Article

S|S|S

Social Studies of Science
2014, Vol. 44(3) 315–341

DOI: 10.1177/0306312713511868
sss.sagepub.com
SAGE

Robot visions

Claudia Castañeda
Emerson College, Boston, MA, USA

Lucy Suchman
Department of Sociology, Lancaster University, Lancaster, UK

Abstract

This article explores the resonating figures of primate, child, and robot in contemporary technoscientific corporealizations of the 'almost human'. We take as our model (in)organism 'Lucy the Robot Orangutan', roboticist Steve Grand's project to create an artificial life form with a mind of its own. One aspect of Lucy's figuration by Grand, we argue, which ties her to Haraway's analysis of the primate, is of the robot as a model for animal, and more specifically (or aspirationally) human, cognition. We follow the trope of 'model organism' as it is under discussion within science and technology studies and as an ironic descriptor for our own interest in Lucy as an entity/project through which to illuminate figurations within robotics more widely. Primate and robot together are forms of natureculture that help to clarify how the categories of animal and machine are entangled, while making explicit investments in their differences from one another, and from the third category of the human. We conclude, again following Haraway, by imagining what other possibilities there might be for figuring humans, robots, and their relations if we escape the reiterative imaginary of the robot as proxy for becoming human.

Keywords

figuration, model organism, primatology, robotics

> Children, artificial intelligence (AI) computer programs, and nonhuman primates all here embody 'almost minds'. Who or what has fully human status? … What is the end, or telos, of this discourse of approximation, reproduction, and communication, in which the boundaries among and within machines, animals, and humans are exceedingly permeable? Where will this evolutionary, developmental, and historical communicative commerce take us in the techno-bio-politics of difference?
>
> (Haraway, 1989: 376)

Corresponding author:
Lucy Suchman, Department of Sociology, Lancaster University, Lancaster LA1 4YT, UK.
Email: l.suchman@lancaster.ac.uk

The cover of roboticist Steve Grand's *Growing Up With Lucy: How to Build an Android in Twenty Easy Steps* (2003) sports the image of a torso and arms made of metal, wires, black boxes, and bolts, powered by a chunky rechargeable battery held in place by rubber bands, and topped by two bulging eyes staring out at the viewer from a sparsely orange-haired yellowish rubber mask. 'Lucy the Orangutan Robot' is the first prototype in a Cyberlife-Research Ltd project and the corporealization of Grand's long-term endeavor to create an artificial life form with a mind of its own. Corporealization, as Donna Haraway explains it, is a process through which new bodies, both human and nonhuman, are brought into being. She reminds us that '[t]he bodies are perfectly "real" and nothing about corporealization is "merely" fiction. But corporealization is tropic, and historically specific at every layer of its tissues' (Haraway, 1997: 142). Haraway adopts the term *figuration* 'to make explicit and inescapable the tropic quality of all material-semiotic processes, especially in technoscience' (p. 11). For Haraway, the material-semiotic names the quality of bodies, whose nature can never be simply known but instead is constituted in and through the process of knowledge making in concert with the agency of 'nature' itself. Figuration extends the focus from bodies as corporeal to the ways in which objects (natural or otherwise) condense whole worlds of significance beyond the literal, even as these worlds may be effectively occluded.

Lucy the Orangutan Robot can be located within a longstanding and multiply sited historical project that we would characterize most broadly as the human aspiration to fashion what are figured as animal, and more specifically humanlike, capacities out of inorganic materials.[1] The more particular and contemporary context in which Lucy appears comprises developments in robotics first associated with the laboratory of Rodney Brooks (1999) at the Massachusetts Institute of Technology, distinguished, among other things, by a turn away from an AI focused on computational logics taken to be foundational to but independent of specific implementations, to a concern for artificial minds demonstrably at work in, and formed out of the operation of, robotic bodies. Characterized broadly as 'situated' robotics and identified with machines figured variously as humanoid, android, social, and personal, these initiatives share with the wider project of AI an investment in automata not only as useful bodies (where form follows function according to operational criteria), but also as recognizable approximations of cognizing minds. Roboticists explicitly acknowledge the indebtedness of their commitment to machinic entities figured as 'almost minds' to popular cultural imaginaries, and those imaginaries in turn sustain a perpetual stream of promissory announcements and anticipatory sightings of the project's realization on the part of the media. We emphasize the promissory and anticipatory temporalities of humanoid robotics insofar as there is a consistent gap between the imaginaries that inspire the projects, and the actual technical achievements that are evident inside robotics laboratories, particularly beyond the carefully orchestrated confines of the demonstration. The point here is not only to provide a critique of the gap for its mystifications (though that is certainly an important project), but also to re-enchant the actual engineering achievements.[2] As the inseparability of science and/as culture is well recognized within contemporary science and technology studies (STS), perhaps nowhere is this more obvious than in the imaginaries that animate the sciences devoted to the genesis of intelligent machines.

It is in this context that we adopt Lucy, 'a robot with the mind of a baby, who looks vaguely like an orang-utan',[3] as our model organism for exploring the resonating figures of robot, child, and primate in contemporary technoscientific corporealizations of 'almost minds'. In exploring Lucy as a figuration, we seek to unravel the worlds condensed in her form, to consider the worlds that constitute her figuration as well as the worlds that she figures forth (see also Castañeda, 2002). In this sense, we do not consider Lucy as a case study in robotics so much as a figure whose uncanny resonance with the epigraph that opens this article invites us to read her story diffractively[4] through the multifaceted lens provided by the source of the quotation, Donna Haraway's *Primate Visions* (1989). Haraway's writings on the quasi-integrated circuits of humans, animals and machines help us to elucidate and expand upon Lucy's status as a proto-hominid robot, and to recover from the singular bodies of Grand and Lucy the complex histories and imaginaries that give them life.[5] Lucy invites us as well to read together our own previous research on figuration, the child and robotics (Castañeda, 2001, 2002; Suchman, 2007a, 2007b, 2011), and to bring that research in turn into conversation with Haraway's prescient and generative works.

The quotation from *Primate Visions* with which we open sets out the stakes of these readings: the ambiguous, ambivalent mix of possibilities offered by those figured as approximations (specifically here children, AI computer programs, and nonhuman primates) to the adult (White male) human. As they are historically positioned – that is, as entities with aspirations to a universalized, fully human status, where that is taken to be of a higher order – these figures reiterate developmental/evolutionary discourses born in the crucible of imperial projects of expansion and domination. Each is of interest to the extent that it validates the superior status of the adult (White male)/rational knower/human, at the same time that it promises something that might exceed (under proper tutelage) the capacities of its progenitors. At the same time, released from the confines of one order of being to which all entities aspire, these figures suggest the possibility of a techno-bio-politics very differently configured, one with less fear of lack of coherence and more hope for radically transformative processes of generative interspecies congress.

In what follows we explore the questions: How does Grand corporealize assumptions about nature – and in particular human nature – through Lucy's figuration as a robot? What kinds of bodies does he imagine, and what limits and possibilities do his robot visions embody? The evidentiary materials for our account are a layered strata set down for us by Grand, in the form of a periodically updated hypertext of stories and images, conveyed through web pages, popular and technical publications, media representations, and public lectures. We work from the premise that while AI creations like Lucy tend to be figured in terms of the timeless and placeless universality so familiar to scientific discourses of 'the human', they rely upon a range of cultural resources and material practices that help to locate them within more historically specific imaginaries. In considering Lucy's figuration as a culturally and historically specific robot, moreover, we take seriously her orangutan kinship. In *Primate Visions* (1989), Haraway explores the primate as a powerful resource for articulating the human within scientific discourses and popular imaginaries. She argues that as an object of knowledge, positioned in such a way that both nature and culture can be investigated through its body, the primate has

provided the raw material for knowledge making about gender, race, and (human) nature in the 20th century. At the opening of the 21st century, nature is under reconstruction not only as the object of a knowledge-making gaze, but in the form of artificial creatures naturalized through rhetorics of species (phylogenic) evolution and individual (ontogenic) development. The project of Lucy the orangutan robot provides a particularly vivid case in point. Just how she is corporealized – what kind of body she is, and what kinds of values she embodies – becomes significant insofar as it contributes to establishing the pasts that inform contemporary imaginaries, as well as the future worlds that we (humans and humanoids?) might come to inhabit.

We begin with a closer examination of Lucy's material-semiotic configuration within an imaginary of the computational recreation of the 'emergence' of life and intelligence, and how her fabrication reiterates and elaborates the robot/animal body as 'model (in) organism' for the human. We follow the trope of 'model organism' as it is under discussion within STS, and as a (slightly tongue in cheek) characterization of our own interest in Lucy as an entity/project that guides us in interrogating figurations within robotics more widely. With those interchanges as our contextualizing frame, we turn to Grand's account of Lucy's becoming, reading it as a blend of (auto)biographical and natural–historical storytelling. Understanding Lucy as a robot primate imagined as proto-humanoid, we consider the question of just how the Lucy project figures a particular conception of human nature through her invocation of human origins and human–primate kinship ties. We conclude, again following Haraway, by imagining what other possibilities there might be for figuring humans, robots, and their relations if we escape the reiterative imaginary of the robot as a mirror for and/or more primitive version of the 'higher order' human. We close with some reflections on how Lucy might be refigured in ways that could challenge rather than reproduce received histories and familiar futures for animals, humans, and machines.

