Educating the Eyes: Biocultural Anthropology and Physical Education

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Abstract: Diverse forms of physical education form in their participants' skills, perceptual abilities and physiological adaptations that distinguish them from practitioners of other activities. These traits, many unconscious, are little studied in sociocultural anthropology in spite of their widespread prevalence. This article specifically explores how practitioners of *capoeira,* an Afro-Brazilian dance and martial art, learn to do a *bananeira,* a form of handstand. Its form, practical demands and training techniques make the bananeira a radically different exercise than other forms of handstand, such as that done by gymnasts. Capoeira practitioners develop a distinctive sense of balance—a dynamic assembly of perceptual skills and motor responses—that they use to keep upright while inverted. Across all cultures, forms of physical education and apprenticeship assemble distinctive physical skills, forms of cultural difference that should be defended as ardently as other forms of distinctiveness.

Keywords: Perceptual learning, physical education, embodiment, capoeira

Introduction

One can search anthropological studies of education for references to physical education long and hard without finding many. In spite of its invisibility, physical education—sports, games, dance, drills and other bodily activities—is pervasive crossculturally, not only in formal schooling, but also in training of all sorts, such as religious orders, military indoctrination and social initiation. Many factors are likely to contribute to this invisibility, but sociocultural anthropologists often seem to neglect bodily variability because they fear that even to entertain discussions of physiology invites biological determinism. Whatever the reasons for the neglect, the effects are detrimental to sociocultural anthropology, to theorising embodiment, to applying our discipline to education and human development, and to engaging in public debates about the variability of human physiology (see Downey 2005a).

Sport would appear to be the ideal field for anthropologists to study embodiment because athletes induce extraordinary variety in their own physiques. Robert Sands has argued that 'the holistic, cross-cultural and ethnographic traditions that define anthropology as an endeavor have never been more pronounced than in the field of sport' (1999: xiv). In sport, cultural values clearly take hold of the individual's development, both psychologically and physiologically, in obvious, tangible practices that an ethnographer might easily examine. In the Western world, exercise regimens and diet have emerged as two of the preeminent dimensions of 'technologies' for ethical self-formation, what Foucault calls 'technologies of the self' (Foucault 1988). In addition, athletes subject themselves (or their elders subject them) to physical regimens so arduous that no researcher could ever entice a subject—ethically or practically—to adhere to them merely for research purposes.

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In this essay, a close study of a single skill from an Afro-Brazilian art, *capoeira*, a form of physical education, demonstrates how skill acquisition undermines both over-cognitive models of culture and simplistic understandings of physical education as promoting a universalised notion of 'health'. This article focuses particularly on the *bananeira,* the 'banana tree', a form of handstand that practitioners of capoeira learn. The practical demands and teaching strategies of the bananeira pose a range of physical challenges for the practitioner to 'solve' on the way to acquiring the skill. Comparing the bananeira to other inverted postures will demonstrate that, when a *capoeirista,* or capoeira practitioner, grows accomplished in the bananeira, he or she is not learning a reified movement, like a motor programme or automatic reflex. The skill alters the sensitivity of practitioners' central nervous systems, their behavioural repertoires, their sensory information flows and even their bodies' gross structure. The acquisition of the skill shapes the body.

Understanding skill acquisition as physiological, neurological, perceptual and behavioural modification suggests that physical education activities are not interchangeable. Each skill set shapes peculiar clusters of physical traits in its practitioners' bodies. Cultural distinctiveness inheres not only in behavioural patterns and cognitive 'contents'—symbols, signs, representations—but also in the way that physical practices shape the unfolding development of a skilled body. The bananeira differs from an Olympic handstand, for example, in the specific skills that it encourages players to develop, not merely in its outward form or aesthetic principles. For anthropologists to neglect physical education means that we ignore the pervasive, subtle cultivation of physically distinct, enabled bodies. Recognising particular physical patterns of what Tim Ingold (2000: 417) has termed 'enskilment' leads to an appreciation of the diverse ways in which societies raise their children. Culturally distinct forms of physical education shape distinctive bodies in a literal sense, forging muscles, crafting tendons, assembling sensory systems and generating physical capabilities.

The Case of Capoeira

Capoeira is a physically demanding, acrobatic martial art and dance. Two players at a time enter a *roda,* or capoeira ring, where they try to out-manoeuvre, outwit, trip or knock down their adversary, all the while harmonising their movements with music provided by a percussion ensemble and call-and-response songs. The game has both cooperative and competitive dimensions, and typically results in no clear 'winner', players simply deriving satisfaction from the give and take of interaction. To someone who has never seen the genre, the traditional style, *Capoeira Angola,* resembles slow-motion, noncontact sparring between circus performers, or perhaps two break-dancers play-fighting.[1]

Prior to its incorporation into 'physical education' and contemporary sports culture in Brazil, capoeira was an informal type of technical-bodily education, among Afro-Brazilian and mixed-race working men in the state of Bahia in Brazil's northeast. Although Brazilian police once persecuted the practice, along with other Afro-Brazilian customs such as *candomblé* religious ceremonies, capoeira is now taught in sporting academies, fitness classes and school physical education programmes (Assunção 2005). One can still see, however, adolescent boys doing the game's distinctive cartwheels and kicks on the beach, sometimes playing pick-up games in the streets, or even joining in more formal capoeira rodas held on special occasions in public plazas.

