi and Kan, 2006; Usui, 2005: 58). The majority of Japanese women in their 20s and early 30s choose to continue to work and to live with their parents instead of marrying, in order to economize. Masahiro Yamada, who coined the phrase 'parasite single' (*parasaito shinguru*) in a rather disparaging reference to these women (and men), observes that women's standard of living falls dramatically once they marry. Not only do they have to do all the housework, but they are sure to lose two-thirds of their disposable income (Yamada, 1999).

The premium placed on technology as domestic policy is clearly evident in *Innovation 25*, the central government's visionary blueprint for revitalizing Japanese society – and especially the household – by 2025.[15] Introduced in February 2007 by former Prime Minister Shinzō Abe, *Innovation 25* promotes a robot-dependent society and lifestyle that is safe (*anzen*), comfort-inducing (*anshin*) and convenient (*benri*). Subtitled, *Making the Future: Toward the Challenge of Limitless Possibilities, Innovation 25* promotes a 'robotic lifestyle' epitomized by security and convenience, and earmarks $26 billion for distribution over the next ten years to promote robot technology, the industry that will 'rescue' Japan from an ongoing recession and stabilize sociocultural institutions (see Nakayama, 2006).

One section of *Innovation 25* is a detailed, illustrated ethnographic sketch of a day in the life of the 'Inobe family' – their fabricated last name is a shortened form of *inobēshon* (innovation). The Inobes, introduced as constituting *the* typical Japanese household of the (near) future, consist of a heterosexual married couple, their daughter and son, the husband's parents, and a male-gendered robot. (A couple of matronly female-gendered nurse robots also feature in *Innovation 25*.) Each family member's daily routine is recorded in the sketch. The day begins at 6:30 when the elderly couple arises, and ends at 23:00, when the LED lights in the house dim and then turn off automatically. The household's wife has the closest relationship with the family robot. This is not surprising as household robots are imagined to serve as surrogate housewives (Figure 2). Implicit in the humanoid robotics

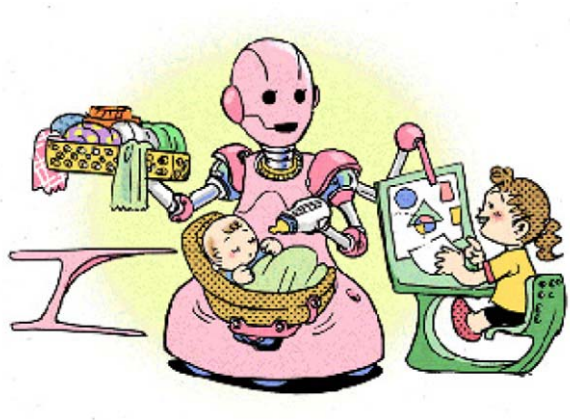

Figure 2 Housewife robot featured in *Innovation 25*
Source: http://www.cao.go.jp/innovation/innovation/point.html

literature is the notion that a married woman who is freed from housekeeping and caretaking chores will be more able and willing to have more children.

No other country (as yet) attributes to robots and robotics such powerful agency and efficacy as does Japan. The five-year Humanoid Robotics Project, launched in 1998 by the Japanese Ministry of Economy, Trade and Industry (METI), gave a consortium of 12 corporations and 10 universities a mandate to develop first-generation intelligent humanoid robots, able to use hand tools and work in human environments, including hospitals, offices and households. This project laid the groundwork for *Innovation 25*.

Consumers in the public sphere provide Japanese roboticists with important data on human robot interactions. For example, at Expo 2005 in Aichi Prefecture, Japan, roboticists were able to closely observe tens of thousands of visitors participating in 'robot interaction experiments', as a result of which a 'variety of research and performance improvements … [were carried out] … that … advance[d] the research and development of personal robots'.[16] Based on my interviews with staff and visitors, the same was true of the 2008 Robo Japan Expo in Yokohama that I attended on 10 October. It is clear that the sites of humanoid robot-based services and entertainment, from exhibitions halls to the home, are utilized by robot engineers as giant

laboratories. In fact, Japanese society is arguably an enormous proving ground for robot research and development.[17] Nevertheless, as I show, robot makers and manufacturers have not, as a result of their 'fieldwork', questioned their own assumptions informing the gendering of their high-tech creations.

Culture, Nature and Topos

There are two key cultural factors that influence the dominant perception among Japanese of robots as benign, benevolent *living* entities. First and foremost is Shinto, the native animistic beliefs about life and death. It differs from the three major monotheisms (that have never had a home in Japan) in that it lacks complex metaphysical and theological theories. Shinto is primarily concerned with notions of purity and pollution. Vital energies or forces called *kami* are present in all aspects of the world and universe; some *kami* are cosmic and others infuse trees, streams, rocks, insects, animals and humans, as well as human creations, such as dolls, cars and robots.[18] The second factor concerns the meanings of life and living – fertility and fecundity are especially celebrated in Shinto. *Inochi* is the Japanese word for life. It encompasses three basic, seemingly contradictory but interarticulated meanings: a power that infuses sentient beings from generation to generation; a period between birth and death; and the most essential quality of something, whether it is a living being or a made object, such as a puppet (adapted from Morioka, 1991: 85–7). This last definition is key: robots, humanoid and otherwise, are living things within the Shinto universe, and in that sense, are part of the natural world.