Configuring Lucy

As a technical project, Lucy constitutes one of a variety of responses to a lineage of research in AI tracing back to the 1950s and associated most closely with founding fathers Allen Newell and Herbert Simon.[6] Named by critics with the acronym GOFAI, or 'Good Old Fashioned AI', the early approaches and their contemporary descendants adhere to a strategy of formal representation that makes stipulation of reasoning procedures and relevant propositions at the outset, or from the 'top down', a precondition for intelligent behavior. The increasingly evident problems with this approach have encouraged an alternative movement dedicated to the creation of intelligent life from the 'bottom up', requiring the discovery of some primordial mechanism from which intelligence might grow. This latter strategy, to which Grand subscribes, takes its inspiration from biological rather than logical antecedents, and imagines a developmental/evolutionary path through which simple 'creatures' endowed with basic mechanisms will emerge as intelligent agents.

The concept of 'emergence' is the trope through which proponents of the 'New AI' 'secure a form of digital naturalism in the face of the evident constructivism of "artificial" life' (Kember, 2003: 56). Rather than creationism in the biblical sense, where

creatures spring forth fully formed, the idea is to fabricate the basis for a life that will then realize itself. This shift involves a change in focus from production of the actualized entity to creation of the potential for its eventual realization. In this respect 'New AI' maintains the natural scientist's insistence on the independent agency of nature and the alienable character of the object of knowledge (Haraway, 1989: 185; Shapin and Schaffer, 1985: 77). Kember (2003) sums this as 'the paradox of creation which is at the heart of the ALife project: the God-like act of creating life is "stolen" or appropriated by man and then credited to the computer' (p. 55). 'Emergence' is the key to the bootstrapping process whereby the resulting creatures continue after the hand of their creators is removed.[7]

With some exceptions, situated robotics projects have tended either to focus on navigation (famous examples include, Rodney Brooks' early work on the insect-like robot Genghis, prototype in part for the Mars Rover, and follow-on commercial products like the Roomba® 'intelligent' vacuum cleaner marketed by Brooks' former company iRobot; Honda's decade long efforts to stabilize the walking robot Asimo; and, most recently, Boston Dynamics' range of military-sponsored navigational robots) or to address 'higher order' functions involved in sociality, often taking the form either of stationary humanlike robots configured from the waist (or neck) up (again most famously Brooks' Cog, Breazeal's Kismet) or full-body androids fashioned after specific human models, a specialty of Japanese roboticist Ishiguro.[8] These and other humanoid robotics projects of major university and industrial research labs in the United States, the United Kingdom, and Japan share with Grand's a commitment to principles of embodiment, including the centrality of navigation and, ultimately, social interaction, to becoming humanlike.[9] They share as well the massive engineering problems of effective locomotion, perception, cognition, and interaction, even as laboratories work to distinguish themselves not only through the specific figurations of their robots but more technically through the adoption of different approaches or specialization in different aspects of robotic engineering. In this context, while Grand is something of an outlier in his position outside of the major university/industry networks, his work is nonetheless directly engaged with discourses and technical practices that are central to the field of contemporary AI and robotics.[10]

All of these initiatives project success as progress from an initial set of capabilities to a range of future competencies. The capabilities they take to be essential vary, but generally include some combination of navigation, vision, object manipulation, and speech generation and recognition. At the same time, a desire for release from the inexorably slow processes of phylogenic development accompanies the commitment to emergent intelligence, however it is defined. Alongside this wish comes the inclination to shift from scientist–observer to inventor–creator, with not only knowledge of the materials but also control over their manipulation. Creators of so-called situated robots exhibit their own particular set of discontents. Rodney Brooks (2002), the most prominent early proponent of navigational capabilities as a basis for emergent intelligence, embarked with his students on a new set of projects under the heading of humanoid or sociable robots in the early 1990s. Unwilling to leave robotic evolution to time frames beyond the researcher's productive career, Brooks and others have sought to explore human-level intelligence more directly by leapfrogging to the other end of the evolutionary order. According to Grand, it is the 'huge gap in the market … between the biologically tractable but not

really very intelligent world of insects and sea slugs, and the far-too-hard, conscious, language-using world of human' that the Lucy project also aims to address.[11]

Like many proponents of the New AI, Grand maintains that to be called intelligent, a creature must be capable of developing through experience and adjusting itself continuously to new situations. In this he remains true to narratives that constitute the child as the key site of a developmental process that gives rise to the fully formed and complete human.[12] Grand expresses his hope that Lucy will 'work her way through nursery school, learning to coordinate her muscles, to form spoken words and eventually to paint pictures'.[13] This somewhat eclectic list presages a commitment to new forms of robotic embodiment, sociality, and creativity. While the aims are familiar in contemporary robotics, Grand asserts that a radically new kind of artificial brain will underlie Lucy's accomplishments, one that begins with very few capabilities and generates its own increasing complexity. For Grand, the best chance for engineering this capacity is to create a material substrate for intelligence that functions like a 'mammalian brain': 'Lucy's brain is designed around a key set of hunches about how such a mechanism can be made using (simulated) neurons and biochemicals and how something similar might have evolved in nature'.[14] These 'hunches' can be located in contemporary neuroscientific understandings of the developing mind, also linked in its scientific figuration to human – and specifically brain – evolution. Just as Grand insists that Lucy requires a body to replicate the development of human-style intelligence, so too contemporary developmental neuroscience has materialized a child-brain whose development proceeds in response to the child-body's interactions with the world. Embedded in this understanding of the developing brain is the possibility of cultural differentiation according to how 'the world' looks, smells, feels, sounds, and tastes. Depending on the nature of the child's culturally specific environment, cognitive capacity is differentially established. But the dominant version of the child's neurological flexibility relies on a universal child-brain that is shaped through its contact with a generic environment of sound, sight, touch, and so on (Castañeda, 2002: 77–79).

The ability that Grand proposes will most dramatically distinguish Lucy from her robot predecessors, however, will be her access to the realm of fantasy: 'She will not be as smart as a human or ape baby of the same age, but she will learn for herself and she will have something that no robot has ever had before – an *imagination*' (original emphasis).[15] Grand (2003) characterizes imagination as a virtual world inside our heads that we inhabit, and which mediates our active perception of the world outside:

> What Lucy's brain will ultimately do (I hope) is create a mental narrative about the world; a constantly updated explanation of what is happening now and therefore what might happen next. If I get it right she will have more direct and meaningful access to this internal narrative than she does to the information entering her senses. What she will see is what she expects to see, not what her senses are belatedly telling her. She, like us, will live not in the real world, but in a virtual world inside her head. (p. 107)

While Grand's approach carefully limits claims to human likeness, it nevertheless repeats the assumption that human (or humanlike) existence is individual, cognitive, and based first and foremost in the brain/mind. And while he takes embodiment as essential to the

development of imagination (in the same way that developmental neurosciences consider the body as crucial in neurological development), Grand ultimately accords the brain supremacy over the rest of the body and equates imagination with intellectual capacity. He also retains a generic figuration of mind, development, imagination, and body, which erases their historical and cultural contingency. It is this premise of Lucy's generalizability that affiliates her with other nonhuman bodies taken as models for the human, and with the body of relevant scholarship in STS.

The animal/robot body as model human

In their careful review of the emergence of the model organism in the contemporary biological sciences, Ankeny and Leonelli (2011) argue that model organisms should be distinguished as a subclass of what they more broadly call experimental organisms. The defining criteria that they set out for the model organism include the proposition that the organism can be taken to represent a larger group beyond itself and, more specifically, that the model organism represents a relatively simplified form of 'higher level' organism, usually of the human (Ankeny and Leonelli, 2011: 318). The model organism is a model not for one specific biological phenomenon, moreover, but for 'whole organisms, whose potential representational scope extends to all living beings' (Ankeny and Leonelli, 2011: 320). At the same time, as Ankeny and Leonelli (2011) observe, 'the actual relationships between the model organisms and this target group often are very ill-articulated in the early stages of model organism work' (p. 318). They propose that model organisms

> are simultaneously samples of nature and artifacts: they are systems that have been engineered and modified to enable the controlled investigation of specific phenomena, yet at the same time they remain largely mysterious products of millennia of evolution … (p. 315)

It is on these grounds that, while they point out that model organisms are not themselves 'natural' (having been designed for standardization), Ankeny and Leonelli insist on their specifically biological nature, questioning whether non-living entities could ever, even metaphorically, serve in their place.

STS scholars have written extensively on the natural sciences' figuration of animal bodies as model organisms for the human. Friese and Clarke (2012) review this literature with a focus on 'the entanglement of human and other animal bodies in the making and remaking of knowledge, techniques and products' over the past century of biological and biomedical research (p. 31). They detail how a rich corpus of writing articulates the work performed by the model organism, inter alia: materializing relations of theory and data; comprising both a site of current scientific practice and a template for future research; and serving as a key actant in the creation of political, economic, and technical infrastructures for wider scientific projects.[16] At the same time, they identify the question of comparison and generalizability, or 'transposition', as a central problematic for the animal model: how findings demonstrated through some bodies can be transferred to knowledge making about others and, more specifically in the biological sciences, how the nonhuman animal can be constructed as an analytic object whose attributes might be

generalized to the human (Friese and Clarke, 2012: 31). As a foundational move of scientific method, the transposition of assertions constructed in a particular place and with reference to a specific animal (individual) to others (within or across species) remains a central challenge and an always contingent accomplishment.