While in Brazil from 1993 to 1995, I worked closely with the *Grupo de Capoeira Angola Pelourinho,* an organisation dedicated to the practice and preservation of *Capoeira Angola,* the form of capoeira considered the most traditional by many scholars and practitioners. The GCAP

(Grupo de Capoeira Angola Pelourinho) took its name from the Pelourinho region of Salvador, the former capital of Brazil and the current state capital of Bahia. The Pelourinho neighbourhood was part of colonial Salvador's 'Upper City', the region on the bluff over-looking the Bay of All Saints where the city's oldest cathedrals, first medical school, governor's home, and fortresses had been built. Named after the *pelourinho,* or 'whipping pole', that once stood in a central plaza, Pelourinho neighbourhood's economic fate was rebounding after decades of decay and neglect. Police routed squatters and poor families from the region and restored colonial buildings, painting them bright colours and turning them into trendy boutiques and restaurants as part of a massive effort to make Salvador an attractive tourist destination.

Squeezed between city officials' aspirations, tourism projects and the poverty of many families in Salvador was a host of *meninos da rua* (children of the street), children who spent most, if not all, of their days fending for themselves. Some fled violent or impoverished homes, hoping for better on their own; others were abandoned by parents too ill, too poor or too addicted to take care of them. Some families could not afford to keep their children in school, so they played in the city's parks, begged for change, sold sweets on buses, or otherwise spent their days unsupervised. In Rio de Janeiro in 1994, a death squad composed of off-duty police officers massacred seven sleeping street children on the front steps of Candelaria Church, drawing international attention to the plight of these children.

In Salvador, an award-winning nongovernmental organisation, *Projeto Axé,* sought to bring meninos da rua in from the streets, to teach them essential skills, and to provide them with cultural activities to reinforce their self-esteem. The Grupo de Capoeira Angola Pelourinho was a partner organisation in Projeto Axé, teaching a group of children Capoeira Angola. Other partners enrolled children in drumming classes, in circus arts or in training to sew costumes, some for an internationally renowned carnival group. Dozens of children, aged about seven to sixteen, attended GCAP's capoeira sessions in the collapsing Forte de Santo Antonio, a decrepit former prison that gained a new life as a centre for popular culture in the 1990s. In GCAP, the children of Projeto Axé received a hot meal, elementary education, classes on Afro-Brazilian culture and capoeira training.

When I asked members of GCAP, including its educational director, to explain the benefits of teaching Capoeira Angola to the children, group members invariably asserted that the children developed ethnic pride and gained self-esteem. The meninos da rua were disproportionately of African descent, and they faced a popular culture with pervasive racial biases and prejudices. Exposed to few dark-skinned popular figures outside sports or entertainment, and taught nothing about Africans' contributions to Brazilian culture, the children assumed that being *negro,* or Afro-Brazilian, limited their life choices, according to the vice-president of GCAP. Classes in capoeira demonstrated the cultural legacy of Africans and their descendants in Brazil. In addition, GCAP argued publicly that capoeira was an artefact of resistance against slavery, oppression and racist mistreatment (e.g., GCAP 1989; GCAP 1993). The Afro-Brazilian art, with traditional songs and oral history, was a living record of defiance. Members of the group's board of directors argued that this history of resistance helped the students develop a critical perspective on Brazilian society and reinforced 'citizenship' *(cidadania),* that is, awareness of one's rights and responsibilities as a member of Brazilian society.

Although this answer was politically savvy, the connection between classes in movement techniques, on the one hand, and ethnic pride, personal dignity and social change, on the other, seemed remote. If sociopolitical awareness, shared historical memory and ethnic pride were the goals of capoeira practice, why could they not be pursued directly, without recourse to an arduous physical practice? To become politically conscious, why was it necessary for Afro-Brazilian children to spend hours and hours each week kicking, dodging, learning acrobatics, standing on their hands or playing musical instruments? The fact that the group lectured the children explicitly on political, historical and ethnic matters seemed to demonstrate that they were not wholly convinced that physical practice alone might have the desired effect on the children's consciousness.

Much of the academic literature on physical education is equally unhelpful for exploring the links between group identity and distinctive forms of bodily practice; this literature focuses on health and activity level, making irrelevant any differences between types of physical education, except for the grossest quantitative distinctions, such as between 'high', 'moderate' and 'low intensity', or universalising qualitative distinctions, such as the contrast of 'aerobic' and 'anaerobic' activities. This tendency to lump physical education types by activity level is especially pronounced due to concerns about obesity, battles over educational funding, and recognition that boys and girls demonstrate different patterns of activity (for a review, see Dufour 1997). Although these studies cannot agree on what is an 'optimum level' of activity for children (Puhl et al. 1990), the strong normative orientation of public health-influenced anthropological studies makes it difficult to ask what might be important about the distinctive practical and kinesthetic character of capoeira, if anything. Hay and Shephard's (1998) comparison of physical activity among Mohawk or Cayuga youth and among non-native adolescents in Southern Ontario, for example, focuses almost entirely on the increasingly sedentary lifestyle of Native Americans, marking no distinctions between prior 'vigorous physical activity' and contemporary physical education, no doubt because of their concern about increasing rates of chronic disease associated with inactivity.