Historians of technology and literary scholars alike have long noted that robots and artificial humans have been imagined in Euro-American popular culture past and present, with few exceptions, as both threatening to humans and wholly *unnatural*. A consideration of what is labeled and understood by the terms 'nature' and 'natural' will explain further the positive image and even friendly characteristics in Japanese popular culture of robots as living things. The most common Japanese term for 'nature', *shizen*, more or less stabilized in the 1890s when scientific-mindedness was being newly promoted in schools and the mass media as the key

to modernization. 'Nature' remains a discontinuous field, shifting in meaning as it is attached as a prefix to different fields of interpretation, as in the case of *shizenshugi* (naturalism), *shizenhō* (natural law) and *shizen kagaku* (natural science), among other categories (Thomas, 2001: 7).[19] The phrase 'natural world' thus implies far more than what is understood today as the environment or ecology. As Julia Adeney Thomas perspicaciously points out, in Japanese discourse – her focus is mostly on political ideology but is relevant here – 'nature' is a 'protean monster' (2001: 7), a monster assimilated and shaped, like *bonsai*, through social and ritual interventions (Kalland, 1995) and scientific experiments alike.[20] Nature is not external to culture and society, but is an immanent component or constituent of them; its reality, moreover, is contingent upon human artifice and mediation.

Japanese roboticists draw from this synergistic nature-culture 'platform' in advocating not only the interchangeability of robots and humans in everyday life but also their mutual enhancement and even mutual constituency. An excerpt from a recent publication co-authored by roboticist Hiroshi Ishiguro, whose work is discussed in the pages that follow, is illustrative of this point:

> If you want to understand how people interact with a mechanical-looking robot, you use a mechanical-looking robot. If you want to understand how people interact with each other, a mechanical-looking robot is not enough. Since we want to understand human beings, we build androids. We intend to develop a science of human–*human* interaction, not a science of human [mechanical-looking robot] interaction, although these other sciences would be of interest to the people who built these robots. But from the perspective of those who set government funding objectives, a science of human[–human] interaction would be better positioned to compete with such other worthy priorities as curing cancer and AIDS. (MacDorman and Ishiguro, 2006: 365; italics in original)

Ishiguro and MacDorman sidestep anthropology, a discipline devoted in large part to human human interactions![21] Needless to say, they leave self-evident their turgid claims that the study of human human interactions is best pursued by building androids and, moreover, that building androids is as critically important as 'curing cancer and AIDS'.

In robotics, 'platform' refers to either or both hardware architecture or a software framework. Platform has a specific resonance in Japan in connection with the theory of *ba*, or place,

or topos. The concept and theory of *ba* – the term is often used interchangeably with *basho* – is closely associated with the work of Kitarō Nishida (1870–1945), generally regarded as the founder of modern Japanese philosophy. A brief summary of Nishida's idea of *ba* follows, despite the certain risk of my oversimplifying the complexity of his thought. According to Nishida, *ba* (*basho*) encompasses a non-dualistic concrete logic meant to overcome the inadequacy of the subject object distinction. He proposes instead a dynamic tension of opposites that, contrary to Hegel, never resolves in a synthesis. This notion of *ba* is also concomitant with self-determination. Nishida declared that 'a self-determining entity cannot be located in something other than itself'. Moreover, the place (*ba*) of dynamic tension and the self-determined self are always in an incomplete or emergent state. Nishida's theory of *ba* and self-determination stand in stark contrast to the logic of so-called Western rationality (and perhaps monotheistic thinking more generally), which is based on a separated self (subject), where an object is observed as definitely separate by the subject who occupies the position of observer. The philosophy of *ba* proposes instead that a living system lives and maintains self-consistency by the *contingent* convergence of the separated self and the non-separated self (Huh, 1990; Inoue, 2003; Kopf, 2004; Nishida, 1988, 1990 [1921]: 70). Yoshihiro Miyake, a bioengineer in the Department of Computational Intelligence and Systems Science, Tokyo Institute of Technology, is among the many Japanese roboticists who believe that artificial systems should maintain a kind of 'active incompleteness'. In this way, he argues, a co-created (*kyōsō*) *ba* (in the sense of a shared space for emerging relationships) between an artificial system (such as a humanoid robot) and humans can be occasioned in real-time (Miyake, 2004: 17).[22]

So, why do Japanese roboticists, who are, for the most part, culturally and philosophically attuned to notions of *ba*, contingency, co-creation, and shared spaces of emergent relationships – issues that their European and North American counterparts and critics struggle with (e.g. Kember, 2003: 53–82; Suchman, 2007: 226–40) – remain indifferent to the dialectical dynamics of gendered relationships among humans and to the utter lack of contingency in their gendered robotic creations? One reason,

I suggest, is that their theorizing about human robot relations treats humans and robots as gender-neutral categories (despite all evidence to the contrary). Another reason is grounded in their upbringing and socialization: like the average person, roboticists remain unconscious of and take for granted their habitual, everyday behavior, which is resistant to change and thus reproduced in the stereotypic forms they give, and activities they assign, to their robots (see Mutch, 2003: 388). I will return to this apparent irony of selective insight/oversight, and the consequences of such; an irony which I describe as a retrograde application of advanced technology.

Embodied Intelligence

Up until now, I have referred to robots as obvious things. But, what exactly is a robot? The word itself was coined by the Czech playwright Karel Čapek from the word *robota* or forced labor. His play *R.U.R. (Rossum's Universal Robots)*, which premiered in Prague in 1922, was about a factory in the near future where synthetic slaves, or robots, were mass produced for export all over the world. Performed in Tokyo in 1924 under the title *Artificial Human* (*Jinzō ningen*), *R.U.R.* sparked a 'robot boom' in Japanese popular culture that has continued to this day, from Atomu to the androids who dominate animation films (*anime*) like *Kōkaku kidōtai* (*Ghost in the Shell*, 1995).