The robot's closest kin in the biological sciences today is arguably the laboratory mouse, taken as the experimental prototype for modeling the human. Like the robot to human mapping, and despite well rehearsed arguments for the mouse's efficacy as a model organism, claims for its value in modeling the human must be built up with the aid of what Nelson (2013) terms 'epistemic scaffolds' (p. 3). Taking seriously the premise that knowledge claims must be constructed, Nelson uses the metaphor of the scaffold to describe how the laboratory mouse is constituted as an independent (albeit highly controlled) basis for evidentiary claims in animal behavior genetics. Subject to close scrutiny within an apparatus designed to render the target behavior legible, she describes how the individual animal is tested and measured as one among many members of a standard category, which in turn is taken as a basis for transposition to different but arguably related organisms. While the design of devices is inescapably material (down to the level of debates over how the use of plastic versus metal mazes might affect experimental outcomes), the crucial move in getting from animal behavior to claims about the human is, again, a tropic one, as pathologies identified with humans are made legible in the actions of the mouse:

> Describing animal models as 'exemplars' or modeling as a process of 'extrapolation' creates the impression that findings are first worked out in model systems and then translated to other cases, thereby obscuring the ongoing interactions between the model and the modeled that take place during all stages of animal modeling work. (Nelson, 2013: 6)

The model organism is haunted, in this respect, by what Keller (2007: 341) describes as its 'circular trajectory', as models become apparently independent test beds for assessing the very theories that they materialize in the first place.

If, as Friese and Clarke (2012) propose, transposition 'directs analytic attention to the ways in which models create dynamic and iterative connections between different kinds of things' (p. 33), how might these insights into the animal body as a model organism be transposed to our analysis of the work being done by Lucy the orangutan robot? Most obviously, Lucy's figuration as a primate frames the work of robotics as a natural science, whose object is not the machine as such, but the machine as model for the animal. Just as primatology faces the task of demonstrating the transposability of findings from primates to humans, so too robotics reworks the rhetorical ground (and relies on the considerable discursive and material infrastructure laid down since the middle of the last century by the information sciences), to render plausible the transposition of findings from machines to humans. And however pervasive, these moves of transposition go largely unremarked.

Studies on model organisms suggest as well some differences between robots and animal models. Rather than aiming for the creation of a standardized device for use across laboratories (the model organism as technology), in the spirit of entrepreneurial inventiveness robotics researchers must work to distinguish their creations from those of

other laboratories.[17] And while Nelson (2013) describes being chastised by a fellow researcher for anthropomorphizing or ascribing intentions to a mouse under observation, rather than using more carefully chosen descriptors of the mouse's observable behavior (p. 19), attributions of mental state are, as we have seen, central to the premise of robots as 'almost minds'. In other words, while the robotic object is subjectified, the mouse subject is objectified (see also Lynch, 1988; Suchman, 2011). As Nelson elaborates,

> [F]ields such as ethology [are] built around the central premise that only animal behavior (and not the animal mind) is accessible to scientists (Crist, 1999). While a few of the researchers I met privately claimed to have a sense of the subjective experiences of the animals with which they worked, including this information as part of building the case for the use of particular models would create a vulnerable link in the epistemic scaffolding of their models. (p. 21)

Like other technosciences, robotics as a project of creation implicates the array of devices that compose the scientist's toolbox, including his or her body, into the conditions of possibility for the model under construction (see Alač, 2009). Confirming the inseparability of objects and agencies of observation described by Barad (2007) for the apparatuses of the physical sciences (pp. 171–172), the sciences of the artificial construct their research objects in a more literal sense. At the same time, Lucy's case affirms the agencies, including resistances, of the materials that Grand has available to link Lucy's inorganic body to an argument about the nature of the organic, and more specifically human, animal. And as a prototype, Lucy is not only a product of the infrastructures available but also – like the model organism – an argument for funding the longer term initiative and a larger technoscientific institution of humanoid robotics. Like the promise of the primate colony as a domestic source of animal bodies (Friese and Clarke, 2012: 38), the robot suggests that the experimental basis for the biological and human sciences might one day be ensured through bodies that are purpose-built and ready to hand in ways that are similar to, but perhaps go beyond, the standardized animal model of the laboratory. This promise resonates with initiatives in the artificial reproduction of living but endangered organisms described by Friese and Clarke (2012: 39) in the case of cloning. As the traffic between birthing and making intensifies, they argue, subjects are increasingly made to be more like their models (p. 46). Noting the difficulty of creating standardized machines to investigate animal bodies, Friese and Clarke point out that recalcitrance does not simply constitute an obstacle to transposition, but also generates new questions. In the project of animal cloning, attempts to transfer materials and associated theory between species make those species' uniqueness more apparent. So in the case of robotics, a renewed appreciation for specificity and difference over generalizability may ultimately be the most robust line of transposition between the biological sciences and humanlike machines.

'Growing up with Lucy': a natural–technical history

While the model organism focuses our attention on the laboratory, the figure of the primate takes us into the relations of laboratory and field. In her review of primatologists' popular accounts of their relationships with their research subjects, Amanda Rees (2007)

argues for the importance of 'a genre of scientific writing that defies easy classification: part adventure story, part autobiography, part textbook' (p. 882). She sets these writings in the context of post-Second World War research on the sociology of animal behavior, which appeared at a time when nonhuman animals and machines were simultaneously enrolled in the project of a human science. The methodological turn to identifying individual animals in the field facilitated their treatment as unique characters whose behavior and lives could be narrated biographically and, in that way, made intelligible to non-specialist readers. 'What characterizes these narratives, and distinguishes them from the research reports', she observes,

> is not just their description of the context of scientific production, but also their depiction of the animals at the heart of the research process. All of these texts treat the animals as characters, as individuals with lives, feelings, histories, and motives of their own. (Rees, 2007: 883)

She goes on to discuss how both the individualization of the animals and the necessary relation between researchers and their subjects were framed in service to the objectivity of methods. The habituation of the animals to human presence and the close tracking of individuals were essential to the erasure of the human scientists, required in turn for the observation of the animal's 'natural' behavior.

While the concern with maintaining a difference between observation and intervention would seem to distinguish primatology as a field science from robotics as a science based in engineering, roboticists equally aspire to naturalism. More specifically, as we have discussed, robotics objectifies the effects of its engineering efforts through the process of subjectification, in the investment of the robot with agencies independent from those of the roboticist him or herself. The ambivalence of robotics as field and laboratory science is evident in Grand's characterization of Lucy as a 'research platform' designed to help develop ideas about how the human brain might work, animated by her creator's 'curiosity about the nature of life and mind'.[18] Grand's personal web page lists his job as 'Digital god',[19] and this motif of ironic and culturally saturated metaphor permeates his prose (compare Helmreich, 1998). As a research platform for experiments in artificial life, Lucy sits at the intersection of laboratory science, where organisms are engineered to be model subjects, and robotics, where the virtual subject is constructed out of inorganic materials. In the case of the primate laboratory, Haraway (1989) observes that by the 1950s the aim was not simply to study the animal as it was, but simultaneously to demonstrate the plasticity of primate (and by extension human) nature, and model the directions that progressive human engineering should take (p. 64). This melding of observational science and engineering mirrored the promise of its natural–technical object:

> The laboratory animal in general possessed the highest value for human beings precisely because it was *designed* and standardized, in short, engineered, to answer human queries. But the animal's epistemological status was also as a *natural* object yielding objective understandings. (Haraway, 1989: 62, original emphasis)

While the robot operates as a model organism within a regime of invention rather than discovery, Grand lays claim to the latter as well by telling Lucy's story as a natural history.

We can read the 'Lucy' web pages, accordingly, as a kind of Internet-based diorama (Haraway, 1989: 30), presenting the robot's history and habitats through a series of carefully arranged scenes. The earliest announcement of Lucy's birth appears on the Cyberlife-Research website update for August 25, 2000, which lists the date of her 'conception' as May of that year.[20] Grand traces Lucy's ancestry to an autonomously piloted glider project,[21] from which she inherited the servomotor technology that serves as her 'musculature', and he projects her life as a baby orangutan robot forward across successive versions named Lucy MKI and MKII.[22] Her kinship network is drawn on a web page titled 'Some of my friends', with pointers to her 'cousins in the wild and captivity', a collection of primate research and conservation sites, along with websites detailing research on artificial brains, humanoid robots, artificial life, and adaptive systems.[23] Lucy's 'Scrapbook' offers a series of images of Grand at work on Lucy's 'brain' in his home workshop in Somerset, England, and Lucy getting a 'cuddle' from Grand's wife Ann. Reproductive kinship is complicated, as the Grand's son, identified as Lucy's 'big brother', is shown at the workbench as well, contributing to his sister's creation.[24]

Like taxidermy, robotics is organized around the construction of simulacra – realistic restorations out of heterogeneous materials including parts of original flesh in the former case, synthesis out of predominately electronic materials in the latter (see Haraway, 1989: 38). The original plan for Lucy involved the 'skinning' of a stuffed toy orangutan purchased at Toys'R Us, which would become the epidermis for the hardware and circuit boards of Lucy's body. Various practical problems undermined this plan, however, as the necessity of additional circuit boards meant that Lucy 'outgrew' her skin, and an appropriate replacement proved hard to find. These practical problems contributed to a policy of making Lucy's inner workings evident, leaving her a more unapologetically hybrid mix of simulated simian and 'visible robot'.[25] Grand explains that her kinship with toys is meant to signal as well her lack of utility or instrumentality, a sign of basic versus applied research, the general versus the particular.