Turning attention instead to skill development, specifically its neurological and perceptual impact, the subtle distinctions among sports of the same 'intensity' are taking on greater relevance. Although all may be strenuous, the practical demands of long-distance running, football, wrestling, gymnastics, chasing animals, defending oneself, climbing trees or carrying water are obviously great. Moreover, studies of neural plasticity increasingly reveal that what were once considered to be fixed biological structures, such as regional specialisation in the cortex, in fact, may be liable to extensive remodelling through shifts in activity patterns (Huttenlocher 2002). Human (and animal) skill development typically entails some degree of physiological change (see, for example, Salmon and Butters 1995; Karni and Bertini 1997; Karni et al. 1998; Gilbert et al. 2001; Hermer-Vazquez et al. 2005). If practising the violin or learning to read Braille has measurable effects on the brain's structure, what might learning capoeira or other demanding physical disciplines do to the brain?

As Tim Ingold (1998: 31) writes, 'in the course of their social lives', humans '*grow* one another, establishing by their actions the conditions for each other's development'. For anthropologists to sit idly by while this source of human variety is under attack is akin to watching language extinction; we do not even realise what perceptual abilities and physiological variety, induced by the conditions we create for children's development, are extinguished as the variety of games and forms of physical training yield to uniform exercise regimens dedicated to maintaining high heart rates, decreasing obesity statistics and meeting measurable standards. For this reason, the members of GCAP, who advocate the inclusion of traditional physical arts in education, in my opinion, hold open routes to ways of perceiving and being in the world that might otherwise be closed. Capoeira Angola is important, not simply because it teaches children self-esteem or ethnic identity, but because it teaches them to listen like capoeiristas, to see in distinctive ways and to balance using a novel conjunction of motor skills and senses.

The World Turned Upside-Down

Players of Capoeira Angola spend a great deal of time upside-down, their bodies inverted while they balance on their hands or heads. When students first start taking classes, they are pushed to develop equilibrium when inverted: they are told that they should work hard to demonstrate this hallmark of the traditional style. During a capoeira event at a nontraditionalist school, for example, a teacher of a 'modernised' style called me over during a game and told me to 'jump up more on your hands, *angoleiro*'. While I was trying to conform to the movement style of this non-Angola school, even this instructor wanted me to demonstrate this characteristic movement trait, perhaps so that his students might gain experience facing the traditional techniques.

When members of the Grupo de Capoeira Angola Pelourinho move close to the ground, they frequently employ the head as a fifth limb, putting their weight on it in moves such as the *bananeira na cabeça* ('banana tree on the head', or headstand) and the *aú na cabeça* (a cartwheel done with the head on the ground). The head also holds up the body in acrobatic flourishes such as the *pião* (the 'top', in which the body spins upside-down, balanced on the top of the head) or the *escovão* (the 'big brush' or 'push-broom', a horizontal slide on the top of the head across the floor), as well as a host of transitional moves and unnamed variants on the headstand.[2]

Academic researchers have tended to treat inverted capoeira postures as signs to be interpreted. For example, the upside-down body is sometimes considered to be a symbol of social inversion, when the lowly, like the feet, are raised up. Other scholars treat inversion as a carnivalesque reversal of daily order, when concerns of the 'mind' that normally dominate are temporarily subordinated to bodily acumen. Or, some scholars suggest that inverted posture is a reference to an 'upside-down' world of the afterlife or African spirituality.[3]

No doubt, an upside-down body can serve as a powerful symbol for some players. But one also has to ask what has to happen to a person in order to be able to balance inverted, and whether acquiring the skill has effects on perception, identity or behaviour. If so, the changes produced by the bananeira are 'cultural' in that they are neither universal nor inevitable, but rather induced by variations in how humans are raised; but the traits might also be seen as 'biological' because they directly affect a person's body rather than simply influencing a separate ideational or mental realm. By treating the bananeira as a skill rather than a symbol, and by attending to its physiological effects, we might better see how the hours spent honing one's equilibrium in a distinctive, 'cultural' fashion, with social incentives, models and coaching, has measurable 'biological' effects on perception and physiology.

The 'Sense' of Balance

In order to maintain upright posture, people typically make use of a number of senses and, from these different flows of information, assemble the information needed to keep their bodies balanced (Massion 1994; Horak and Macpherson 1996; van der Kooij et al. 1999). Normal postural control in an upright position, for example, is maintained by sensations from the legs due to their position, from the semicircular canals in the inner ear, from the otoliths (small bones in the ears), from pressure sensors in the bottom of the feet, and from vision (Mergner et al. 2003). When we stumble forward, we notice that we are falling because the otoliths and ear canals sense a sudden acceleration, our legs feel out of position under us, our joints no longer align in familiar angles, the pressure diminishes on the bottoms of our feet, our frontal visual field suddenly starts to fill with the ground, and our peripheral vision detects the blur of movement or 'optic flow'. In other words, the 'sense' of balance is actually a synthesis of diverse inputs. In addition, however, the 'sense' of balance is not just a passive avenue for taking in information. While we are moving, our awareness of our own movement is combined with our perception of the environment; we recognise that the acceleration of our head is normal for walking, not a sign that we are toppling over.