In practical usage, a robot is an autonomous or semi-autonomous device that performs its tasks either according to direct human control, partial control with human supervision or completely autonomously.[23] A robot is an aggregation of different technologies – sensors, software, telecommunications tools, motors and batteries – that make it capable of interacting with its environment. Industrial robots look like pieces of machinery, whereas to be called a humanoid, a robot must meet two criteria: it has to have a body that resembles a human (head, arms, torso, legs) and it has to act like a human in environments designed for the capabilities of the human body, such as an office, hospital or house. There are basically two categories of humanoid robots with respect to their gendered embodiment: those designed to 'pass' as human and those whose overall shape bears some resemblance to human morphology.

What distinguished Japanese robotics early on – and now almost all roboticists have followed suit – is the concept of embodied intelligence or embodied cognition (Asada et al., 1999; MacDorman and Cowley, 2006). Roboticists point out that intelligence cannot merely exist in the form of an abstract algorithm, but requires a physical instantiation; that is, a material body. Embodiment in this sense follows a phenomenological paradigm in recognizing that the body (whether human or robotic) is actively and continually in touch with its surroundings. Moreover, cognitive processes originate in an organism's sensory-motor experience. Dynamic interaction between a robot and its environment generates emergent autonomous behavior, as opposed to behavior initiated by some external control system. Advances in artificial life, including nanotechnology and self-evolving genetic algorithms, have led to the development of new sensory, actuation and locomotion components that enable the actualization of embodied (artificial) cognition. Also contributing to the refinement of the concept of embodied intelligence are new robot designs based on a deeper understanding of the role of form and material properties in shaping the physical, behavioral and overall performance characteristics and capacities of robots (Inman, 2006). These new designs, along with discoveries in neurophysiology, have confirmed the relationship between the 'motor system' and the 'cognition system' (Adenzato and Garbarini, 2006: 749).

Central to the emphasis in robotics on embodied intelligence have been qualitative studies in the field of child development.[24] Data from studies of infants are also used dialectically. In June 2007, the Japanese Science and Technology Agency unveiled the 'Child Robot with Biomimetic Body', or CB2, that will teach researchers about sensory-motor development in human children. CB2 moves like a human child between the ages of 1 and 3 years old, although it is disproportionately large and heavy at 1.2 meters tall and 33 kilograms. The humanoid has neither genitals nor an attributed gender identity – yet. Its 56 actuators take the place of muscles, and it has 197 sensors for touch, small cameras working as eyes, and an audio sensor. CB2 can also speak through a set of artificial vocal chords. With this robot, researchers hope to 'study human recognition development', such as

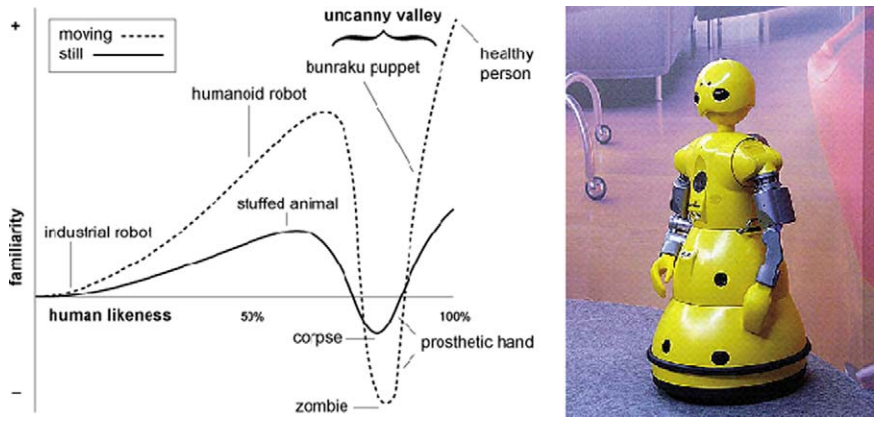

Figure 3 A diagram of Mori's theory of the 'Uncanny Valley' and Wakamaru
Source: http://www.cnet.com.au/i/r/2006/Games/uncannyvalley1_422x330.jpg, http://itc.ua/img/ko/2003/17/wakamaru_1_copy.jpg

language acquisition and communication skills. Left unaddressed is how gender identity is formed, inasmuch as the gender attribution process and the performance of gender roles alike are premised on language and communication. Roboticists involved with CB2 are keen on the eventual creation of a new intelligent 'robo species'.[25] It seems to be the case that it is in Japan that the possibility that humans and machines will meld into a new, superior species is most actively pursued. The bones of the ancestors of *Homo sapiens sapiens* were discovered in Tanzania's Olduvai Gorge; Japan is a cyber-Olduvai Gorge, where the newest forms of human(oid)s are emerging.

CB2 and other humanoids notwithstanding, there is considerable debate among roboticists about what embodiment entails: how human-like – how female-like or male-like – should humanoid robots look? How should their bodies be proportioned? Should they be bipedal or move about on wheels? Germane here is Masahiro Mori's widely cited 'theory of the Uncanny Valley' (*bukimi no tani*). A roboticist who focuses on humans' emotional response to non-human entities, Mori argues that a thing, such as a prosthetic hand, that looks real but lacks the feel and temperature of a 'living hand' creates a sense of the uncanny or sudden unfamiliarity. Conversely, a wheeled robot like Wakamaru,

which has only a general resemblance to the human body but who speaks and gestures like humans, generates a sense of familiarity (Figure 3). Mori thus recommends that engineers retain the metallic and synthetic properties of robots so as to avoid the creepiness factor and forestall any cognitive-emotional confusion among humans (Mori, 1970).