At the end of 2001, Lucy is given her own website, in the form of a first person Diary. She introduces herself and locates this moment as pivotal in her ontogenic progress and her prospects for future autonomy:

> I was conceived in May 2000, and my dad has steadily been developing my body and the less tricky parts of my brain ever since. Now he's at last about ready to start building the important part – the very large neural network that ties my vision, hearing, voice, muscles and proprioceptors together to make me into a complete organism. After that it's up to me.[26]

A row of snapshots of Lucy 'paper clipped' to the side of the main page suggests that she has made her way out into the world (or at least to the local shopping mall) (Figure 1).[27] She has now assumed her most widely circulating appearance, the unapologetically robotic torso and a rubber mask head, with synthetic orange 'orangutan' hair, and inset 'eyes'.

In April 2002, a new set of pages explains in Grand's voice that Lucy has allowed him to take over her diary in order to report on a setback in the project.[28] These pages include a classically posed 'family portrait' of Ann and Steve Grand, both looking quite severe, with a somewhat demonically countenanced Lucy (Figure 2).

Figure 1. Snapshots of Lucy from her 'Diary'.
Source: http://web.archive.org/web/20021227220202/http://www.cyberlife-research.com/diary/0104.htm (accessed September 2004).

The text explains that while the project is progressing well, perhaps even on the edge of breakthroughs in 'demonstrating many of the major engineering principles that may lie behind the function of mammalian cerebral cortex', the money is running out. In November of that year, however, Grand received a NESTA DreamTime Fellowship for Technology,[29] and as Lucy reports in her diary,

Figure 2. Family portrait.
Source: http://web.archive.org/web/20021020103414/www.cyberlife-research.com/diary/0204.htm (accessed September 2013).

> This means he gets a year's (modest) income, to give him time and space to come up with a whole new me. And there's money for my development – my new body and the tools to make it. I'm going to have my own bank account – he'll have to give me hands this time, so I can sign the cheques! See you when I have new eyes to see you with![30]

The site remains largely unchanged over the following year, until Grand replaces the Diary in 2004 with a new more conventional website format, reporting on Lucy's development but again in Grand's voice.[31] Lucy MKI has been replaced by Lucy MKII, a more elegantly engineered, but also unadorned robotic figure (Figure 3).

Despite the added resources of new tools, however (a lathe, a small computer-aided design (CAD)–computer-aided manufacturing (CAM) machine, a better soldering iron), Grand reports that the project has temporarily foundered on the problem of Lucy's 'musculature', a system of servomotors extended – and complicated – with springs that would approximate both the demands and the possibilities of human muscle control: 'This, combined with a lot of bugs in the very expensive CAD software I'd bought for designing her many circuit boards, meant that the end of the year came and went far too soon'. The money has once again run out, but a popular book about the project (Grand, 2003) sustains the hope of its revival.

Assembling origin stories

With these brief scenes of Grand's designs and desires for Lucy as a backdrop, we return to the question of just how the Lucy project figures a particular conception of human

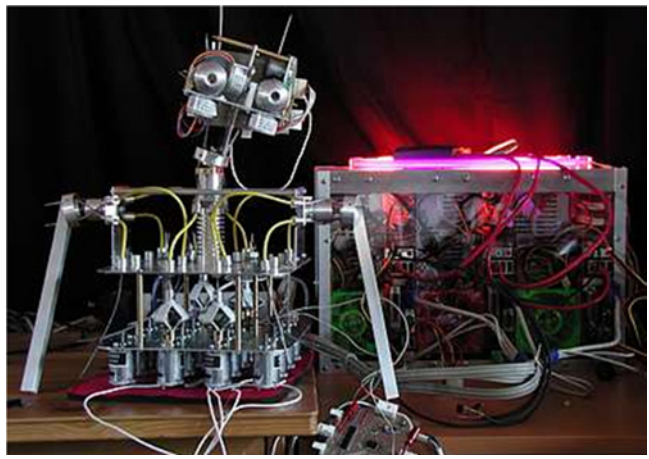

Figure 3. Lucy MKII.
Source: http://web.archive.org/web/20080511160142/http://www.cyberlife-research.com/ (accessed September 2013).

nature. One of Haraway's central observations is that scientific investigations have invested primates with significance as humans' evolutionary antecedents, through whom both the past and potential future of humanity might be observed. Inspired by this argument, we examine how, at the same time that the project of robotics aims at advancing the artificial, in this case the object of that advance is a reconstruction of the natural in the sense of an evolutionary humanism that progresses from primate pasts to machinic futures.

Haraway (1989) observes that naming 'is a key rhetorical device bestowing a particular kind of individuality in the form of an apparently timeless, universal selfhood', which, in the absence of a more particularized history, accrues to the entity in virtue of the naming itself (p. 146). In a narrative arc that identifies Lucy as part of the primate-hominid 'great chain of being', Grand has named his novel robot creation after the fossil Lucy *Australopithecus afarensis*, established in the 1970s as the earliest known human ancestor. Lucy the robot's naming 'after' Lucy *Australopithecus* lays claim to the robot's place in a particular kind of history: not the very immediate conditions that mark Lucy's present time in the early 21st century, but the longer evolutionary history of humanity. As Lucy *Australopithecus*' namesake, moreover, Lucy the robot is linked to a wider scientific and cultural project aimed at establishing the value of the human above other life forms through the truth of its extended, evolutionary history. In the case of paleoanthropology, the stuff of human history is the fossil, the matter from which scientists generate and continually amend the story of evolution. The Lucy *Australopithecus* fossils were unearthed in 1974, and paleoanthropologists constructed the *Australopithecus* skeleton by piecing fragments found at the main site together with others dug from an entirely different site. From the created fact of the resulting skeletal form, scientists generated a specific question that was to be answered in a variety of ways in the years to come: what was the significance of Lucy's erect bipedal structure and small brain casing (Haraway,

1989: 190–193)? Owen Lovejoy, who read into Lucy's bones a story of female limitation, male capacity, and the dawn of the nuclear family, offered one answer to the question. For Lovejoy, the transformation of 'the matrifocal group into the human bifocal "primitive nuclear family" constituted … the key evolutionary turn from ape to man' (Lovejoy, in Haraway, 1989: 192). As in other narratives of the time,[32] Lovejoy's makes Lucy a point of origin for the human within a longer evolutionary trajectory that stretches from before human existence to the present. Grand's naming of Lucy after the *Australopithecus afarensis* skeleton situates Lucy in the same trajectory.

Family ties

However effectively they may work to locate Grand's Lucy in the human evolutionary trajectory, though, dry fragments of bones have their limits. Grand secures Lucy's positioning by linking the robot to a second namesake, Lucy the chimpanzee, who was raised from infancy to adulthood in the home of psychotherapist Maurice Temerlin and his wife Jane, complete with a human sibling named Steven.[33] Grand similarly figures Lucy the robot baby as his and his wife Ann's daughter, as their human son's sibling, and, by extension, as kin to other child-apes who have approximated humans in scientific research on the origins and essence of human nature. Grand's knowing, if playful, identification of Lucy the robot as a primate, coupled with her characterization as a child and daughter whom he is 'growing up' as part of his own family, provides a suggestive set of linkages to the wider scientific and literary nexus of Lucy's creation.

Lucy the robot's association with the live bodies of nonhuman primates – orangutans and other apes – provides further means of balancing her on the almost-human boundary. The orangutan, which Grand identifies as Lucy's prototype in the primate world, has a specific history in the field of primatology. The orangutan has been featured, for example, in the drawing of 19th century racial hierarchies based on skull and facial measurements, and in later 20th-century field studies. Haraway excavates popular culture, field photographs, and scientific writings to expose their racialized underpinnings, in particular their unmarked Whiteness with its attendant racism. In keeping with Grand's location in early 21st-century British scientific and cultural circuits, Grand's own family remains unmarked, while Lucy's physical appearance within the family suggests an uncertain provenance. From this point of view, Grand implicitly posits the White, middle-class, and heterosexual nuclear family as the crucible of humanity, thereby suggesting its universal status while only hinting at possibilities for other, differently marked (by gender, race, class, sexuality, etc.) 'family' groupings. At the very least, Lucy's primate mask bears an ambivalent, albeit unspoken, relation to the contemporary legacies of a range of bodily hierarchies. Does Lucy signify a 'dirtying', or at least rendering more primitive, of the White nuclear family that might be purified through a more successful incarnation of humanlike intelligence? Or does she stand as a counter to discourses of purity, including the separation of the natural from the artificial?