Ecological psychologist James Gibson (1966; 1979) is the best-known advocate for considering senses as 'perceptual systems', that is, complexes of sensory, motor and behavioural components that allow us to search, perceive and interact with our environment. Gibson noted that senses, like vision, are not the passive function of an isolated organ. Sight is an active ability to engage with the world that deploys, not merely the eyes, but other parts of the body: orienting muscles that turn and focus the eyes, a rotating head, a guiding ear, a swivelling neck, a trained brain and a mobile body. And this sense must be coupled with the motor skills necessary to act upon perceptions. The 'sense of balance', for example, is a motor-sensory complex that keeps us upright, not just a mechanism for detecting shifts in balance. When standing, the 'sense of balance' includes the hips and ankles, which figure predominantly in correcting for the constant swaying of our body, adjustments so slight and automatic that we do not typically perceive them.

Most contemporary students of how humans maintain upright postures when moving suggest that equilibrium results not so much from rigid stability or a fixed action pattern, but rather from keeping the body's position under surveillance and quickly compensating for sway or to correct imbalance. Very close studies of balance note that there are regular patterns of sway, easily compensated for when they are detected by one of the senses that contributes to balance (Fujisawa et al. 2005).

Deprived of one of these senses—made to stand in the dark or with our calves vibrating so that we cannot sense muscle tension—we lose some of our stability, and sway becomes more pronounced. Studies of difficult situations, such as having one sensory channel confounded or being asked to maintain an unusual posture, have suggested that, within certain limits, subjects can 'reweight' this hierarchy of senses, depending more heavily on channels providing adequate information. Over longer terms, even more extensive shifts or 'reweightings' are possible (Nashner et al.1982; Bronstein 1986; Horak and Macpherson 1996; van der Kooij et al. 2001). This ability is especially important when, at times, we have to make sense of conflicting information from different senses (Jeka et al. 2000).

This understanding of equilibrium and other movement skills as motor-perceptual loops and open-ended abilities contrasts with information-processing models of skill acquisition, especially the idea that a skill is a stored motor pattern. Research on human movement belies the idea that the brain stores stereotypical motor patterns or fixed, identical actions. Instead, researchers such as Nicholai Bernstein (1996) have drawn attention to how a finely tuned coupling of motor abilities and perceptual skills constantly adjusts the body to shifting conditions, in part because the body simply has too many 'degrees of freedom' to reliably execute identical actions. With approximately eight hundred independent muscles and one hundred joints (Handford et al. 1997: 623), with the constantly changing condition of the task setting, and with the variability in the human body's response to its own impulses (for example, the elasticity of muscle fibers varies), the body does not stay upright by being stationary or accomplish a task by sending the same neural impulses to the limbs. Rather, the body compensates quickly as perceptions constantly track postural changes (Slobounov and Newell 1996: 185–86). Studies of catching movements, for example, show that skilful catchers respond to variations in the environment and the task by organising kinematically different, but successful, responses (Handford et al. 1997: 622).

The complex system that maintains balance, the integration of fine muscle control with perceptual abilities in the visual, vestibular and proprioceptive senses, can be significantly affected by training (van der Kooij et al. 2001). Skills like sports or dance often demand that practitioners become more stable in difficult contexts: a skier while travelling at high speeds, a ballet dancer when spinning, a judo practitioner when pushed or grabbed, or a basketball player while shifting direction abruptly when running. To become proficient, practitioners must find dependable ways to keep from falling, making do without some of the information that they rely upon in normal circumstances. Gymnasts, for example, have proven less dependent upon attention when trying to balance in difficult circumstances (Vuillerme et al. 2001a; Vuillerme et al. 2001b; Vuillerme and Nougier 2004); and sharpshooters have proven capable of maintaining better postural control than non-athletes (Aalto et al. 1990; Perrin et al. 2002; cf. Asseman et al. 2004). Although there is some debate about whether postural ability can transfer from the specific skills in a sport to a more general superior ability to 'balance' (see Kioumourtzoglou et al. 1998; Vuillerme et al. 2001; Asseman et al 2004), training clearly has lasting effect, indicating that some stable change has occurred in the practitioner.

Learning How to 'Plant the Banana Tree'

When I first tried to do a bananeira (handstand), my sense of balance was terrible. I put my hands on the ground, flung my legs upward, and then stayed aloft only as long as it took for gravity to roll back the momentum of my initial jump. I could not stay inverted for long and had no sense for where my body's point of equilibrium might be in that inverted posture. I would hold my hands up, rock forward onto them and launch my feet skyward, as though, if the kick supplied just the right amount of force, my inverted body would land precisely at the point of equilibrium. Invariably, the effort failed, and I quickly returned to my feet.