Among the few roboticists who have not followed Mori's advice are Fumio Hara and Hiroshi Ishiguro. They create 'face robots' and androids that can 'pass' as humans. Whereas Hara is working on facilitating emotional interactions between humans and humanoids (or 'morpho-functional machines'), Ishiguro believes that android and gynoid twins offer an improvement on teleconferencing because they enable the physical presence of *particular* humans and not just their video images and voices.[26] Ishiguro is among those who rationalize that the creation of 'soft-bodied systems' will facilitate human machine communication and interaction, and will stimulate the development of new biocompatible materials, including artificial muscles, tendons, tissues, as well as biosensors (Hara and Pfeifer, 2003). Whereas both Hara and Ishiguro are intent on creating female and male proxies, Cynthia Breazeal, an MIT roboticist, eschews anatomically realistic sociable robots. Kismet, Breazeal's first, somewhat cartoony sociable robot was purposively designed as a gender-neutral creature – 'kismet' is Turkish for 'fate' (Breazeal, 2002: 48).[27] In contrast, the majority of Japanese roboticists designing humanoids that will interact with humans in everyday living and working environments proceed with an idea of the gender of their creation in mind.

Gendering Humanoids

Tomotaka Takahashi, a leading robot designer and founder of Robo Garage,[28] predicts that over half all future humanoids will be female. In April 2006, Takahashi unveiled the bipedal FT (*efutei*), for Female Type, his first fembot. Up until that time, he explained:

> ... the great majority of robots were either machine-like, male-like or child-like for the reasons that not only are virtually all roboticists male, but also that fembots posed greater technical difficulties. Not only did the servo motor and platform have to be 'interiorized' (*naizōsuru*), but the

> body [of the fembot] needed to be slender, both extremely difficult undertakings. (Takahashi, 2006: 194)

Technical difficulties aside, Takahashi – and my research suggests that he is representative of Japanese roboticists in general – invokes, in no uncertain terms, his common-sense view that an attribution of female gender requires an interiorized, slender body, and male gender an exteriorized, stocky body. Takahashi has not been consistent in equating the interiorization of body parts per se with a female-gendered body as his very first robot, the Atomu-inspired Neon, was specifically assembled so as 'not to have any of its mechanical components visible' (Takahashi, 2006: 67). Thus, in order to feminize FT over and beyond her interiorized body, Takahashi consulted with a number of professional fashion models in developing an algorithm enabling the 33 centimeter diva-bot to 'perform a graceful catwalk with all the twists, turns and poses of a supermodel' (Figure 4).[29]

Several years before FT's debut, Tatsuya Matsui, Takahashi's contemporary and the founder of Flower Robotics, created Posy and Pino, two humanoids that typify the common-sense attributes of female and male gender noted above (Figure 5). For Matsui, aesthetics is a 'technological issue … inseparable from [a] robot's primary mechanical functions'. Although he does not use the word 'gender', his allusions to the gendered character of his technological creations are numerous and striking.

The bipedal Pino, whose pointy nose recapitulates that of Pinocchio, his Italian namesake, was scaled to the size of 'a one year old child taking its first steps', or about 75 centimeters tall. According to Matsui: 'the scale of a fully grown adult pose[s] a threatening presence and would …cause a general sense of unease, being less a companion than a cumbersome and overpowering mechanical object' (2000).

> It was deemed necessary to design its [Pino's] proportions as recognizably human as possible; deviating too far from the instantly recognizable form of a human child could cause it to be seen as an altogether different object. From a psychological point of view, we noted that even the casual observer focused more attentively and ultimately more affectionately upon a similarly structured form. (Matsui, 2000)

Figure 4 The catwalking FT (Female Type)
Source: Adapted from http://dvice.com/pics/ft_robot_1.jpg

Pino's masculinity is suggested through the incorporation of conventionalized male gender markers, such as a squarish head, angular jaw, firm chin, sturdy neck and straight shoulders. His visor changes colors depending on his mood. Matsui claims that Pino's segmented body was inspired by the lithe muscularity of male ballet dancers, and, echoing Takahashi's notion of exteriorized masculinity, that he left the boybot's internal machinery visible to underscore his anatomy (Burein Nabi, 2002: 83).

Unlike Pino, whose segmented body is 'incomplete' or 'unfinished' (*mikansei*), Posy's veiled body imparts a sense of modesty and innocence. Although he modeled Posy after a flower girl at a church wedding, Matsui claims that he imagines her serving as a receptionist (Burein Nabi, 2002: 83–4). Posy's two almond-shaped, and feminine, eyes represent a technological breakthrough. Most humanoids have visors or large eyes that accommodate a CCD camera within the head.[30] Posy's

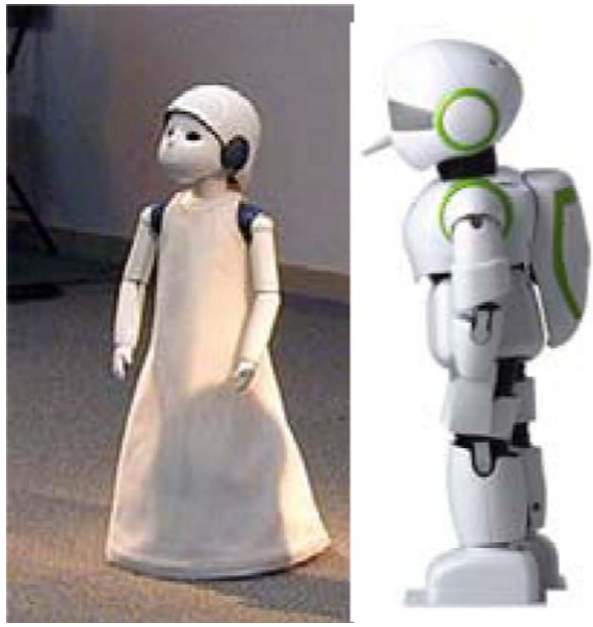

Figure 5 Flower Robotics' Posy (left) and Pino (right)
Source: http://www.sky-s.net/.../659339eecca2_A6BF/posy_01.jpg; http://www.otherlandtoys.co.uk/images/pino1_800.jpg

symmetrical human-like eyes required that two separate but conjoined cameras be installed. Like Hello Kitty, Posy lacks a mouth (as does Pino). Her head, in the form of a page-boy haircut, sits atop a willowy neck, and the robot's puffy cheeks conjure the image of cherubic young girls. A sleeveless gossamer dress simultaneously gives Posy an angelic appearance, highlights her smooth, anthropomorphic arms and hands, and covers ('interiorizes') the unfeminine network of wires and metal plates forming her body.