A more explicit trope in the association between Grand's robot and living nonhuman primates is not evolutionary time, but ontogenic development. The robot's association with the second Lucy, the chimp who lived as part of Temerlin's family and was herself named after Lucy *Australopithecus*, situates Lucy the robot on the human/animal and

adult/child boundary. On this border, the child-primate embodies developmental capacities that mirror the human child's. These capacities are normatively tied to the heterosexual nuclear family that nurtures them into full expression. It is clear from Haraway's accounts of child-primates reared in their surrogate fathers' family homes that whatever its specific features may be, the family narrative brings the nonhuman primate into the realm of human nature (the child's developmental potential) and culture (kinship and love).

Haraway's history offers us another primate-child named Prince Chim, a pygmy chimpanzee raised by primate biologist Robert Means Yerkes in the 1920s. In the carefully controlled space of the laboratory, Yerkes used chimpanzees as model organisms for the human. The apes constituted 'pure units of personality', and were therefore 'particularly plastic to reason, called engineering, and could be models for control of the productive forces of human life' (Haraway, 1989: 65). When located outside the laboratory, however, in the domestic space of the home, Chim was less a research subject than a 'surrogate son' (Haraway, 1989: 61). In keeping with this more familial relation, Chim and his female counterpart Panzee traveled with Yerkes to Cuba to visit Mme. Abreu's primate brood, and (like Lucy with the Grands) appeared in a close-up family photograph (Haraway, 1989: 58–59).[34]

Yet like the son who must carry on the family name and business, Chim still embodied for Yerkes a potential that would only be fully realized in the lab. As Haraway (1989) puts it, Chim's

> noble epistemological and moral status inhered not in his closeness to wilderness and to man as hunter, but in his promise as a bright, lively, and docile child in Yerkes' dream of establishing that most modern of institutions – the experimental laboratory. (p. 61)

Consistent with a widespread use of the child in scientific and popular cultures (see Castañeda, 2002), the child's time – childhood – and self ('personality', in Yerkes' terms) function in child-primate histories as sites of possibility from which a later, fully realized project and body will develop. Grand's naming of his robot after Temerlin's Lucy relies on a similar positioning, such that Lucy the robot shares the natural–cultural space of the almost human with Lucy the chimp and her child-primate counterparts. Like all primate-children, Lucy's story is cast in the frame of individual human development, from infancy to adulthood. And Lucy the robot's association with nonhuman primate-children works to install in her the child's developmental potentiality to become fully human.

Conceived by 'Daddy' Steve Grand and cultured in silicon with the aid of her 'Mummy', Grand's wife Ann, Lucy is explicitly the progeny of her creator. And like Lucy the chimp who is taught by the Temerlins to speak American Sign Language, robot Lucy is afforded the basic requirements for normal development through her placement in a nuclear family. Haraway reminds us that the key figure in the nuclear family (as compared to the matrifocal group) is the father-provider. Despite the shadowy presence of the human mother in scientists' stories, it is the father who plays the transformative role in the family drama. In her review of a 1975 *Psychology Today* article on Temerlin and Lucy, Haraway (1989: 399, fn. 23) notes that like Yerkes, who mourned the early death of Chim from respiratory illness, Temerlin had an emotionally intense relationship

with Lucy, complete with parental love and Freudian desire. While Grand does not claim any such emotional bond, he does complain about his paternal 'labour pains', much worse than the 'almost effortless process' of natural childbirth. Father-scientists, including Grand, share in the legacy of masculinist birthing, which is almost always better – less messy and more controlled, and in this case more challenging – than female birthing. Taken together, the tropes of developmentalism, kinship, and childhood endow Lucy with social and cultural trappings that make a collection of wires and bolts into the specific proto-human entity of the roboticist's dreams.

While the heterosexually gendered and reproductive couple is perhaps less dominant than it has been at other times in (even recent) Anglo-US history, it remains central to understandings of human relationality and optimal childrearing. To locate Lucy in this family crucible is to lay claim to the value of her robotic configuration through a kind of commonsense that turns on race and class as well as gender. She is situated in the relational nexus most suited to her proper development as a proto-human, a White middle-class home complete with a mother in charge of domestic tasks and a devoted father encouraging and tracking her development. Even as Grand seeks to distance her from humanness, Lucy's repeated domestication becomes central to her figuration and, arguably, to the limits of Grand's own imagination *of* her imagination. To what extent, in other words, does Grand's figuration of Lucy in these very specific terms suture the mind she 'develops' to the limited domain of the machinic and the human as we know them? To what extent does Grand's imagination *of* Lucy end up limiting the alternative imagination he so passionately seeks to generate?

Refiguring Lucy

In a footnote to *Modest_Witness*, Haraway (1997) poses a challenge to STS scholars:

> How to 'figure' actions and entities nonanthropomorphically and nonreductively is a fundamental theoretical, moral and political problem. Practices of figuration and narration are much more than literary decoration. Kinds of membership and kinds of liveliness … are the issues for all of us. (p. 284)

Our interest in this article has been to think further about the intersection of 'almost human' simian and cyborg figures developed in primatology and robotics. The question of how we (humans) conceptualize the nature of our relations with those entities that are at once like us and not us runs through each of these fields. Rather than treating the question as a comparative one to be contemplated in principle or at a distance, both primatology and robotics address it through forms of direct engagement with the 'others' whom it concerns. While the forms of engagement are understood very differently in each case – as observation on one hand, invention on the other – a closer consideration of the relations involved suggests the generative possibilities of thinking primatology and robotics through each other. Haraway has shown us the multiple ways in which the primate is not a self-same or naturally occurring entity, but a product of our culturally, historically, and politically saturated figurations of the beings classified under that name. And through the cyborg figure, she has equally instructed us on how to appreciate the intimacy of our

Table 1. A progressive natural history of the disciplines.

Field	Approach
Paleoanthropology	Proto/early hominids
Field primatology	Naturalism and rehabilitation
Laboratory primate studies	Social engineering and the model organism
Robotics	Synthesis and the post-(or other than)human

associations with machines. Accounts like Grand's specify these propositions further, making clear that just as the primate is rendered as a technical object, so too the material practices of robotic invention are caught up in naturalized histories of human evolution, development, and kinship. Primate and robot together are forms of natureculture that help clarify how the categories of animal and machine are entangled, while making explicit our investments in their differences from one another, and from the third category of the human.

We share with Grand the premise that imagination is one identifying (albeit probably not exclusive) mark of the human. Rather than locating imagination within the cerebral cortex, however, the STS sensorium directs our attention to cultural imaginaries and the material practices that they animate and that give them their life. Claims about universals always come from particular locations (Haraway, 1989: 211), and cultural imaginaries, however longstanding and widely circulating, are therefore also fundamentally specific. The genealogical and ethnographic inquiry that traces imaginaries is quite different from the search for a holy grail of the human that is true everywhere and for all time. In this spirit, Haraway's (1989) writings about the history of primatology question the assumed innocence of the stories that she reviews, with their 'rigorous exclusion of contextualizing politics' (p. 156). Her project aims, among other things, to restore marks that have been erased.

Primate Visions provides an historical and cultural template that helps us to anchor Grand's more free-floating account of Lucy, and its attendant claims on the human. We have explored the ways in which Grand's account of his robotic project as one of 'growing up' with Lucy conjoins narratives of species evolution and individual development, and places the latter as well within the familiar frame of the father figure and heteronormative Anglo-European kinship. Reading Grand through Haraway, we have traced the ways in which these kinship ties also operate in primatology, which made nonhuman primates the precursors of the hominid, and incorporated individual animals more literally into the human family. Like their counterparts, the child and the nonhuman primate, AI robotics figures its creations as always already constituted sites of potentiality whose realization and elaboration is the work of technoscience. The AI robot's potentiality is temporal in that it allows scientists to reach further backward or forward in time, and material in that it requires the physical construction or reconstruction of bodies. Within humanoid robotics' evolutionary narratives, the central figures are ancestors and progeny, developmental orderings, and teleologies of progress and becoming.

In reading Grand's project through the lens of *Primate Visions*, we can trace a kind of natural history joining paleoanthropology to robotics (see Table 1).

Like many histories, this one suggests a linear progression, where increasingly synthetic projects displace archaeological ones, and engineering replaces science. One of Haraway's central aims is to complicate any simple linearity, however, showing instead the ongoing traffic that operates across and also within the successive historical 'moments' of the natural and social sciences, and undermining associated narratives of progressive development from primate to human. Just as Lucy's figuration relies on resonances between children, nonhuman primates, and AI, so too we can relocate her to the historical and cultural nexus Haraway identifies for primate studies, where these resonances were established. At the same time, the lesson that *Primate Visions* teaches is that while the still lively ghosts of its predecessors haunt each moment in the history of the human sciences, that history is also intricately entangled with contemporary preoccupations. Lucy's story is no exception. By anchoring Lucy the robot in human evolutionary history through the process of naming, Grand lays claim to his robotic project's value in a way that trades on both her actuality (what Grand has achieved to date) and her potentiality (the promise for future incarnation that the Lucy project holds out). The evolutionary story that underwrites these progressions is still there, but now loops back to a new form of creationism for which science and engineering are the invisible hands. The great chain of mechanism follows the same ordering as that of organism; that is, humans are the highest order of machine, for whom the dominion of brain over body is most complete.