In capoeira classes, instructors gave students exercises to try to improve our balance. Some had us balance against a wall with our backs to it, or they made us do the bananeira while facing a wall, and then put one leg out horizontally to brace against it. Other instructors held their students upright in the handstand, physically securing them against falling. But most often, we simply tried again and again, until we finally developed the ability—in spite of chronic errors—to maintain balance for longer periods and with greater facility.

The bananeira, however, is no typical handstand; some of the demands of the posture make the position more difficult than other sorts of inverted postures, such as the handstand typical in Olympic gymnastics. One of the crucial differences is the positioning of the head and eyes. In most handstands, the head is kept tilted back, allowing the subject to look down at the ground; during a capoeira game, a player cannot afford to look away from an adversary, so the head must be held vertical, or even flexed toward the chest, so that he or she can track the other player. Clément and Rézette (1985) found that, just as vision was an important part of maintaining normal upright posture, anchoring the gaze was a technique that gymnasts used to control posture in a handstand. As Asseman and Gahéry (2005: 134) discuss, the visual fix becomes a perceptual 'benchmark' that contributes to stability and the ability to respond to sway. Like 'spotting' in ballet, gymnasts typically fix their vision on some point, which allows them to notice quickly if they vary from the vertical axis.

The standard position for gymnasts in Asseman and Gahéry's research was flexed back (dorsiflexed) about 55° (ibid.: 135). When Asseman and Gahéry asked their subjects, all expert gymnasts, to align their heads downward or hold them ventroflexed—that is, bent toward the chest—all found it much more difficult to maintain the handstand. (In contrast, over-dorsiflexion, well past 55°, did not cause their performance to drop off so precipitously, although it was also unfamiliar.) One explanation for the difficulties of the new posture is that the gymnasts in the study were not comfortable 'spotting' with their heads inverted or that the upheaval of the vestibular system is just too severe. The experience of capoeiristas suggests that, with training, practitioners can learn to orient with the head inverted. When they first attempt a bananeira, however, I have yet to encounter a student who did not assume the dorsiflexed posture preferred by gymnasts; all have to be repeatedly corrected to assume the more difficult, fully inverted head posture.

In addition, while capoeiristas are not deprived of sight altogether for use in balance, they are not able to resort to techniques of visual fixing or 'spotting' because of the demands of capoeira games. They must track an adversary who is likely to be moving, especially because capoeiristas consider the bananeira a vulnerable posture when held by a shaky novice. If a player holds his or her legs extended upward, for example, rather than keeping them bent down to protect the torso, the position is 'open', vulnerable to a headbutt to the stomach. The easier posture to maintain—legs extended or splayed upward—is far from ideal for defensive purposes. During many drills to learn the bananeira, instructors often had students kick their feet down vigorously. Ironically, one study of motor strategies to maintain inverted balance found that movements of the feet were the variable best correlated with 'instability' (Kerwin and Trewartha 2001).

Flexing the neck to bring the head to the chest and preserve visual contact with an adversary may also be difficult because it may initiate a primitive nervous system reaction, the tonic postural response. Although some neuroscientists debate whether adults maintain tonic postural reflexes, researchers like Fukuda (1984) argue that the reflexes of the neck help to distribute muscle tension in the upper body (cf. Hellebrandt et al. 1956; Hellebrandt et al. 1962; Asseman and Gahéry 2005). If the tonic postural response is operative in adults, it would provoke the spine to curve forward if the neck were to flex to the front; this reflex would make it virtually impossible to stay inverted and upright. In order to bend the neck forward while keeping equilibrium, a student would have to actively suppress the reflex. Whether or not Fukuda and others are right about the postural response being held over from earlier developmental stages, many students exhibit this pattern of behaviour. Prior to learning of Fukuda's research, I had assumed the response was a learned protective reaction to the danger of striking the ground head first, especially because many students who struggled most with the reflex had trained in other martial arts, in which they responded to being thrown or flipped to an inverted position by tucking the head to roll onto their backs. Reflexes honed in another art were in direct conflict with developing the bananeira.

Finally, the head-flexed-forward bananeira position is difficult to maintain, especially if the player also 'closes' the body, bending the legs down to protect the torso, because the player's torso has to be arched backwards to counterbalance this asymmetry. If a player is going to achieve inverted equilibrium with the legs held in front of the axis of balance, some equally heavy part of the body has to be held behind that axis. This usually means that a player's posterior has to bend backwards, arching the back and rotating the shoulder past vertical, as if the hands were held straight up from the shoulders behind the head. Students report that shifting the body this way demands different parts of the shoulder bear the body's weight, and they feel much weaker. Instead of those on the front of the shoulder, muscles on the back of the rotator cuff must now hold up the body—muscles that any weightlifter knows are not as strong as those in the front. At first, the shift requires the shoulders to extend to the limit of their flexibility and strength. When I have trained students to do this inverted posture against a wall, where stability was no longer a challenge, the relative weakness of this part of the shoulder was excruciatingly obvious. *Mestre* (teacher) Cobra Mansa recommended to advanced students that they practice this posture against a support, bending the head as far forward as possible while bringing the knees down, eventually progressing to balance on one arm. The position is not sustainable, obviously, but the robust 'sense of balance' developed through this exercise, being able to find temporary equilibrium in extremely awkward postures, helped make less ambitious inverted postures easy by comparison.