Gendering Face Robots

Because face robots – gynoids and androids – are designed to pass as humans, roboticists either model them after specific females or males, or resort to giving them standardized and stereotypically gendered features. Ishiguro's first creation was a gynoid, Repliee R1, a robotic clone of his 4-year-old daughter. It was capable of only basic movements, and thus was not quite lifelike. Ishiguro's

Figure 6 Fujii Ayako (left) and gynoid Actroid Repliee Q1 (right)
Source: http://cimg2.163.com/tech/2006/7/11/20060711111021ab466.jpg

daughter was so terrified by her uncanny look-alike that for a long time she refused to set foot in Ishiguro's lab after seeing it, and the inventor himself was uneasy in the gynoid's presence (Brook, 2007). Since then, Ishiguro has designed only adult humanoids, which seem to be less likely to send humans tumbling into the Uncanny Valley.

Ishiguro's first adult gynoid, Actroid Repliee Q1, covered in skin-like silicone, was modeled after Fujii Ayako, a newscaster at NHK (Japan Broadcasting Corporation) (Figure 6). She debuted at the 2005 World Expo in Aichi prefecture. Sophisticated actuators made it possible for ARQ1 to mimic Fujii's facial and upper body movements, and internal sensors enabled her to react in a natural manner. Specifically, subtle, seemingly unconscious movements gave the gynoid her eerie verisimilitude: the slight

Figure 7 Actroid Repliee Q2, a composite of the 'average' Japanese female
Source: http://www.slipperybrick.com/2006/10/actroid-der2/#more-349

flutter of the eyelids, the gentle rising and falling of the chest (giving the appearance of breathing), and the constant, nearly imperceptible shifting so familiar to humans. However, unlike bipedal humanoids such as Honda's Asimo, she cannot walk.[31]

Ishiguro created a second fembot who also debuted at Expo 2005. Instead of utilizing an actual female model, Actroid Repliee Q2's face was a composite of the 'average' Japanese female visage (Figure 7). That is, several young Japanese women's faces were scanned and the images combined to derive a statistically average, composite face. The result is both an anonymous and a singular *Japanese female* face. In short, for Ishiguro, a face, as a constellation of features, is not just 'a unique three-dimensional barcode' of a particular individual's gender identity, but also a topographical map of and for a *national ethnic* identity. Actroid

Repliee Q2's Japaneseness was further underscored by her voice, which was 'high-pitched' and 'girlish' (Wood, 2005).

Actroid Repliee's male designers clearly equated gender (femininity) *and* nationality (and ethnicity) with voice. Even if they were not intentionally aiming to reify a pernicious stereotype, they nevertheless reinforced Japanese 'men's language' and 'women's language' as essentializing performances. Based on my fieldwork and literature review, I doubt that most roboticists would think of a 'high-pitched, girlish voice' as *un*natural! As feminist linguists argue compellingly, in reality, Japanese women's speech is a prescribed norm that *does not* reflect how most women actually speak. High voice pitch is a feminine ideal and a cultural constraint promoted in recent history by the government in collusion with the popular media (Shibamoto, 1985), and reinforced today by robot designers.

Numerous YouTube videos of Actroid Repliee versions can be viewed to corroborate my point. The gynoid featured in the video at http://www.youtube.com/watch?v=4sjV_lxSVQo&feature=related, for example, is over-determinedly feminine, from her breathy, girlish voice, to her shaggy brown hair and manicured nails. She is dressed in a white cheerleader's sweatshirt emblazoned with 'I ♥ Hello Kitty,' a black miniskirt hemmed with white lace, and chartreuse pumps festooned with a large bow of the same color. In the YouTube spot, Actroid Repliee Q2 protectively covers her chest with her right arm and, in a teasingly cute voice, warns (the presumably male) visitors to the robot expo that touching her bosom constitutes 'sexual harassment'.

Will human females be replaced by their humanoid counterparts within decades? It was not an accident that Actroid Repliee was named after the French *repliquer*, to replace. Already the many uses (male) roboticists imagine for the gynoids include their employment 'in upmarket coffee shops, bars, information booths, office complexes, and museums to greet customers and to give directions'.[32] An advertising poster also suggests the use of Actroid Repliee as an ambassador, a spiritual leader and a nurse. No further details of these applications are provided, although the nurse Actroid is shown presumably interacting with a patient. Clearly she cannot perform any nursing task except perhaps formulaic intake interviews, but it is conceivable that

Figure 8 Hiroshi Ishiguro (left) and Geminoid HI-1 (right)
Source: http://www.techepics.com/files/robotscientist.jpg

even this may be of some value in situations where there are staff shortages and long waiting times. Rentals currently cost about $4000 for a five-day period, plus charges to choreograph the gynoid's software.[33]

Meanwhile, in July 2006, Ishiguro's lab built a robot twin of Ishiguro himself named Geminoid HI-1, 'H' and 'I' being the roboticist's initials (Figure 8). The android was purposively created by Ishiguro as a doppelgänger through which he aims to distribute his unique personhood through the process of tele-presencing (McDorman and Ishiguro, 2006). Briefly, 'distributed personhood' refers to the ability of human actors to intentionally relocate some of their agency into things beyond the body-boundary. To borrow from Alfred Gell, Geminoid HI-1 is an objective embodiment of '*the power or capacity to will* [its/his] *use*' (1998: 21). As Ishiguro himself explains:

> We coined 'geminoid' from the Latin 'geminus,' meaning 'twin' or 'double,' and added 'oides,' which indicates 'similarity' or being a twin. As the name suggests, a geminoid is a robot that will work as a duplicate of an existing person. It appears and behaves as a person and is connected to the person by a computer network. . . . With geminoids, we can study such personal aspects as presence or personality traits, tracing their origins and implementation into robots. (Nishio et al., 2007: 346)

Geminoid HI-1's silicone-and-steel body was made from casts taken of Ishiguro's body and its hair plucked from Ishiguro's own head. Controlled by a motion-capture interface, Geminoid HI-1 can imitate Ishiguro's singularly distinctive body and facial movements, and it can reproduce his voice in synchronization with his posture and movements. The android wears his maker's unfashionable beige shirt, dark trousers and black windbreaker jacket. Ishiguro hopes to develop the android's human-like presence to such a degree that he could use it to teach his classes remotely, lecturing from home while Geminoid HI-1 interacts with students at Osaka University.

To summarize from a limited sample based on Ishiguro's precedent-setting creations, whereas gynoids (Actroid Repliees) were designed to replace flesh-and-blood females, including as substitute teachers, Geminoid HI-1 – the only android created thus far – is designed to augment and multiply the agency of a particular human male, namely, Ishiguro. Tele-presencing is Ishiguro's solution to enabling robots to conduct sustained conversations. Whether female or male, a geminoid's appearance must be based on that of an existing person and not 'on the imagination of designers' so as to facilitate humanoid–human communication. Ishiguro rationalized that using himself, the main researcher, as 'the original' would enable him to 'offer meaningful insights into the experiments' (McDorman and Ishiguro, 2006), although, by the same token, any member of his laboratory would have qualified (Nishio et al., 2007: 346–7).

Enter HRP-4C, a new-generation gynoid that was unveiled in the spring of 2009 as a body double of and for (or to replace?) the average human female (Figure 9). Her 'name' is an acronym for *H*umanoid *R*obotics *P*roject-*4*th *C*yborg, and she sports a silicone face – framed by shoulder-length black hair in a page-boy – fashioned from a composite photograph of five female employees at AIST (Advanced Institute of Science and Technology) where she was created. HRP-4C's dimensions are based on average values for young Japanese females recorded in the Japanese Body Dimension Database (1997–8): she is 158 cm tall and weighs 43 kilograms (including the battery). Her height is about average but she is about 10 kilograms lighter than the average Japanese woman. Like her face, her hands are also covered in a silicone skin. The rest of her

Figure 9 HRP-4C
Source: http://asia.cnet.com/i/r/2009/crave/ft/63009626/japanese_supermodel_robot_500x321.jpg

anthropometrically exact body consists of silver and black plastic molded to resemble a Barbarella-like costume, which accentuates her ample breasts and shapely, naturalistic buttocks. The fembot's movements were part of an algorithm developed by motion-capturing those of human females and then mimicking them. Similarly, the robo-Barbarella's interactions with humans have been enabled through speech and gesture recognition.[34] HRP-4C debuted at a fashion show held during the eighth Japan Fashion Week in Tokyo, which opened on 23 March 2009. As explained somewhat tautologically on the AIST website, 'HRP-4C is expected to pave the way for the early practical application of humanoid robots by utilizing the key characteristic of humanoid robots, namely a human appearance'.[35]

Suffice it to suggest for now (and I will develop this train of thought in a future essay) that HRP-4C marks the beginning of the 'cyborgization' of not humans but robots; that is, her robot body has been enhanced by the integration of anthropometric features. Although the usual understanding of cyborgs positions a human as the altered agent, it makes perfect sense to view a

robot as the altered agent, in so far as a cyborg is an 'equal opportunity' hybrid form, at once *both* human *and* robot.

Critical Coda: Freedom vs Robo-sexism

The Humanoid Robotics Project was spurred by demographic problems facing Japanese society, namely the looming population crisis caused by a declining birthrate coupled with a rapidly aging society.[36] How will robots change these disturbing trends, in part the consequence of Japanese women's reluctance to marry and to bear children? As I have noted, most roboticists reinforce in and through their humanoids, by default arising from indifference, quite unprogressive notions of gender dynamics and the sexual division of labor, along with discriminatory attitudes toward non-Japanese migrant workers.

In commentary relevant to robotics, critical theorist Manuela Rossini notes that 'the inventors and scientific users of biomedical technologies are also *imagineers*, not just of bodies but of cultural configurations and social arrangements as well' (2003: 1). But the act of imagining per se does not necessarily yield fresh or progressive results. *Innovation 25* and the Japanese humanoid robot industry exemplify 'retro-tech', or advanced technology in the service of traditionalism. A vision of and for new technologies that facilitates the transcendence of ethnocentrism, paternalism and sexism, and their associated power relations, apparently is shared by neither roboticists nor the government committee and planners responsible for *Innovation 25*.

The demographic data strongly indicate that the 'good wife, wise mother' ideal of female sex and gender since the late 19th century is increasingly rejected by Japanese women who are not keen to marry, much less have children. The discourse of individual rights, or freedom from second-class citizenship, first guaranteed for women and men in the postwar (1946) constitution, is now morphing into a discourse of 'freedom to': the freedom for Japanese individuals to do whatever they desire, or to not do whatever they do not desire. It seems that this unprecedented exercise of self-interested agency, accompanied by a generalized antagonism toward migrant workers, has occasioned a societal environment facilitating the robotization of work, play and

homelife. There are plenty of informative websites and blogs devoted to robot-related topics that also feature enthralled reports, and sometimes sardonic commentaries, on the latest Japanese humanoids.[37] But what has yet to be broached among roboticists and policy-makers is a serious and sweeping discussion about the existential, ethical, humane, social and interpersonal limits of the safety, comfort and convenience associated with the 'robotic lifestyle' advocated in *Innovation 25* and in the mass media.