In her consideration of the historical and conceptual circuits that link primatology with cybernetics, N. Katherine Hayles (1999) observes that while the former trades in similarities and differences between primate and human, the latter works through analogy of human and machine. As primatology traditionally privileges the old, unchanging, and foundational, cybernetics valorizes the new, malleable, and reconstructable. 'Whereas the most socially loaded arguments in primatology center on inertia', she argues, 'the most socially loaded arguments in cybernetics project acceleration' (Hayles, 1999: 157). Hayles is particularly interested in the trope of the 'life cycle', where the combination of organic and cybernetic results not in any simple anthropomorphic projection, but just as powerfully in 'narrative patterns that overlay upon the arc of human life a map generated from assembly and disassembly zones' (p. 159), in a move that shifts progressively from narrative 'overlay' to irreversible conceptual and material 'interpenetration'.

Writing about the relational shift between nature and artifice in early 21st-century technoscience, Haraway (1997) suggests that nature has become 'a source of certainty and legitimacy for the designed and engineered' (p. 103). Lucy *Australopithecus* and Lucy the robot both involve the assembly from available materials of a narrative of becoming human: the earliest Lucy from various pieces of organic remains – nature – worked up, as Haraway reminds us, through an array of technoscientific rendering and inscription devices, and the most recent Lucy from a heterogeneous assembly of servomechanisms, springs, batteries, circuit boards, and solder. In both cases, circulating cultural historical imaginaries animate these natural–technical creations, and extensive labors sustain them. An evolutionary narrative of becoming intelligent also found the two Lucys, though in the robot's case the machine becomes the universal metaphor for life, and the automaton the ancestor of autonomy.

The grounds of the 'almost human' differ in the case of primates versus robots, in the sense that the primate has a species difference from the human, with its alternate evolutionary and taxonomic place, while the robot's difference lies in its material substrate, as a simulation. But both share the sense of an approximation to the human with respect to capabilities – that is, the potential of becoming more humanlike through various courses of instruction in the one case (e.g. in language use), engineering in the other. More than assembled artifact, Grand's (2003) robot child displaces a commitment to life or consciousness as privileged characteristics of the organic, opening the way for the genesis of a 'mammal-style intelligence' in the machine (p. 37). While inspired by primate/human fantasies, Lucy's abilities are not projected to be simple replicas of primate or human intelligence, but something recognizably intelligent in its own right. As the primate provides a mirror for the human scientist that observes her, and the child for the adult she is to become, the robot mirrors its inventor but also promises something different.

The questions of how the robot could be other than approximate to the human, and how both human and robot could be figured in ways that do not repeat the violence of the generic and the universal, align with the same questions in primatology. Haraway's account of the 'rehabilitation' of the Temerlins' Lucy on Baboon Island in Gambia points in one possible direction. Not at all unproblematic in their colonialist positioning, this and other such camps run by deeply committed, White women scientists in the 1980s nevertheless provided a space for alternative relations between humans and apes. For Haraway (1989), '[t]he people and animals in these stories are *actors* enmeshed in history, not simply objects of knowledge, observers or victims' (p. 129). Writing poignantly about the relationships between the female primatologist Janis Carter and Lucy, Haraway emphasizes the blurring of key categories such as nature and culture, wild and civilized, that are so fundamental to the history of primatology she recounts. Rather than recapitulating that history, 'Lucy's and Carter's cross-species contact may be read as an allegory of reinventing nature in a world where the cost and the work of the construction can no longer be made invisible' (Haraway, 1989: 131).

Unpacking the universal and generic exposes their particularity, and the workings of power that establish certain particulars as the (only) real. At the same time, unpacking is only the first step toward creating alternative figurations and attendant possibilities for a more richly livable future. In the final chapter of *Primate Visions*, Haraway offers a different story, taking as a case in point the text *Primate Societies* (Smuts et al., 1987) published in the same year. She reads the latter as a feminist project, still multiply implicated in its disciplinary inheritance, but offering an antidote to more normative uses of the primate in its commitment to 'specificity and non-reductive difference':

> When biology is practiced as a radically situational discourse and animals are experienced/constructed as active, non-unitary subjects in complex relation to each other and to writers and observers, the gaps between discourses on nature and culture seem very narrow indeed. (Haraway, 1989: 373)

In turning from animals to robots we encounter a different kind of difference, that between the organic and the engineered. In her *Companion Species Manifesto*, Haraway (2003) insists that however imploded the boundaries of nature and culture, organism and

artifact, 'the differences between even the most politically correct cyborg and an ordinary dog matter' (p. 4). This proposition stands in tension with Grand's and other AI researchers' insistence that as humans we *are* machines. The literalization of machinic metaphors erases difference in the name of a new form of hyper-humanism (Haraway, 1989: 110), replacing an a priori commitment to human uniqueness with an equally essentialist investment in fundamental mechanicity. When Haraway (2008) asks, 'How is "becoming with" a practice of becoming worldly?' (p. 4), she opens a new conceptual space for thinking difference and relationality together – what Barad (2007) has developed as the trope of 'exteriority-within-phenomena', the agential cuts through which we are implicated in 'the ongoing reconfigurings of the world' (pp. 140–141). Considered within these conceptual frames, robotics might rethink itself as a very different project, in ways that could not only re-articulate already existing material practices, but also suggest new lines of research and development less focused on the figure of the autonomous human, and more on infrastructures and artifacts for planetary sustainability.

Reading contemporary developments in science and technology is necessary both for identifying the ways in which emerging technological formations revitalize old agendas, and as a means to discover the spaces available for resistance, intervention, and transformation. Read through Haraway's (1991) lens, cyborg figures like Lucy might help us to realize not only Cold War legacies of communication and control, but also 'lived social and bodily realities in which people are not afraid of their joint kinship with animals and machines' (p. 154). What might be needed is a more differentiated set of starting points for the robot that admit possibilities for multiple kinds of bodies and associated capacities, as well as more various cultural environments: not just the nuclear family, but social collectives that more effectively represent and challenge the many forms of relationality that exist both within and outside of the United States, Britain, and Europe; not just the normally developing child, but differently abled bodies; and not just a limited notion of imagination, but varied forms of engagement with the world. Lucy as a cyborg daughter could certainly be part of that re-imagining, as long as she sees beyond the bounds of single, apparently innocent visions of her own ancestry.

Such points of departure are ultimately no more complex than the universalized individual robotic imaginer that Grand is working toward, nor is his project antithetical to them. Sarah Kember (2003) has proposed that 'Grand's insistence on an unconventionally holistic view of the organism in situ mitigates against an unproblematic autonomy and outlines a form of co-evolutionary dependence between organism/agent and its environment' (p. 199). AI robots' necessary embodiment and their co-evolutionary natures only just begin, however, to work against the mind/body split and individualist autonomy so familiar to Western technoscientific imaginaries, including more traditional AI. The directions robotic AI takes remains a question to be answered by the ongoing practices of borrowing and re-tooling already evident in both primate studies and AI. Framed not as the importation of mind into matter, but as the rematerialization of bodies and subjectivities in ways that challenge familiar assumptions about the naturalness of normative forms, primates, robots, and robot-primates might become sites for transformation rather than further reiteration. This requires stories that are implicated, however, aware of the 'circuits' between the discursive and the material, and animated by imaginaries that remember their own histories.

Acknowledgements

We are grateful to three anonymous reviewers for their thoughtful comments and very helpful suggestions for the improvement of this article, and to Donna Haraway who, without knowing who we were, kindly revealed her own identity as a fourth (highly supportive) reviewer. Needless to say, this meant a great deal to us. We are grateful as well to Steve Grand for his generous reading of an early draft, to Michael Lynch for his insightful comments and editorial guidance, and to Sergio Sismondo for his final shepherding of this manuscript to publication.