One other great difference between the motor-sensory perceptual system of inverted equilibrium that capoeiristas forge through training, and that used by gymnasts is the repertoire of motor techniques used to keep the body upright. When a gymnast begins to feel off balance, he or she typically responds by shifting the wrists, elbows and hips in order to maintain the feet in as constant a position as possible. Gymnasts work very hard to minimise sway and to keep the torso and head as still as possible (Slobounov and Newell 1996; cf. Kerwin and Trewartha 2001). In contrast, capoeiristas are encouraged to move in order to preserve their balance, bicycling or kicking the legs as counterbalances and walking on their hands to get the hands under a shifting centre of gravity.

Rather than keep the arms straight and toes pointed, as demanded by ideals of good bodily form in gymnastics (Kerwin and Trewartha 2001: 1183), capoeiristas learn to move their legs, bend their arms if necessary, even descend from the handstand into a headstand to keep upright in the inverted posture. Whereas a handstand in Olympics ideally *appears* to be static (in fact, it requires constant subtle adjustments), the bananeira in capoeira should be dynamic, mobile and constantly changing so as not to become an easy target.

The motor components of the bananeira so contradict those of the gymnastic handstand because the goals of the training are diametrically opposed. Gymnasts train to maintain an idealised posture, perfectly erect, not wavering, with no visible movement to compensate for swaying. The posture is the goal of training. In contrast, the goal of training in the bananeira is no particular posture; instead, capoeira instructors cultivate a general capacity to balance inverted, even if only in transition, while observing and interacting with an adversary. Just as training to stand perfectly upright and still would not necessarily develop the ability to dance or walk, training to a geometrically perfect ideal does not necessarily develop the sensory-motor skills necessary to make a quick transition to inverted postures from any range of starting points or to respond while inverted if conditions changed; for example, an Olympic gymnast might not be able to suddenly kick a leg downward to fend off a headbutt while in a handstand, something capoeiristas should be able to do during a bananeira. Instead of depending heavily on visual channels to maintain inverted balance, as gymnasts do, the training exercises for the bananeira emphasise refinement of somatosensory (touch), proprioceptive (position) and velocity-sensing capacities so that the eyes and head are free to move about as much as necessary to track an adversary. The 'sense of balance' for capoeiristas in this position draws on a different repertoire of sensory inputs and proprioceptive references than that of a gymnast.

This ability is so different from the stationary inverted balance of gymnasts that the research methods used to test gymnastic handstands would simply not capture the motor-perceptual skill capoeiristas strive to create. Vuillerme, Teasdale and Nougier (2001: 74), for example, tested subjects by having them remain 'as immobile as possible' on a pressure plate—a demand anathema to capoeira. In contrast, my capoeira instructors led exercises specifically intended to teach students to compensate for disequilibrium or oscillation when inverted by using gross movements. In one exercise, we were asked to jump over a chair into a handstand and then walk away from the chair; in another, we sought to walk inverted as far as possible, taking large strides with our arms. In one difficult exercise, students were encouraged to pick up one hand, touching it to the chest before putting it back down to lift the other in a kind of inverted 'high stepping'. Instead of a finely tuned motor-perceptual complex to eliminate even miniscule movements, the technical and practical demands of capoeira play drove us to couple a vigorous set of motor responses with an inverted posture 'sense of balance' in which the channels of sensory input were necessarily weighted in very different fashion to that used in static handstands. Although the human body clearly has certain 'organismic constraints' on how the challenge of preserving inverted posture might be surmounted, different strategies might be used to keep balanced; the cultural constraints of the capoeira roda drive practitioners to skilled solutions that differed markedly from those found by Olympic gymnasts (Slobounov and Newell 1996: 194–95).

Sensory-motor Learning and Embodiment in Anthropology

We generally accept that the body will change in response to physical education: muscles grow larger and denser, body composition shifts, and cardiovascular efficiency increases with aerobic activity. A central development in the neurosciences in recent decades, however, is the recognition that skill acquisition and changes in perceptual or motor abilities—such as learning to stand on one's hands—may entail significant shifts in how the brain accomplishes tasks, in the cerebral regions recruited into the neural networks responsible for them, and even in the brain areas dedicated to particular functions (Karni and Bertini 1997; Huttenlocher 2002). Many researchers are currently exploring the degree to which neural systems are malleable and respond to changes in the demands placed upon them by measurable physical alterations. Termed 'plasticity', this 'experience-dependent alteration of functional properties and circuits' is both widespread and maintained in adult brains, although clearly not infinite (Gilbert et al. 2001: 68).