It is fitting to close with a paradox involving 'freedom'. Separate from the 'freedom to' possibilities that gendered humanoids are imagined to make possible for the Japanese people, robots themselves are designed on the basis of 'degrees of freedom'. This expression alludes to the defined motion capabilities of robots: 'the number of degrees of freedom is equal to the total number of independent displacements or aspects of motion'.[38] Simple robots usually have three degrees of freedom – that is, they can move in three ways: up and down, left and right, and forward and backward. In order to appear humanly lifelike, Geminoid HI-1 and HRP-4C are provided with more degrees of freedom than other humanoids, like Asimo, who has 17. The cyborgized fembot, modeled after the typical Japanese 20-something, was designed with 42 degrees of freedom, and the geminoid, roboticist Ishiguro Hiroshi's body-double, with 50. If a robot's degrees of freedom are extrapolated allegorically, the implication here is that *individuality*, gendered male, as opposed to *typicality*, gendered female, is equipped with more (degrees of) 'freedom'. The question then arises, how many degrees of freedom will flesh-and-blood women enjoy in the robotized Japan of 2025?

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Humanities (Advanced Research in the Social Sciences on Japan) and a 2008 faculty research grant from the Center for Japanese Studies, University of Michigan. This article is part of a book-in-progress tentatively titled, *Robo sapiens japanicus*. I have rendered Japanese names in the Anglophone format of first name first, last name last (instead of the inverse), even in the case of authors writing in Japanese, to simplify matters. All translations from the Japanese are mine unless otherwise noted.

Notes

1. See: http://www.360fashion.net/360tech/2009/03/hrp-4c-fashion-model-robot-launched-tokyo-fashion-week-2009-by-national-institute-of-advanced-indust.php. Most websites cited were consulted in June 2007; those dated later than June 2007 were consulted in June 2009.

2. See: namelessme at 1:11 p.m. on 20 March 2009, at http://dvice.com/archives/2009/03/hrp-4c_robot_re.php

3. The gender(ed) technologies of cartoon and fictional robots have been incisively analyzed by Susan Napier (2001) and Miri Nakamura (2007), among others. A tangential issue that I do not address explicitly in this article is how roboticists perform gender roles in their own everyday lives and laboratories. The dearth of female roboticists (and not just in Japan), and nascent efforts to encourage more female students to major in robotics, was the subject of a special issue in 2006 of the *Journal of the Robotics Society of Japan* (vol. 25, no. 5), featuring profiles on 16 female roboticists from North America, Europe and East Asia, including two from Japan. The leading popular robotics magazine, *Robocon*, also reported on female roboticists in a 2006 issue (Moriyama, 2006). In 2005, Mihoko Otake proposed and developed the website 'Women in Robotics and Automation towards Human Science, Technology and Society' (http://women.ws100h.net/), which has not been updated since 2007. The site was originally started by advocates of FRAU, the network for female researchers in robotics and automation in Japan, of which Otake was a member.

4. Tezuka's *Princess Knight* (1953) inspired comic-book artist Ikeda Riyoko's *Berysaiyu no bara* (*The Rose of Versailles*, 1972–4), which is performed at regular intervals by the Takarazuka Revue, and is one of the most successful of their post-war revues. *The Rose of Versailles* dwells on the adventures of Oscar, a female raised as a boy in order to ensure the patrilineal continuity of a family of generals (Robertson, 2001 [1998]: 74).

5. I made a similar argument with reference to the practice in the Edo period (1603–1867) of attributing gender to plants and seeds based on aesthetic and cosmological (and not anatomical) criteria (Robertson, 1984). Habitus is a mindless or unconscious orchestration of actions that do not presuppose agency and intentionality. It is a set of internalized predispositions that enable people to cope with unexpected situations and to improvise (see Bourdieu, 1977).

6. Sex robots, which are fitted with human-like genitalia, are an exception. I do not deal with these sex toys here (see Dorfman, 2005; Levy, 2007; http://www.ananova.com/news/story/sm_1361247.html; http://kafee.wordpress.com/2007/10/28/sex-dolls-robots-love-and-marriage/). Except for the moment of gender assignment at birth, at which time a newborn is determined to either have or lack

a penis, actual physical genitals play little role in gender attribution among humans. Those infants whose genitals are 'unintelligible' for various reasons are often 'corrected' surgically and later, hormonally (Kessler and McKenna, 1985: 58–9).

7. This is true of male and (the comparatively few) female roboticists (see also note 3 above).

8. The following quasi-fictional report makes this point: HER name is MARIE, and her impressive set of skills comes in handy in a nursing home. MARIE can walk around under her own power. She can distinguish among similar-looking objects, such as different bottles of medicine, and has a delicate enough touch to work with frail patients. MARIE can interpret a range of facial expressions and gestures, and respond in ways that suggest compassion. Although her language skills are not ideal, she can recognise (*sic*) speech and respond clearly. Above all, she is inexpensive. Unfortunately for MARIE, however, she has one glaring trait that makes it hard for Japanese patients to accept her: she is a flesh-and-blood human being from the Philippines. If only she were a robot instead. ('Better than People', 2005)

9. See: http://www.bouncingredball.com/2008/12/14/japan-robot-nation/

10. See: http://www.robocasa.com/pdf/press_release.pdf

11. See: http://www.stat.go.jp/english/data/jinsui/tsuki/index.htm

12. See: http://www.robocasa.com/pdf/abstract_and_general_overview.pdf

13. From January through March 2007, I was a visiting professor of anthropology at the University of Tokyo.

14. The seven-volume set of *The Book of Wabot* (*Wabotto no hon*) – Wabot refers to Waseda University robot – exemplifies this tendency. The set is published in Tokyo by Chūō Kōron Shinsha, (2002–7). I have written on Waseda University's efforts to popularize robotics in Robertson (2007).