Funding

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Notes

1. By characterizing the project this way, we by no means want to suggest a universal or singular trajectory, but rather to acknowledge the myriad times and places in which initiatives in what would in contemporary technoscientific discourses be termed 'artificial life' can be sited analytically. Some of the earliest known animal and humanoid automata, for example, are attributed to 13th century Mesopotamian scholar Al Jazari, and the fashioning of what anthropologist Alfred Gell (1998) identifies as '"things" which somehow "appear as", or do duty as, persons' is, arguably, culturally, historically, and geographically ubiquitous (p. 9). For an invaluable introduction to the history and philosophy of artificial life as a more specifically Anglo-European project, see Riskin (2007).
2. This argument is developed at greater length in Suchman (2007b, 2011).
3. We were first introduced to Grand and Lucy through the writings of Sarah Kember (2003). While her study makes only brief mention of Lucy, Kember's analysis of Grand's project and the wider enterprise of artificial life informs our own. The second author subsequently shared a stage with both Grand and Lucy at an event devoted to discussion of 'Creative Evolution' at Goldsmiths College, University of London in February, 2005. The web pages referred to in this article were accessed through the site that Grand previously maintained at http://www.cyberlife-research.com/, and subsequently through the Internet Archives WayBack Machine available at http://web.archive.org/web/20080511160142/http://www.cyberlife-research.com/. This quote was found at http://www.cyberlife-research.com/ (accessed September 2004).
4. Diffraction, a term borrowed from optics, is Haraway's metaphor for the bending, spreading, or splitting effected by the reading of one thing through or against another; see Haraway and Goodeve (2000: 103). For an extensive discussion, see Barad (2007, ch. 2).
5. Haraway urges us to emphasize that the figures, discourses, and natures examined in *Primate Visions* are themselves each nationally located, and that race, gender, species, and so on are never, in themselves, 'universal' categories (personal communication).
6. For critical and contextualizing histories of AI, see Adam (1998), Dreyfus (1992), Edwards (1996), Hayles (1999) and Suchman (2007a). For more on Grand's vision of 'New AI', see Kember (2003).
7. The premise that agency is measurable through autonomy is itself, of course, a culturally and historically specific one. For an illuminating repositioning of robotic sociality from inherent capacities of either humans or robots to the generative effects of bodies-in-interaction including, centrally, the bodies of roboticists' themselves, see Alač (2009) and Alač et al. (2011). Alač et al. (2011) demonstrate in detail that robots, like humans, 'become legible as social

actors in relation to careful interactional engagements and the spatial arrangements of people and things' (p. 920). See also Suchman (2011). On human–animal bodies-in-interaction, see Crist (1999) and Despret (2004).

8. The cultural specificity of robotics projects is complicated by the density of transnational traffic within computer science and engineering. As one example, Joan Fujimura's (2005) investigation of computer science's influence in the field of systems biology takes her to the laboratory of Japanese roboticist Kitano, distinctive for its synthesis of computational modeling with 'wet lab' experimentation. In systems biology, as in humanlike robotics projects, cybernetics provides the machine model that in turn informs investigation into the workings of the organism. Before turning to systems biology, Fujimura (2005) observes, Kitano helped to develop 'a robot with humanlike neuronal control systems that would enable the robot to learn and develop. This was SONY's AIBO', another companion species look-alike (pp. 211–212). Jennifer Robertson (2010) examines popular cultural inflections of robotics in Japan, with particular attention to the heteronormative gendering of both roboticists and their artifacts. Most recently, Selma Šabanović (2014) considers how roboticists in Japan themselves invoke cultural specificity in accounting for their projects, in a process that she names the 'repeated assemblage' of models of Japanese culture which are mobilized to legitimate robotics projects, and are in turn legitimated by the artifacts that are produced.
9. The sense of embodiment here is far from that developed within contemporary feminist theory. See, for example, Butler (1993), Grosz (1994), Shildrick and Price (1999), and Schiebinger (2000). For a discussion of the difference between physicality and embodiment from a friendly critic within the cognitive sciences and philosophy of mind, see Boden (2006).
10. Boden (2006) refers briefly and dismissively to Grand's 'robot-gorilla', and attributes its interest on the part of the media to its fur coat, of which more below. Again, our engagement with Grand and Lucy is not on the basis of their prominence in the field, but rather their generative resonance with the child/robot/primate intersections that join our respective interests with Haraway's writings. At the same time, we mean to take seriously both Lucy's particular species identification and her mediagenic figuration; the latter serves more to align her with other projects in humanoid robotics, we would argue, than to set her apart.
11. 'Lucy's FAQ' available at: http://web.archive.org/web/20030604111509/cyberlife-research.com/about/faq.htm (accessed September 2013).
12. Other famous robot children include Breazeal's Kismet; CB2, a child robot developed by Minoru Asada and colleagues at Osaka University as part of the Cognitive Developmental Robotics project; and Nico, in development by Brian Scasselati (formerly of the MIT AI Lab and co-creator of Kismet) and his students at Yale University. Our thanks to one of the anonymous reviewers of this article for reminding us of the larger cohort of which Lucy is part.
13. 'Lucy's FAQ' available at: http://web.archive.org/web/20030604111509/cyberlife-research.com/about/faq.htm (accessed September 2004).
14. 'Lucy's FAQ' available at: http://web.archive.org/web/20030604111509/cyberlife-research.com/about/faq.htm, 'How will her brain work?' (accessed September 2013).
15. 'Lucy's FAQ' available at: http://web.archive.org/web/20030604111509/cyberlife-research.com/about/faq.htm (accessed September 2004). Kember (2002) mentions Lucy as one of Grand's future projects, of which he says, 'I'm trying to create a robot that can make plans and rehearse them in her head – that is, she will have an imagination' (p. 114).
16. See also Clarke (1987), Lynch (1988), Kohler (1994), Keller (2000). Creager (2002), Rader (2004), Asdal (2008), Davies (2010) and Nelson (2013).
17. In this respect, robots are perhaps more accurately characterized as 'experimental' rather than 'model' (in)organisms, insofar as the latter 'are a specific subgroup of organisms that have been standardized to fit an integrative and comparative mode of research' (Ankeny

and Leonelli, 2011: 313). As we have mentioned, Ankeny and Leonelli argue as well for a more restricted definition of the model organism as 'distinctively biological' (p. 314). While acknowledging the care and precision of their review, we allow ourselves some greater poetic license here in order to trace the imaginaries that travel between the biological sciences and the sciences of the artificial.

18. 'Where will it all lead?' available at: http://web.archive.org/web/20030604111509/cyberlife-research.com/about/faq.htm (accessed September 2013).
19. 'SteveGrand'spersonalpages'availableat:http://web.archive.org/web/20020811051339/www.cyberlife-research.com/people/steve/index.htm (accessed September 2013).
20. 'Meet Lucy!' available at: http://web.archive.org/web/20001003233743/www.cyberlife-research.com/Lucy/index.htm (accessed September 2013). Relations of conception and birth become ever more imploded in the case of artificial life forms.
21. Like many of her predecessors, Lucy's origins trace back to military roots. Kember (2003) reports that in 1998 CyberLife signed a contract with the Ministry of Defense's Defense Evaluation Research Agency 'to construct an artificial pilot capable of flying a simulated military aircraft' (p. 107).
22. This naming follows the engineering convention of designating prototypes as 'Mark 1', 'Mark II', and so on, to indicate their level of development, a convention that derives from the making of a 'mark' to measure height or progress.
23. 'Some of my friends' available at: http://web.archive.org/web/20020805025556/http://www.cyberlife-research.com/friends/index.htm (accessed September 2013).
24. 'My Scrapbook' available at: http://web.archive.org/web/20021203232440/http://www.cyberlife-research.com/scrapbook/index.htm (accessed September 2013).
25. Lucy's Diary (of which more below) reports an early encounter with the press, before she had outgrown her body suit:

    There was a funny thing about the photographers. They asked mum if she could take off my body skin, so they could see my insides. Artistically, I have to agree they were quite right – when I'm still, I look like just any old stuffed toy. But when mum offered to take off my head skin, they went all squeamish – "ah god no!" they said. Odd people, humans – naked bodies are OK, but naked heads aren't! (April 2001; available at: http://web.archive.org/web/20021227220202/http://www.cyberlife-research.com/diary/0104.htm, accessed September 2013)

26. 'About me' available at: http://web.archive.org/web/20021003190121/http://www.cyberlife-research.com/about/index.htm (accessed September 2013).
27. 'April 2001' available at: http://web.archive.org/web/20021227220202/http://www.cyberlife-research.com/diary/0104.htm (accessed September 2004). This image was subsequently removed from the site and we are unable to relocate it.
28. 'November 2002' available at: http://web.archive.org/web/20021020103414/www.cyberlife-research.com/diary/0204.htm (accessed September 2013).
29. NESTA is UK's National Endowment for Science, Technology and the Arts.
30. 'Novemer 2002' available at: http://web.archive.org/web/20030206184256/www.cyberlife-research.com/diary/0211.htm (accessed September 2013).
31. 'Welcome to Cyberlife Research' available at: http://web.archive.org/web/20080511160142/http://www.cyberlife-research.com/ (accessed September 2013).
32. Haraway notes as well Lucy's changing significance at the hands of sociobiologist E. O. Wilson, for whom Lucy takes on a newly central role. In Wilson's account of social strategy as the motor of evolutionary change,

> [t]he key fossil was no longer the hunter australopithecine confidently striding out into history, but the diminutive bipedal Lucy facing a reproductive crisis as her body failed her in difficult ecological times, requiring that she tie herself to her husband at all costs. (Haraway, 1989: 127–128)

33. Grand's book title, *Growing Up With Lucy* is a direct citation of Temerlin's 1976 book *Lucy: Growing Up Human*. Grand mistakenly identifies Temerlin with the first name 'Richard'. See 'Why's she called Lucy?' available at: http://web.archive.org/web/20030604111509/cyberlife-research.com/about/faq.htm (accessed September 2013). On Maurice Temerlin, see Haraway (1989: 59, 129–32, 39).
34. In his comments on this article, Michael Lynch reminded us of 'Nim Chimpsky', a chimpanzee subjected to an extended series of experiments on language acquisition at Columbia University during the closing decades of the 20th century. Nim's name links him, via a pun, to the famous language theorist Noam Chomsky. Lynch points out that just as Chomsky's great opponent B. F. Skinner subjected his own child to experiments in operant conditioning employing the (in)famous Skinner box, Chomsky's nuclear family itself became an occasion for studying language acquisition. In an observation resonant with Castañeda's (2002) inquiry into the figure of the child, Lynch points out that sometimes human children are made to serve as model organisms as well.