In fact, extreme neuroplasticity is a defining trait of humans: the reason that we are capable of learning complex skills (Donald 2001: 90; Rossano 2003; cf. Oyama 1985; Pigliucci 2001; Ehrlich and Feldman 2003; West-Eberhard 2003). Studies have shown, for example, that regions of the sensorimotor cortex dedicated to controlling the fingers become greater with the practice of the violin or in readers of Braille, and that even relatively short periods of training in monkeys can increase the areas of the cortex dedicated to the limbs exercised. As Avi Karni (1996: 39) writes in a review of literature on motor and sensory learning, '[i]t is reasonable to assume that a gain in performance reflects a change in brain processing which is triggered by practice'.

Although both the body and the concept of 'embodied culture' have become common coin in anthropology, few sociocultural anthropologists have sought to explore how culture might have physiological effects (Downey 2005a).[4] The 'body' that has emerged in sociocultural anthropology is abstract, serving rhetorical ends in theorising rather than influencing sociocultural anthropologists' research agendas to take account of human biology. Tim Ingold, in a discussion of this gap, suggests:

> It seems to me that the theoretical gains brought by the paradigm of embodiment will be more apparent than real, so long as we fail to take one final, and crucial step, which is to recognize that the body *is* the human organism, and that the process of embodiment is one and the same as the development of that organism in its environment. (Ingold 1998: 28)

Taking seriously the organic nature of the culturally inflected human body means attempting to span the gap between our discipline and biological sciences.

In my eyes, the *practical* gains of the embodiment paradigm will also be more apparent than real until anthropologists are better able to discuss organic dimensions of corporeal enculturation. Sociocultural anthropologists talking about 'the body' as an abstraction invariably face exclusion from discussions about human variation by those who employ a more biological language, or use methods producing data seen to have greater physiological validity. Instead, we might combat simplistic, genetic determinist arguments in the public sector with plausible discussions of physiological mechanisms for culturally divergent paths of human development. Discussing the physical changes induced by physical education, like capoeira apprenticeship, means considering what research psychiatrist Jeffrey Schwartz calls 'directed neuroplasticity' (Schwartz and Begley 2002: 19).

One place where we can see clearly the effects of culture on physiology is in implicit forms of 'perceptual learning'.[5] 'Perceptual learning' occurs when, through training, an organism gets progressively better at making distinctions that are relevant to the tasks it undertakes. Close study of how training affects perceptual acuity suggests that, while some of this increased acuity can be attributed to strictly 'cognitive' dimensions of these tasks, many of the effects blur the boundary between perception and cognition or clearly arise in the perceptual system itself, prior to self-conscious interpretation. In other words, eyes can become better tools for accomplishing certain tasks because of the neural connections between them and the brain and the amount of the brain's resources devoted to visual tasks. As Crist et al. (2001: 519) discuss, cortical plasticity may underlie the functional changes that accompany experience and learning. What we do with our senses affects them physiologically, sometimes in long-lasting ways.

The reason that this discussion of the bananeira includes such extensive description of the differences between this skill and the handstands done by gymnasts is to highlight the role of 'top-down' influences—technical demands of capoeira interaction, coaching, aesthetic ideals—in the assembly of perceptual and motor systems that accomplish inverted postures in both arts. Doing a handstand and a bananeira probably do not have the same effect on practitioners because the two postures are accomplished in such different ways. The fact that perceptual learning depends in important ways upon attention and reward (Gilbert et al. 2001), suggests that sociocultural factors will help to shape the neural architecture of motor-sensory systems. Far from being biologically 'reductionist', a careful attention to neural plasticity and perceptual learning allows students of culture to understand better how behaviour and experience shape physiology in ways that ramify across our perceptions.

Avi Karni (1996) argues that neurological changes occur at the 'lowest level' possible in the perceptual system to complete a task, even in the primary sensory cortex, 'upstream' from the brain regions associated with consciousness or abstraction (cf. Gilbert et al. 2001). In other words, rather than being a change in how sensory information is 'processed' at a later point in thinking, neurological changes are made as close as possible to the sensory organs themselves (cf. Zenger and Sagi 2002; Seitz and Watanabe 2005). Seitz and Watanabe (2005: 329) explain that the specificity and narrowness of perceptual learning suggest that modification occurs close to the point where neural processes begin, rather than downstream, where their effects would be generalised. Manfred Fahle (2002), for instance, studied visual 'hyperacuity' in experiments in which trained subjects could perceive objects below the physical threshold of foveal photoreceptors due to their small size. He argues that localisation of hyperacuity in a single eye (ibid.: 217) suggests that learning is happening not 'deep in the brain', but close to the retina before visual information from both eyes is consolidated. The neurological system itself is 'learning' or becoming skilled to extract implicit information from the retinal image. Moreover, Fahle found that the adult primary visual system had a great deal of plasiticity and that the learning process was 'top down', improving only with careful attention and feedback (ibid.: 214–17; cf. Herzog and Fahle 2002; Seitz and Watanabe 2005).