15. Information here and elsewhere on *Innovation 25* is from http://www.kantei.go.jp/jp/innovation/index.html unless indicated otherwise. See Robertson (2007) for a more extensive analysis of *Innovation 25* and for an introduction to the Japanese family of the near future.

16. See: http://www.incx.nec.co.jp/robot/english/childcare/expo.html

17. In the United States, in contrast, the military (the Defense Advanced Research Projects Agency, or DARPA) is deeply invested in robotic technology. One can reasonably speculate that data from entertainment and household robot experiments are also being utilized by Japan's new Ministry of Defense, whose annual white papers include a section on robotics. A cabinet-level official I interviewed in the fall of 2008 was taken aback by my mentioning to him that the theme of the amateur robotics competition at the 2008 Robo Japan Expo was 'Robots that can fight in outer space'. The inventor whose robot could right itself and walk three steps after being thrown down, three times in a row, would win a berth for the robot on the next Japanese space mission. None of the five competitors qualified.

18. Many journalists, roboticists, and scholars writing about the robot-friendliness of Japan cite Shinto as an important factor.

19. The present Japanese term for science, *kagaku*, was coined in 1871, and refers to a spectrum of specialized research topics and methods that produce experiment-based systematic, rational knowledge of a part of the world.

20. *Bonsai* is the art of dwarfing trees or plants and developing them into an aesthetically appealing shape by pruning and training them in containers according to prescribed techniques. Without the application of what might be called *bonsai kata*, these trees would grow to their normal size – they are not dwarf trees to begin with.

21. Cognitive science is the 'human' studies field most often cited in Ishiguro's work.

22. Along with *ba*, Miyake includes the concept of *ma*, or time-space, in order to emphasize the real-time temporality of co-creation. His research can be perused on his website (http://www.myk.dis.titech.ac.jp).

23. Autonomous (or semi-autonomous) robots did not become possible until the 1950s and 1960s with the invention of transistors and integrated circuits. Compact, reliable electronics and a growing computer industry were also critical. In the computing world, having more transistors on a chip means more speed and possibly more functions. Moreover, as the component density of chips radically increases the chips themselves become smaller and thinner, which has enabled developments in humanoid robotics in the area of emergent and embodied intelligence.

24. Among the more recent studies linking robotics with child development studies are the articles in a special issue of *Infant and Child Development* (Berthouze and Prince, 2008). See also Lindblom and Ziemke (2006).

25. See: http://forum.ebaumsworld.com/archive/index.php/t-206094.html; http://www.pinktentacle.com/2007/06/cb2-baby-humanoid-robot/; http://www.engadget.com/2009/04/06/cb2-child-robot-returns-smarter-creepier-than-ever/. It is in this context that I came up with the title of an earlier article, *Robo sapiens japanicus* (Robertson, 2007).

26. Ishiguro's research team has found that as a robot's motion or appearance comes to resemble that of a human, the degree of familiarity and intimacy increases. However, at a certain degree of familiarity and intimacy, an 'Uncanny Valley' effect occurs. A realistic child-type geminoid quickly occasions uncanniness although an adult humanoid seems to provoke less eeriness and more familiarity (http://www.ed.ams.eng.osaka.ac.jp/research/Android_BehavAppear_e.html).

27. Although she provides an incisive reading of the intimate interactive relationship between (the now mothballed) Kismet and Breazeal that occasions the robot's sociability, Lucy Suchman does not address the gendered (or not) component of actual (as opposed to fictional) humanoids in general (Suchman, 2007: 235–8, 245–6).

28. Takahashi established his robot laboratory, Robo Garage, in 2003 at Kyoto University (http://www.robo-garage.com; see http://www.robo-garage.com/english/robo/ft.html).

29. See: http://www.luxurylaunches.com/auctions/tomotaka_takahashis_ft_female_bot_to_be_auctioned.php; http://cgullworld.blogspot.com/2007/06/ft-female-robot-does-catwalk.html

30. A charge-coupled device (CCD) is an analog shift register, enabling analog signals (electric charges) to be transported through successive stages (capacitors) controlled by a clock signal. CCDs containing grids of pixels are used in digital

cameras, optical scanners and video cameras as light-sensing devices (http://en.wikipedia.org/wiki/Charge-coupled_device).

31. See: http://news.nationalgeographic.com/news/2005/06/0610_050610_robot.html

32. Kokoro does not publish information about which, if any, corporations have actually rented Actroid for these purposes.

33. See: http://en.wikipedia.org/wiki/Actroid

34. HRP-4C was developed as part of the User Centered Robot Open Architecture (UCROA), one of the projects under the Industrial Transformation Research Initiative, a three-year industry academia joint project implemented by AIST in 2006 with intended applications in the entertainment industry.

35. See: http://www.aist.go.jp/aist_e/latest_research/2009/20090513/20090513.html

36. I address these problems at length in Robertson (2007), including a discussion of roboticists' patriarchal imagination of the quintessential Japanese household that robots will share with humans.

37. For example, www.pinktentacle.com and www.endgadget.com.

38. See: http://whatis.techtarget.com/definition/0,,sid9_gci1280377,00.html

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