References

Adam A (1998) *Artificial Knowing: Gender and the Thinking Machine*. New York: Routledge.

Alač M (2009) Moving android: On social robots and body-in-interaction. *Social Studies of Science* 39(4): 491–528.

Alač M, Movellan J and Tanaka F (2011) When a robot is social: Spatial arrangements and multimodal semiotic engagement in the practice of social robotics. *Social Studies of Science* 41(6): 893–926.

Ankeny RA and Leonelli S (2011) What's so special about model organisms? *Studies in History and Philosophy of Science Part A* 42(2): 313–323.

Asdal K (2008) Subjected to parliament: The laboratory of experimental medicine and the animal body. *Social Studies of Science* 38(6): 899–917.

Barad K (2007) *Meeting the Universe Halfway: Quantum Physics and the Entanglement of Matter and Meaning*. Durham, NC: Duke University Press.

Boden MA (2006) Robots and anthropomorphism. Available at: http://www.aaai.org/Papers/Workshops/2006/WS-06-09/WS06-09-013.pdf (accessed on 27 November 2013).

Brooks RA (1999) *Cambrian Intelligence: The Early History of the New AI*. Cambridge, MA: The MIT Press.

Brooks RA (2002) *Flesh and Machines: How Robots Will Change Us*. New York: Pantheon Books.

Butler J (1993) *Bodies that Matter: On the Discursive Limits of 'Sex'*. New York: Routledge.

Castañeda C (2001) Robotic skin: The future of touch? In: Ahmed S and Stacey J (eds) *Thinking through the Skin*. London: Routledge, pp. 223–236.

Castañeda C (2002) *Figurations: Child, Bodies, Worlds*. Durham, NC: Duke University Press.

Clarke AE (1987) Research materials and reproductive science in the United States, 1910–1940. In: Geison GL (ed.) *Physiology in the American Context, 1850–1940*. Bethesda, MD: American Physiological Society, pp. 323–350.

Creager ANH (2002) *The Life of a Virus: Tobacco Mosaic Virus as an Experimental Model, 1930–1965*. Chicago, IL: The University of Chicago Press.

Crist E (1999) *Images of Animals: Anthropomorphism and Animal Mind*. Philadelphia, PA: Temple University Press.

Dautenhahn K, Bond AH, Cañamero L and Edmonds B (eds) (1986) *Socially Intelligent Agents: Creating Relationships with Computers and Robots*. Oxford: Kluwer.
Davies G (2010) Captivating behaviour: Mouse models, experimental genetics and reductionist returns in the neurosciences. In: Parry S and Dupré J (eds) *Nature after the Genome*. London: SAGE, pp. 53–70.
Despret V (2004) The body we care for: Figures of anthropo-zoo-genesis. *Body & Society* 10(2–3): 111–134.
Dreyfus HL (1992) *What Computers Still Can't Do: A Critique of Artificial Reason*. Cambridge, MA: The MIT Press.
Easlea B (1973) An introduction to the history and social studies of science: A seminar course for first-year science students. *Science Studies* 3(2): 185–209.
Edwards PN (1996) *The Closed World: Computers and the Politics of Discourse in Cold War America*. Cambridge, MA: The MIT Press.
Friese C and Clarke AE (2012) Transposing bodies of knowledge and technique: Animal models at work in reproductive sciences. *Social Studies of Science* 42(1): 31–52.
Fujimura JH (2005) Postgenomic futures: Translations across the machine-nature border in systems biology. *New Genetics and Society* 24(2): 195–225.
Gell A (1998) *Art and Agency: An Anthropological Theory*. Oxford: Oxford University Press.
Grand S (2003) *Growing Up with Lucy: How to Build an Android in Twenty Easy Steps*. London: Weidenfeld & Nicholson.
Grosz E (1994) *Volatile Bodies: Toward a Corporeal Feminism*. Bloomington, IN: Indiana University Press.
Haraway D (1989) *Primate Visions: Gender, Race and Nature in the World of Modern Science*. New York: Routledge.
Haraway DJ (1991) *Simians, Cyborgs, and Women: The Reinvention of Nature*. New York: Routledge.
Haraway DJ (1997) *Modest_Witness @Second_Millenium.FemaleMan©_Meets_OncoMouse™: Feminism and Technoscience*. New York: Routledge.
Haraway D (2003) *The Companion Species Manifesto: Dogs, People, and Significant Otherness*. Chicago, IL: Prickly Paradigm Press.
Haraway DJ (2008) *When Species Meet*. Minneapolis, MN: University of Minnesota Press.
Haraway DJ and Goodeve TN (2000) *How Like a Leaf: An Interview with Thyrza Nichols Goodeve*. New York: Routledge.
Hayles NK (1999) *How we Became Posthuman: Virtual Bodies in Cybernetics, Literature, and Informatics*. Chicago, IL: The University of Chicago Press.
Helmreich S (1998) *Silicon Second Nature: Culturing Artificial Life in a Digital World*. Berkeley, CA: University of California.
Keller EF (2000) Models of and models for: Theory and practice in contemporary biology. *Philosophy of Science* 67(Suppl.): S72–S86.
Keller EF (2007) Booting up baby. In: Riskin J (ed.) *Genesis Redux: Essays in the History and Philosophy of Artificial Life*. Chicago, IL: The University of Chicago Press, pp. 334–345.
Kember S (2003) *Cyberfeminism and Artificial Life*. London and New York: Routledge.
Kohler RE (1994) *Lords of the Fly: Drosophila Genetics and the Experimental Life*. Chicago, IL: The University of Chicago Press.
Lynch ME (1988) Sacrifice and the transformation of the animal body into a scientific object: Laboratory culture and ritual practices in the neurosciences. *Social Studies of Science* 18(2): 265–289.
Menzel P and D'Aluisio F (2000) *Robo Sapiens: Evolution of a New Species*. Cambridge, MA: The MIT Press.

Nelson NC (2013) Modeling mouse, human, and discipline: Epistemic scaffolds in animal behavior genetics. *Social Studies of Science* 43(1): 3–29.
Rader K (2004) *Making Mice: Standardizing Animals for American Biomedical Research, 1900–1955*. Princeton, NJ: Princeton University Press.
Rees A (2007) Reflections on the field: Primatology, popular science and the politics of personhood. *Social Studies of Science* 37(6): 881–907.
Riskin J (ed.) (2007) *Genesis Redux: Essays in the History and Philosophy of Artificial Life*. Chicago, IL: The University of Chicago.
Robertson J (2010) Gendering humanoid robots: Robo-sexism in Japan. *Body & Society* 16(2): 1–36.
Šabanović S (2014) Inventing Japan's 'robotics culture': The repeated assembly of science, technology, and culture in social robotics. *Social Studies of Science* 44(3): 342–367.
Schiebinger L (ed.) (2000) *Feminism & the Body*. Oxford: Oxford University Press.
Shapin S and Schaffer S (1985) *Leviathan and the Air-Pump: Hobbes, Boyle, and the Experimental Life*. Princeton, NJ: Princeton University Press.
Shildrick M and Price J (1999) Openings on the body: A critical introduction. In: Price J and Shildrick M (eds) *Feminist Theory and the Body: A Reader*. Edinburgh: Edinburgh University Press, pp. 1–14.
Smuts BB, Cheney DL, Seyfarth RM, Wrangham RW and Struhsaker (eds) (1987) *Primate Societies*. Chicago: University of Chicago Press.
Suchman LA (2007a) Feminist STS and the sciences of the artificial. In: Hackett EJ, Amsterdamska O, Lynch M and Wajcman J (eds) *The Handbook of Science and Technology Studies*, 3rd edn. Cambridge, MA: The MIT Press, pp. 139–163.
Suchman LA (2007b) *Human-Machine Reconfigurations: Plans and Situated Actions*, rev. edn. New York: Cambridge University Press.
Suchman L (2011) Subject objects. *Feminist Theory* 12(2): 119–145.

Author biographies

Claudia Castañeda is Senior Scholar in Residence in the Institute for Interdisciplinary Studies at Emerson College. Her prior work concerned figurations of the child in transnational circuits of exchange, and her current research addresses transgender childhood at the nexus of medical practice, disciplinary power, and transgender politics. She also works as a freelance developmental editor.

Lucy Suchman is Professor of Anthropology of Science and Technology in the Department of Sociology at Lancaster University, and Co-Director of Lancaster's Centre for Science Studies. Before taking up her present post, she spent 20 years as a researcher at Xerox's Palo Alto Research Center. Her current research extends her critical engagement with the field of human–computer interaction to contemporary warfighting, including the figurations that inform immersive simulations, and problems of 'situational awareness' in remotely controlled weapon systems.