This last point—that perceptual development appears to be strongly affected by 'top down' forces—opens the door for considering social and cultural effects on the microbiological processes of perception. O'Regan and Nöe (2001: 970, 977) suggest as much explicitly and also point out that an as-yet inexplicably large number of 'descending' nerve endings link the visual processing areas of the brain back to the retinas. Similar structures in the auditory channels are thought to allow 'higher' brain functions, including emotions, motivations, attention and interpretation, to pre-filter sensual input at the site of perception: in the sense organs themselves. If so, this would be an obvious neuroarchitectural channel for feedback into perceptual mechanisms at a very early stage of the perceptual change. But Seitz and Watanabe's discussion of 'upstream' sensory modification also forms an implicit critique of the limits of anthropological theories of perception that focus on behavioural dimensions of perceptual skill without taking account of the physiological refinement that also accompanies learning.

Conclusion: We Are All Athletes

Physical disciplines like capoeira have profound effects on how bodies develop physically, effacing the division sometimes drawn between biology and culture. Capoeira training takes hold of the entire perceptual system of balance, including not only the eyes, vestibular organs and somatic senses, but also the head and neck, which swivel to keep sight of things while the body is inverted, and even the neural pathways that parse light into useful information for balance. Capoeira training in inverted balance develops or strengthens neural connections to motor systems that can compensate for any imbalances: the muscles and joints of the wrists, the elbows, the torso and the legs. Although this article cannot offer specific data on the neurological impact of capoeira practice, the long-term effects of other sports suggest that profound neurological change underlies the acquisition of sensory-motor skills.

Cristina Grasseni (forthcoming: 9) suggests that some 'virtuosos' excel at particular perceptual skills because of their training in communities of practice. Certainly, virtuoso capoeiristas develop almost supernatural ability to balance while in the bananeira, combining a precise awareness of their bodies' positions with the motor skills necessary to keep themselves upright, even when perched precariously. Their extreme skills, however, make use of the same neural plasticity that all of us possess by virtue of being human. Research in sports physiology and the psychology of perception suggest that senses themselves are, as Edmund Carpenter put it, 'partly a skill and any skill can be cultivated' (1972: 20).

Although this research examines athletes because they push the extremes of humans' ability, in fact, virtually every skill includes perceptual apprenticeship: learning to discern and fasten upon essential qualities of the environment. This transformation is not merely in behaviour patterns; the reason skill acquisition is a slow and arduous process is that the body must harmonise physiologically with the demands of the task. Everyone's senses are educated according to their habitual practices; that training may be 'dis-abling' for certain tasks, but it is an active form of training nonetheless. Laura Sewall (1999: 166), for example, can claim that staring endlessly at flat screens and pages at short range makes it difficult for people to perceive and judge depth, but this is not simply 'damage'; it is the collateral effect of a visual system trained for short-range, fine perception. As Wallman (1994) describes, myopia is an alteration in the shape of the eye as it adapts to sustained focus on nearby objects.

Many neurologists, physiologists and psychologists have realised that organisms, far from being genetically predetermined, are shaped by complex developmental systems (cf. Lewontin 2001; Odling-Smee et al. 2003; West-Eberhard 2003). Although Terrence Deacon (1997: 347) reported to anthropologists more than a half-decade ago that discoveries of brain plasticity indicated that development was guided by 'extrinsic' information, sociocultural anthropologists have been slow to realise the significance of these findings. The minimalism in genetic prescription means that human neurological systems necessarily must have environmental information—including social and cultural feedback—to complete their development (cf. Deacon 2000). The suggestion is not that a 'natural' human neural architecture is modified by behaviour; rather, human perceptual systems come into the world underdetermined, requiring interaction with the environment to supplement the paucity of information in the genetic code (Oyama 1985).

'Culture' understood through the lens of sport includes perceptual, physiological and behavioural change, and the necessity of behaviour in shaping the body's physical structure and capacities. Ironically, sociocultural anthropologists often underestimate the malleability of human physiology, fearing that any discussion of biology is likely to lead to genetic determinism. In fact, awareness of physiological plasticity helps reveal what Merlin Donald (2001: 212) calls the 'deep enculturation' of the human brain and body: how repeated behaviours and intentional physical projects of self-making significantly affect physiology and perception. Athletes know well the degree to which they can reforge their bodies; they demonstrate convincingly that one's destiny is not written in the nuclei of one's cells.

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Notes

1. For a more in-depth study of capoeira, see Browning (1995; 1997), Downey (2005b) or Lewis (1992). For historical discussions of the art's emergence and development, additional resources include Assunção (2005) and Soares (1994).
2. I have also been told that the 'top' is sometimes called *parafuso* (screw). The names of these movements are only included for their descriptive value. In fact, my instructors did not use them. After practitioners in the United States asked me what these techniques were 'called', I consulted published sources.
3. For examples of this sort of interpretation, see Thompson (1988), Lewis (1992: 83–84), Reis (1993: 217, 236–237), (1994: 88, 95, 114) and Browning (1995; 1997). These approaches follow in a strong tradition in anthropology of studying forms of 'embodied meaning', exploring how the human body is used as a symbol.
4. For some of the stronger discussions of 'embodiment' in anthropology, see the work of Csordas (1990; 1992; 1993) and Strathern (1996).
5. For early discussions of perceptual learning, see the work of Gibson (1963; 1988) (cf. Fahle and Poggio 2002; Seitz and Watanabe 2005).

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